TABLE OF CONTENTS

Santa Margarita Water District
Cadiz Valley Water Conservation, Recovery, and Storage Project

Page

Executive Summary ES-1

1. Introduction 1-1
- 1.1 Purpose of the EIR 1-1
- 1.2 Project Overview 1-1
  - 1.2.1 Groundwater Conservation and Recovery Component 1-3
  - 1.2.2 Imported Water Storage Component 1-3
  - 1.2.3 Project Participants 1-4
- 1.3 CEQA Lead Agency and Responsible and Trustee Agencies 1-8
- 1.4 Organization of the Draft EIR 1-9
- 1.5 Level of CEQA Analysis in this Draft EIR 1-11
  - 1.5.1 Geographic Context 1-11
  - 1.5.2 Project-Level Analysis 1-11
  - 1.5.3 Programmatic-Level Analysis 1-11
- 1.6 EIR Review Process 1-12
  - 1.6.1 Notice of Preparation 1-12
  - 1.6.2 Public Scoping Meeting 1-13
  - 1.6.3 Public Review of the Draft EIR 1-13
  - 1.6.4 Final Environmental Impact Report Publication 1-14
  - 1.6.5 Mitigation Monitoring and Reporting Program 1-14
- 1.7 References and Citations 1-14

2. Project Background 2-1
- 2.1 Introduction 2-1
- 2.2 Overview of Cadiz Properties 2-1
  - 2.2.1 Agricultural Operations 2-1
  - 2.2.2 Cadiz Storage and Supply Program with Metropolitan 2-2
- 2.3 Existing Agreements and Permits 2-3
  - 2.3.1 San Bernardino County Groundwater Management Ordinance 2-3
  - 2.3.2 ARZC Lease 2-4
  - 2.3.3 Natural Heritage Institute Agreement 2-5
- 2.4 Overview of Southern California Water Supply 2-6
  - 2.4.1 The State Water Project 2-6
  - 2.4.2 Metropolitan Water District of Southern California and the CRA 2-8
- 2.5 Purpose of the Cadiz Valley Water Conservation, Recovery, and Storage Project 2-10

Page

3. Project Description 3-1
3.1 Project Overview 3-1
3.1.1 Introduction 3-1
3.1.2 Project Location 3-5
3.2 Project Objectives 3-5
3.3 Groundwater Basin Overview 3-7
3.3.1 Watersheds 3-7
3.3.2 Aquifer Properties 3-9
3.3.3 Groundwater Movement and Storage 3-9
3.4 Project Components 3-9
3.4.1 Groundwater Conservation and Recovery Component 3-10
3.4.2 Imported Water Storage Component 3-14
3.4.3 Groundwater Management, Monitoring, and Mitigation 3-16
3.5 Project Participants 3-19
3.5.1 Groundwater Conservation and Recovery Component 3-19
3.5.2 Imported Water Storage Component 3-22
3.6 Proposed Project Facilities 3-22
3.6.1 Groundwater Conservation and Recovery Component 3-23
3.6.2 Imported Water Storage Component 3-41
3.7 Project Construction 3-46
3.7.1 Groundwater Conservation and Recovery Component 3-46
3.7.2 Imported Water Storage Component 3-50
3.8 Agreements, Permits, and Approvals 3-53

4. Environmental Setting, Impacts, and Mitigation Measures 4-1
4.1 Aesthetics 4.1-1
4.1.1 Environmental Setting 4.1-1
4.1.2 Regulatory Framework 4.1-13
4.1.3 Impact and Mitigation Analysis 4.1-14

4.2 Agriculture and Forestry Resources 4.2-1
4.2.1 Environmental Setting 4.2-1
4.2.2 Regulatory Framework 4.2-4
4.2.3 Impact and Mitigation Analysis 4.2-6

4.3 Air Quality 4.3-1
4.3.1 Air Quality Overview 4.3-1
4.3.2 Environmental Setting 4.3-4
4.3.3 Regulatory Framework 4.3-6
4.3.4 Impact and Mitigation Analysis 4.3-9

4.4 Biological Resources 4.4-1
4.4.1 Environmental Setting 4.4-1
4.4.2 Regulatory Framework 4.4-28
4.4.3 Impact and Mitigation Analysis 4.4-35

Page

4. Environmental Setting, Impacts, and Mitigation Measures (cont.)

4.5 Cultural Resources 4.5-1
4.5.1 Environmental Setting 4.5-1
4.5.2 Research Methods and Results 4.5-15
4.5.3 Regulatory Framework 4.5-34
4.5.4 Impact and Mitigation Analysis 4.5-39

4.6 Geology and Soils 4.6-1
4.6.1 Environmental Setting 4.6-1
4.6.2 Regulatory Framework 4.6-22
4.6.3 Impact and Mitigation Analysis 4.6-27

4.7 Greenhouse Gas Emissions 4.7-1
4.7.1 Environmental Setting 4.7-1
4.7.2 Regulatory Framework 4.7-9
4.7.3 Impact and Mitigation Analysis 4.7-17

4.8 Hazards and Hazardous Materials 4.8-1
4.8.1 Environmental Setting 4.8-1
4.8.2 Regulatory Framework 4.8-7
4.8.3 Impact and Mitigation Analysis 4.8-10

4.9 Hydrology and Water Quality 4.9-1
4.9.1 Environmental Setting 4.9-1
4.9.2 Regulatory Framework 4.9-41
4.9.3 Impact and Mitigation Analysis 4.9-45

4.10 Land Use and Planning 4.10-1
4.10.1 Environmental Setting 4.10-1
4.10.2 Regulatory Framework 4.10-9
4.10.3 Impact and Mitigation Analysis 4.10-16

4.11 Mineral Resources 4.11-1
4.11.1 Environmental Setting 4.11-1
4.11.2 Regulatory Framework 4.11-2
4.11.3 Impact and Mitigation Analysis 4.11-6

4.12 Noise 4.12-1
4.12.1 Environmental Setting 4.12-1
4.12.2 Regulatory Framework 4.12-5
4.12.3 Impact and Mitigation Analysis 4.12-8

4.13 Public Services and Utilities 4.13-1
4.13.1 Environmental Setting 4.13-1
4.13.2 Regulatory Framework 4.13-8
4.13.3 Impact and Mitigation Analysis 4.13-10

4.14 Recreation 4.14-1
4.14.1 Environmental Setting 4.14-1
4.13.2 Regulatory Framework 4.14-6
4.14.3 Impact and Mitigation Analysis 4.14-8

Page

4. Environmental Setting, Impacts, and Mitigation Measures (cont.)
4.15 Transportation and Traffic 4.15-1
4.15.1 Environmental Setting 4.15-1
4.15.2 Regulatory Framework 4.15-4
4.15.3 Impact and Mitigation Analysis 4.15-7

5. Cumulative Impacts 5-1
5.1 Introduction and Approach 5-1
5.1.1 CEQA Statutory Guidance 5-1
5.1.2 Approach 5-2
5.2 Projects, Plans, and Programs Relevant to the Project Region 5-9
5.2.1 Energy Plans and Programs 5-11
5.2.2 Open Space / Conservation Plans 5-16
5.3 Cumulative Impacts Analysis 5-27
5.3.1 Aesthetics 5-27
5.3.2 Agriculture and Forestry Resources 5-28
5.3.3 Air Quality 5-29
5.3.4 Biological Resources 5-30
5.3.5 Cultural Resources 5-32
5.3.6 Geology and Soils 5-33
5.3.7 Greenhouse Gas Emissions 5-34
5.3.8 Hazards and Hazardous Materials 5-34
5.3.9 Hydrology and Water Quality 5-35
5.3.10 Land Use and Planning 5-36
5.3.11 Mineral Resources 5-38
5.3.12 Noise 5-39
5.3.13 Public Services and Utilities 5-39
5.3.14 Transportation and Traffic 5-40

6. Growth-Inducement Potential and Secondary Effects of Growth 6-1
6.1 Introduction 6-1
6.1.1 CEQA Requirements 6-1
6.1.2 Approach to Analysis 6-2
6.1.3 Regulatory Context for Land Use Planning and Water Supply Planning 6-6
6.2 Growth Inducement Potential 6-9
6.2.1 Introduction 6-9
6.2.2 Santa Margarita Water District (SMWD) 6-12
6.2.3 Golden State Water Company 6-20
6.2.4 Three Valleys Municipal Water District (Three Valleys) 6-24
6.2.5 Suburban Water Systems (Suburban) 6-29
6.2.6 Jurupa Community Services District (JCSD) 6-33
6.2.7 Cal Water Service Company (Cal Water) 6-38
6.2.8 Future Project Participants 6-42
6.3 Secondary Effects of Growth 6-60
6.3.1 Introduction 6-60
6.3.2 Impact and Mitigation 6-62

Page

7. Alternatives Analysis 7-1
7.1 Introduction 7-1
7.1.1 CEQA Guidance for Alternatives Analysis 7-1
7.1.2 Chapter Organization 7-3
7.2 Project Objectives 7-3
7.3 Significant Impacts of the Proposed Project 7-4
7.4 Alternatives Rejected from Further Consideration 7-4
7.4.1 The Western Alternative 7-5
7.4.2 The Combination Alternative 7-5
7.4.3 The Eastern/Canal Alternative 7-6
7.4.4 Water Conservation Alternative 7-6
7.4.5 Other Supply Sources Alternative 7-10
7.5 Alternatives to the Groundwater Conservation and Recovery Component 7-14
7.6 Alternatives Evaluation – Groundwater Conservation and Recovery Component 7-15
7.6.1 No Project Alternatives 7-19
7.6.2 Project Facility Alternatives 7-25
7.6.3 Project Operational Alternatives 7-37
7.7 Comparison of Alternatives and Identification of the Environmentally Superior Alternative – Groundwater Conservation and Recovery Component 7-45
7.7.1 Comparison of Alternatives 7-45
7.7.2 Environmentally Superior Alternative 7-45
7.8 Alternatives to the Imported Water Storage Component 7-46
7.8.1 No Project Alternative 7-48
7.8.2 Spreading Basins Alternatives 7-48
7.9 Comparison of Alternatives and Identification of the Environmentally Superior Alternative: Imported Water Storage Component 7-51
7.9.1 Comparison of Alternatives 7-51
7.9.2 Environmentally Superior Alternative 7-51

8. Irreversible and Irretrievable Commitment of Resources 8-1
8.1 Introduction and Approach 8-1
8.1.1 CEQA Statutory Guidance 8-1
8.1.2 Approach 8-1
8.2 Analysis of Commitment of Resources 8-2
8.2.1 Conservation and Recovery Component 8-2
8.2.2 Imported Water Storage Component 8-3

9. Report Preparers 9-1
9.1 Project Sponsor / Lead Agency 9-1
9.2 EIR Authors and Consultants 9-1

10. Acronyms 10-1

11. References 11-1

Appendices (DEIR Volumes 2 through 4)

Volume 2

Appendix A: Notice of Preparation and Scoping Report
Appendix B: Groundwater Management
B1: Groundwater Management, Monitoring, and Mitigation Plan
B2: Groundwater Stewardship Committee October 2011 Summary of Findings and Recommendations
Appendix C: Pipeline Alignment Map Book
Appendix D: Power Requirements Analysis

Volume 3

Appendix E: Air Quality Reports
E1: URBEMIS 2007 Output Sheets
E2: Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas
E3: Emissions Worksheets
Appendix F: Biological Resources Reports
F1: Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment
F2: Streambed Delineation
F3: Rare Plant Survey Report
F4: Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping near Bristol and Cadiz Playas
Appendix G: Cultural and Paleontological Resources Reports
G1: Phase I Cultural Resources Assessment
G2: Paleontology Survey and Assessment

Volume 4

Appendix H: Hydrology Reports
H1: Cadiz Groundwater Modeling and Impact Analysis
H2: Supplemental Assessment of Pumping Required
H3: Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs
H4: Springs Fieldwork
H5: Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis
Appendix I: Economic Impact Report
Appendix J: Significant and Unavoidable Impacts Identified in General Plan EIRs for Counties and Cities within the Water Area of Use

Page

List of Figures

ES-1 Key Project Facilities ES-5
ES-2 Conceptual Surface and Groundwater Flow with Project after 50 Years ES-6
ES-3 Participating Water Providers: SMWD, Suburban, Three Valleys, and Jurupa CSD ES-7
ES-4 Participating Water Provider: Golden State Water Company Southern California Service Areas ES-8
1-1 Watershed Boundaries 1-2
1-2 Participating Water Providers: SMWD, Suburban, Three Valleys, and Jurupa CSD 1-5
1-3 Participating Water Provider: Golden State Water Company 1-7
1-4 Geographic Context of Project Assessment 1-12
2-1 California State Water and Colorado River Aqueduct 2-7
3-1 Key Project Facilities 3-3
3-2 Conceptual Surface and Groundwater Flow 3-8
3-3a Conceptual Surface and Groundwater Flow with Project after 50 Years 3-11
3-3b Conceptual Cross Section Showing Groundwater Flow and Evaporation 3-12
3-4 Regional Monitoring Facilities (Wells, Extensometers, Nephelometer Station) 3-17
3-5 Monitoring Facilities (Wells, Extensometers, Nephelometer Station) 3-18
3-6a Proposed Wellfield and Manifold System: Groundwater Conservation and Recovery Component Wellfield Configuration A 3-24
3-6b Proposed Wellfield and Manifold System: Groundwater Conservation and Recovery Component Wellfield Configuration B 3-25
3-7 Typical Well Conceptual Diagram 3-27
3-8 Typical Pipeline Section / Trench 3-28
3-9 Example of Typical Air Relief Valve Structure 3-30
3.10a Potential Staging Areas: Near the Proposed Wellfield Area 3-31
3.10b Potential Staging Areas: Along the ARZC Railroad 3-32
3.10c Potential Staging Areas: Near the CRA Tie-In 3-33
3-11 Proposed CRA Tie-In Option 1 3-35
3.12a Proposed CRA Tie-in Option 2a, Equalization Storage Reservoir Location 3-37
3.12b Proposed CRA Tie-in Option 2b, Equalization Storage Reservoir Location 3-38
3-13 El Paso Pipeline 3-43
3-14 Existing Wellfield 3-44
4.1-1 Photo Viewpoints 4.1-2
4.1-2 Viewpoint 1 4.1-7
4.1-3 Viewpoints 2 and 3 4.1-8
4.1-4 Viewpoint 4 4.1-9
4.1-5 Viewpoint 5 4.1-10
4.1-6 Viewpoint 6 4.1-11
4.1-7 Viewpoint 7 4.1-12
4.2-1 Agricultural Zoning in the Project Area 4.2-3
4.4-1 Streambed Crossings 4.4-6
4.4-2 Sections Surveyed for Desert Tortoise Within the Proposed Wellfield Area 4.4-18
4.4-3 Desert Tortoise Critical Habitat 4.4-20
4.4-4 Bighorn Sheep Range and Movement Corridor 4.4-25
4.6-1 Topography 4.6-3
4.6-2 Simplified Geology 4.6-5
4.6-3a Geology of Fenner Gap Area 4.6-11
4.6-3b Map Key – Geology of Fenner Gap Area 4.6-12
4.6-4 Quaternary Fault Zones and Earthquake Epicenters 4.6-14

Page

List of Figures (cont.)

4.6-5 Model-Predicted Land Subsidence - Project Scenario (Assumes 32,000 AFY Recharge) 4.6-30
4.6-6 Model-Predicted Land Subsidence - Sensitivity Scenario 1 (Assumes 16,000 AFY Recharge) 4.6-31
4.6-7 Model-Predicted Land Subsidence - Sensitivity Scenario 2 (Assumes 5,000 AFY Recharge) 4.6-32
4.9-1 Topographic Map and Watershed Boundaries 4.9-3
4.9-2 Precipitation Isohyets for the 1971–2000 Period 4.9-8
4.9-3 Location of Springs in the Fenner Watershed 4.9-20
4.9-4 Conceptual Cross-Section Showing Water Sources of Springs in the Fenner Watershed 4.9-21
4.9-5 Location of Known Wells in the Fenner, Bristol, and Cadiz Watersheds 4.9-25
4.9-6 2009 Groundwater Elevation Contours 4.9-29
4.9-7 Model-Predicted Saline Water and Freshwater Interface Migration – Project Scenario (Assumes 32,000 AFY Recharge) 4.9-50
4.9-8 Model-Predicted Saline Water and Freshwater Interface Migration – Sensitivity Scenario No. 1 (Assumes 16,000 AFY Recharge) 4.9-51
4.9-9 Model-Predicted Saline Water and Freshwater Interface Migration – Sensitivity Scenario No. 2 (Assumes 5,000 AFY Recharge) 4.9-52
4.9-10 Proximity of Private Property to Saline Groundwater Interface 4.9-54
4.9-11a Conceptual Cross Section Showing Groundwater Flow and Evaporation 4.9-64
4.9-11b Conceptual Cross Section Showing Groundwater Flow and Evaporation during Recovery 4.9-65
4.9-12 Model-Predicted Regional Drawdown - Project Scenario after 50 Years (Assumes 32,000 AFY Recharge) – Well Configuration A 4.9-67
4.9-13 Model-Predicted Regional Drawdown - Sensitivity Scenario No.1 after 50 Years (Assumes 16,000 AFY Recharge) – Well Configuration B 4.9-68
4.9-14 Model-Predicted Regional Drawdown - Sensitivity Scenario No.2 after 50 Years Sensitivity (Assumes 5,000 AFY Recharge) – Well Configuration B 4.9-69
4.10-1 Private Property in the Project Area 4.10-3
4.10-2 General Plan Land Use / Zoning 4.10-12
4.11-1 Current Salt Production and Historical Mining Locations 4.11-3
4.12-1 Effects of Noise on People 4.12-2
4.12-2 Land Use Compatibility for Community Noise Environment 4.12-7
4.13-1 Utilities Corridors near the Pipeline Alignment 4.13-5
4.13-2 Existing Pipelines near the Project Area 4.13-6
4.14-1 BLM Multiple-Use Classes and Wilderness Areas 4.14-4
4.15-1 Regional Transportation Network 4.15-2
5-1 Cumulative Projects 5-10
5-2 Proposed California Desert Protection Act of 2011 5-17
6-1 Metropolitan Water District Service Area 6-5
7-1 Model-Predicted Regional Drawdown – Reduced Alternative Scenario after 25 Years (Assumes 32,000 AFY Recharge) – Well Configuration B 7-43
7-2 Model-Predicted Regional Drawdown - Reduced Alternative Scenario after 25 Years (Assumes 16,000 AFY Recharge) – Well Configuration B 7-44

Page

List of Tables

ES-1 Summary of Impacts and Mitigation Measures Groundwater Conservation and Recovery Component ES-11
ES-2 Summary of Impacts and Mitigation Measures Imported Water Storage Component ES-32
2-1 Sources of Water Supply for the Metropolitan Service Area (acre-feet) 2-9
3-1 Project Water Subscriptions for the Groundwater Conservation and Recovery Component 3-21
3-2 Cadiz Wellfield Power Requirements Groundwater Conservation and Recovery Component 3-39
3-3 Intermediate Pump Station Power Requirements Groundwater Conservation and Recovery Component CRA Tie-In Option 2b 3-39
3-4 Cadiz Wellfield Power Requirements Imported Water Storage Component 3-46
3-5 Construction Equipment Required for the Groundwater Conservation and Recovery Component 3-49
3-6 Construction Equipment Required for the Imported Water Storage Component 3-52
4.1-1 Impacts and Mitigation Summary 4.1-26
4.2-1 Current Agricultural Cultivation in the Project Area 4.2-4
4.2-2 Impacts and Mitigation Summary 4.2-14
4.3-1 California and National Criteria Air Pollutant Standards, Effects, and Sources 4.3-3
4.3-2 Mojave Desert Air Basin Attainment Status 4.3-4
4.3-3 Ambient Air Quality in Project Vicinity (2008–2010) 4.3-6
4.3-4 MDAQMD Air Emissions Significance Thresholds for Construction Activities 4.3-9
4.3-5 Construction Emissions From Groundwater Conservation and Recovery Component 4.3-12
4.3-6 Operational Emissions from Natural Gas Engines 4.3-14
4.3-7 GMMMP Project Design Feature 6.8 – Air Quality 4.3-16
4.3-8 Impacts and Mitigation Summary 4.3-25
4.4-1 Special-Status Species Potentially Occurring in the Study Area 4.4-11
4.4-2 Summary of Impacts 4.4-40
4.4-3 Impacts and Mitigation Summary 4.4-60
4.5-1 Cultural Complexes 4.5-3
4.5-2 Previously Recorded Cultural Resources within 0.5 Mile of the Project Area 4.5-16
4.5-3 Significant Cultural resources 4.5-24
4.5-4 Surficial Mapped Geologic Units within the Paleontological Resources Study Area 4.5-32
4.5-5 Impacts and Mitigation Summary 4.5-52
4.6-1 Modified Mercalli Intensity Scale for Earthquake Intensity 4.6-21
4.6-2 Maximum Rail Line Speeds 4.6-23
4.6-3 Tolerance Limits 4.6-24
4.6-4 Summary of Model-Predicted Subsidence Amounts 4.6-36
4.6-5 GMMMP Project Design Feature 6.3 – Land Subsidence 4.6-37
4.6-6 Impacts and Mitigation Summary 4.6-43
4.7-1 Global Warming Potential for Greenhouse 4.7-2
4.7-2 List of Recommended Actions by Sector 4.7-12
4.7-3 Construction Emissions From groundwater Conservation and Recovery Component 4.7-21
4.7-4 Annual GHG Emissions 4.7-22
4.7-5 Impacts and Mitigation Summary 4.7-25

Page

List of Tables (cont.)

4.8-1 Impacts and Mitigation Summary 4.8-21
4.9-1 Summary of Simulated Changes in Decade-Mean Hydroclimate for the Colorado River above the Imperial Dam 4.9-12
4.9-2 Cadiz Annual Groundwater Use for Agriculture 2002 through 2010 ..... 4.9-27
4.9-3 Summary of 2007 Water Quality Parameters below Parker Dam 4.9-40
4.9-4 Groundwater Beneficial Use Designations 4.9-43
4.9-5 Summary of Model-Predicted Saline Water-Freshwater Interface Migration Distances 4.9-49
4.9-6 GMMMP Project Design Feature 6.2 – Third Party Wells 4.9-55
4.9-7 GMMMP Project Design Feature 6.4 – Induced Flow Of Lower Lower-Quality Water from Bristol and Cadiz Dry Lakes 4.9-56
4.9-8 Summary of General Water Quality Results 4.9-57
4.9-9 Summary of Model-Predicted Drawdown Amounts 4.9-70
4.9-10 Summary of Model-Predicted Storage Response 4.9-71
4.9-11 Summary of Cumulative Net Savings of Water 4.9-72
4.9-12 Impacts and Mitigation Summary 4.9-80
4.10-1 Total 2010 Population, Housing, and Employment 4.10-5
4.10-2 SCAG Population, Housing, and Employment Projections 4.10-6
4.10-3 2010 Race/Ethnicity within Unincorporated San Bernardino County 4.10-6
4.10-4 Household Income and Status 4.10-7
4.10-5 Job-to-Housing Ratio Projections 4.10-8
4.10-6 Economic Impacts during Construction of the Groundwater Conservation and Recovery Component 4.10-22
4.10-7 Economic Impacts during the Imported Water Storage Component 4.10-27
4.10-8 Summary of Total Economic Impacts 4.10-28
4.10-9 Impacts and Mitigation Summary 4.10-30
4.11-1 Summary of Model-Predicted Drawdown under Operation of the Groundwater conservation and Recovery Element of the Project 4.11-9
4.11-2 GMMMP Project Design Feature 6.5 – Brine Resources Underlying Bristol and Cadiz Dry Lakes 4.11-10
4.11-3 Impacts and Mitigation Summary 4.11-13
4.12-1 San Bernardino County Stationary Noise Standards 4.12-6
4.12-2 Typical Noise Levels from Construction Activities 4.12-9
4.12-3 Typical Noise Levels from Construction Equipment 4.12-9
4.12-4 Vibration from Construction Equipment 4.12-12
4.12-5 Impacts and Mitigation Summary 4.12-17
4.13-1 Impacts and Mitigation Summary 4.13-23
4.14-1 County Regional Parks and Community Parks in the Desert Region 4.14-1
4.14-2 CDCA Guidelines for Recreational Activities Allowed in Each of the Multiple-Use Classes (BLM-administered lands only) 4.14-3
4.14-3 BLM Wilderness Areas Located in the Project Vicinity 4.14-7
4.14-4 Impacts and Mitigation Summary 4.14-13
4.15-1 Level of Service Definitions 4.15-5
4.15-2 Local Roadway Service Levels 4.15-5
4.15-3 Impacts and Mitigation Summary 4.15-17
5-1 Summary of Environmental Resource Areas and Associated Geographic Scopes for the Cumulative Effects Analysis 5-6
5-2 Plans, Programs, and Projects Evaluated in the Cumulative Effects Analysis 5-20

Page

List of Tables (cont.)

6-1 Project Water Subscriptions for the Groundwater Conservation and Recovery Component 6-11
6-2 Growth and Water Demand Projections Summary for Participating Water Providers in the Groundwater Conservation and Recovery Component 6-13
6-3 Current and Projected Population in the SMWD Service Area 6-15
6-4 SMWD Past, Current and Projected Water Demand by Water Use Sector 6-15
6-5 Current and Projected Water Demands 6-16
6-6 Projected Normal Water Supply and Demand 6-17
6-7 Projected Population Growth for Applicable Southern California Water Systems in Golden State Regions I, II and III 6-21
6-8 Projected Water Supply / Demand for Applicable Southern California Water Systems in Golden State Regions I, II and III 6-22
6-9 Projected Population Growth in Three Valleys Service Area by City 6-25
6-10 Historic Water Use (2005 – 2009) and Projected Water Supply (2010 – 2035) in the Three Valleys Service Area 6-26
6-11 Total Retail Demand in Three Valleys Service Area with Conservation – Average Year 6-27
6-12 Projected Population Growth in Suburban Water Systems Service Area 6-30
6-13 Total Retail Water Use and Projected Demand in Suburban's Service Area 6-30
6-14 Suburban Water Systems: Existing and Projected Water Supply Sources 6-31
6-15 Historic and Projected Population in JCSD Service Area 6-33
6-16 Current and Projected Water Demand by Customer Class 6-34
6-17 Summary of Current And Planned Water Supplies in JCSD 6-35
6-22 Metropolitan Water District Member Agencies by County 6-43
6-23 SCAG Population Projections in Study Area Counties 6-45
6-24 Areas with Greatest Projected Population Growth in Study Area Counties, by County 6-46
6-25 SANDAG 2030 Population Projections 6-47
6-26 SANDAG 2050 Population Projections 6-48
6-27 Historical Population Growth in the Metropolitan Service Area, by County 6-49
6-28 Projected Population Growth in Metropolitan Service Area by County 6-49
6-29 Total Retail M&I Demand in Metropolitan's Service Area with Conservation and SBX7-7 6-50
6-30 Total Retail Agriculture Demand in Metropolitan's Service Area 6-51
6-31 Sources of Water Supply Used in the Metropolitan Service Area, 2000-2010 6-51
6-32 Existing (2010) and Planned (2035) Water Sources in the Metropolitan Service Area 6-52
6-33 Factors Resulting in Inconsistency of Supply 6-57
6-34 Documents that Have Analyzed Growth in the Project Water Area of Use 6-62
6-35 Agencies Having Authority to Implement Major Mitigation Measures for Growth-Related Impacts 64
7-1 Planned and Future Water Supply Projects and Programs 7-11
7-2 Selected Alternatives for CEQA Analysis 7-16
7-3 Ability of Project Alternatives to Meet Project Objectives 7-17
7-4 Summary Comparison of Project Alternatives 7-18
7-5 Strategies to Avoid or Lessen Significant Environmental Effects of the Imported Water Storage Project 7-47

EXECUTIVE SUMMARY

ES.1 Introduction and Purpose of the EIR (Chapters 1 and 2)

Santa Margarita Water District (SMWD) has prepared this Draft Environmental Impact Report (EIR) to provide the public and responsible and trustee agencies with information about the potential effects on the local and regional environment associated with the construction and operation of the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). This Draft EIR evaluates the environmental effects of the proposed Project and suggests mitigation measures to reduce any significant impacts to a less than significant level. This Draft EIR is intended to also identify and evaluate feasible alternatives to the proposed Project. The Draft EIR has been prepared pursuant to the California Environmental Quality Act (CEQA) of 1970 (as amended), codified at California Public Resources Code Sections 21000 et. seq., and the *CEQA Guidelines* in the Code of Regulations, Title 14, Division 6, Chapter 3. As Lead Agency under CEQA, SMWD may use this EIR to approve the proposed Project, make Findings regarding identified significant impacts, and if necessary, adopt a Statement of Overriding Considerations regarding these impacts.

ES.2 Project Summary (Chapter 3)

Project Overview

Cadiz Inc. (Cadiz) is a private corporation that owns approximately 34,000 mostly contiguous acres in the Cadiz and Fenner Valleys (Cadiz Property), which are located in the Mojave Desert portion of eastern San Bernardino County, California. Cadiz Inc., in collaboration with SMWD and other water providers participating in the Project (Project Participants), have collaboratively developed the Cadiz Valley Water Conservation, Recovery, and Storage Project to implement a comprehensive, long-term groundwater management program for the closed groundwater basin underlying its property that would allow for both the beneficial use of some of the groundwater and storage of imported surface water in the groundwater basin.

Underlying the Cadiz and Fenner Valleys and the adjacent Bristol Valley is a vast groundwater basin that holds an estimated 17 to 34 million acre-feet (MAF) of fresh groundwater. The Project area, which would be sited on Cadiz Property, is located at the confluence of the Fenner, Orange Blossom Wash, Bristol and Cadiz Watersheds (Watersheds), which span over 2,700 square miles.

Within this closed basin system, groundwater percolates and migrates downward from the higher elevations in the Watersheds and eventually flows to Bristol and Cadiz Dry Lakes. The Dry Lakes represent the low point in the closed watershed basin, meaning that all surface and groundwater within the surrounding Watersheds eventually flows down gradient to these Dry Lake areas and not beyond. Once the fresh groundwater reaches the Dry Lake areas, it evaporates, first mixing with the highly saline groundwater zone under the Dry Lakes and getting trapped in the salt sink, no longer fresh, suitable, or available to support freshwater beneficial uses. The portion that evaporates is lost from the groundwater basin and is therefore also unable to support beneficial uses.

Project Purpose

The California Constitution mandates maximizing the reasonable and beneficial use of water and the avoidance of waste. *The fundamental purpose of the Project* is to save substantial quantities of groundwater that are presently wasted and lost to evaporation by natural processes. In the absence of this Project, approximately 3 million acre-feet of groundwater presently held in storage between the proposed wellfield and the Dry Lakes would become saline and evaporate over the next 100 years. By strategically managing groundwater levels, the Project would conserve up to 2 million acre-feet of this water, retrieving it from storage before it is lost to evaporation. The conservation opportunity is unique and garners special emphasis. The proposed conservation is not dependent upon future rainfall, snow pack or the needs and demands of others: the groundwater is already in storage. Moreover, the conservation and resulting water supply augmentation can be achieved independently from the environmental and regulatory conditions that generally constrain the importation of water to Southern California. The geographic isolation of the groundwater makes it non-tributary to the Colorado River system, and therefore eligible for distinctive treatment under federal regulations that may unlock additional complementary storage opportunities, both within the Basin and in Lake Mead.

The Project makes available a reliable water supply for Southern California Project Participants, to supplement or replace existing supplies and enhance dry-year supply reliability. Both the State Water Project (SWP) and Colorado River water supplies are experiencing reductions from historic deliveries. As a result, Southern California water providers are looking for affordable new supplies to replace or augment current supplies and enhance dry-year supply reliability. The Project would optimize the reasonable and beneficial use of water within the aquifer system in a sustainable fashion—conserving water that would otherwise be wasted—to create a local water supply alternative for Southern California water providers.

The objectives of this Project are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation;
- Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought;

- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;
- Enhance dry-year water supply reliability within the service areas of SMWD and other Southern California water provider Project Participants;
- Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of carry-over storage and, for Phase 2, imported water storage;
- Support operational water needs of the Arizona and California Railroad (ARZC) in the Project area;
- Create additional water storage capacity in Southern California to enhance water supply reliability;
- Locate, design, and operate the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

Project Components

The proposed Project includes two distinct but related components:

- Groundwater Conservation and Recovery Component
- Imported Water Storage Component

Under the Groundwater Conservation and Recovery Component, an annual average of 50,000 acre-feet (AF) of groundwater would be pumped from the basin over a 50-year period for delivery to Project Participants in accordance with agreements with Cadiz Inc. and the Cadiz Groundwater Management, Monitoring and Mitigation Plan (GMMMP). The GMMMP has been developed to guide the long-term groundwater management of the basin for the Project. The level of groundwater pumping proposed under the Groundwater Conservation and Recovery Component is designed specifically to extract and conserve groundwater that would otherwise migrate to the Dry Lakes, enter the brine zone, and evaporate. The Groundwater Conservation and Recovery Component is analyzed at a project level in this Draft EIR in accordance with *CEQA Guidelines* Sections 15161 and 15378(a).

The full term of the Project would be 50 years for both components. In the event that circumstances beyond the control of the Project operator required additional time to complete contracted water deliveries, the Project term may be extended for a limited time under the terms of the agreements. If Project Participants elect to extend the Project for an additional term, new agreements and a new environmental analysis would be required.

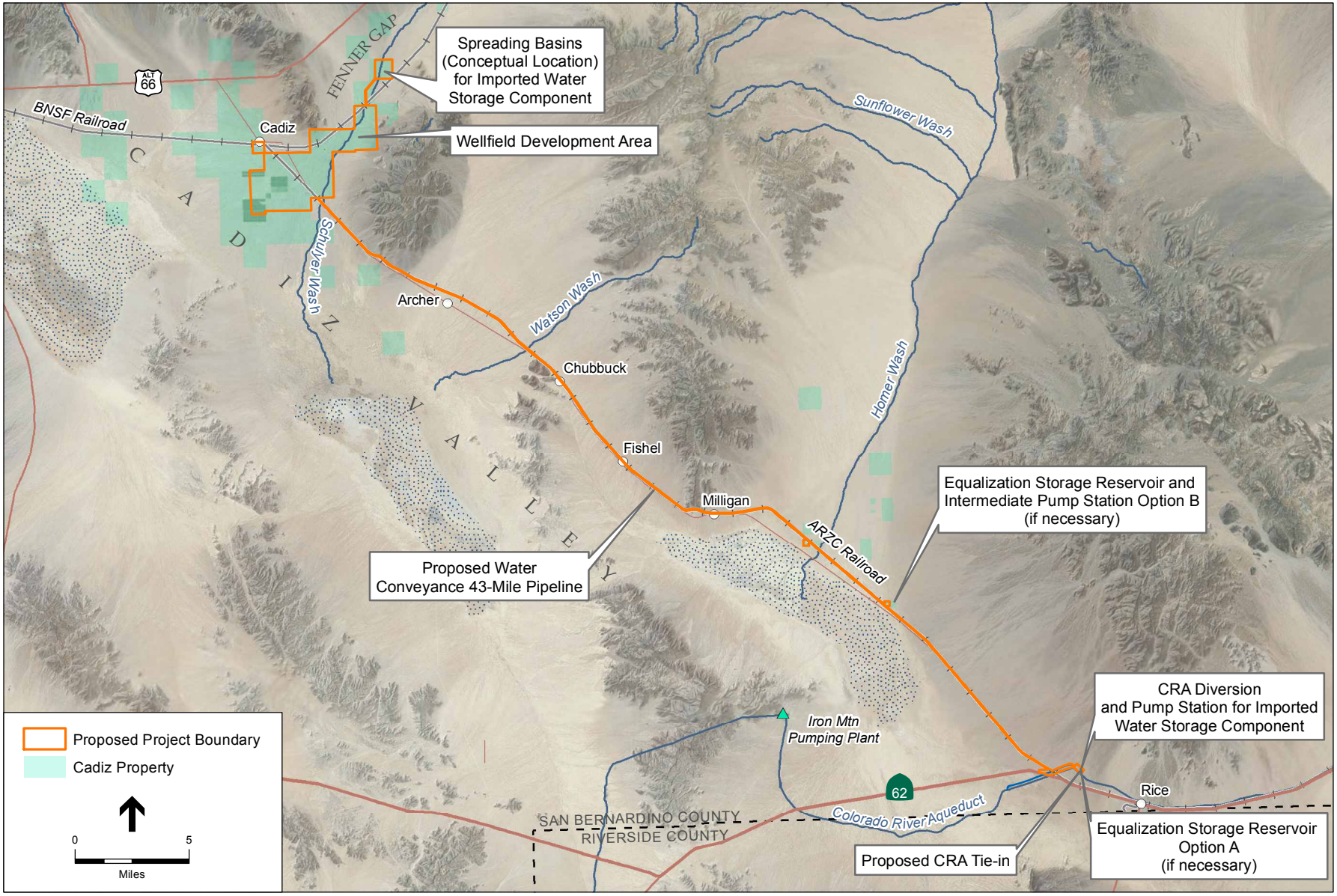
The facilities proposed for this component of the Project include a wellfield, manifold (piping) system, a 43-mile conveyance pipeline, monitoring features, other appurtenances and fire suppression mechanisms. The wellfield and manifold (piping) system would be constructed on

Cadiz Property to carry pumped groundwater to the conveyance pipeline, which would be constructed along the ARZC ROW and tie into the CRA, which would distribute water to Project Participants. A power conveyance system would be installed that would convey energy to the wellfield from natural gas engines or from electricity from the grid. In addition, to meet ARZC's fire suppression and operational water needs, fire hydrants would be installed along the conveyance pipeline at strategic locations along the railroad tracks (e.g., at bridge trestles). Withdrawal of water for this Project component would be limited to a maximum of 75,000 AFY of water in any given year and a total of 50,000 AFY on average over the 50-year term of the Project. These proposed Project facilities are identified in **Figure ES-1**. **Figure ES-2** provides a schematic overview of the proposed Project's groundwater extraction in the Fenner Gap.

As of the publication date of this Draft EIR, Project Participants include SMWD, Three Valleys Municipal Water District, Golden State Water Company, Suburban Water Systems, Jurupa Community Services District, and California Water Service Company, which cover some or all of the following five counties: San Bernardino, Riverside, Orange, Ventura, and Los Angeles (see **Figures ES-3** and **ES-4**). ARZC is also a Project Participant. The Project would serve the railroad's water demands along the ROW, including fire suppression, as well as providing ARZC access to the road along the pipeline that would be constructed as part of the Project. The Project would also serve additional railroad purposes that have been identified by ARZC which will be subject to additional environmental review.

The Imported Water Storage Component would allow participants to send surplus surface water supplies, when available, to the Project area to be recharged via spreading basins and held in storage until needed in future years. When needed, the stored surface water would be pumped out of the groundwater basin and returned to the appropriate Project Participant. The Imported Water Storage Component proposes to store up to 1 MAF. In addition, as part of the Imported Water Storage Component, one or more of the unused natural gas pipelines that exist in the Project area may be converted for use as a water conveyance facility. The purpose of this would be 1) to intertie the Project system to the State Water Project or other potential sources of surface water supply for import and storage at the Project site and/or 2) to connect to other potential Project Participants interested in storing water at the Project area. Initial study indicates that existing natural gas pipelines in the area could be converted for use as water conveyance pipelines with a maximum capacity of 30,000 AFY.

Where possible, the Imported Water Storage Component is analyzed at a project level (i.e., select facilities that are sufficiently defined), but because participants have not been identified and certain elements of the design are still under conceptual development, including the potential quantity and schedule for surface water import, spreading, storage, and extraction, the Imported Water Storage Component of the proposed Project is analyzed primarily at a programmatic level in this Draft EIR in accordance with *CEQA Guidelines* Section 15168. At a time when the Imported Water Storage Component is to be implemented, additional review will be conducted in accordance with *CEQA Guideline* Section 15161 and 15378(a).

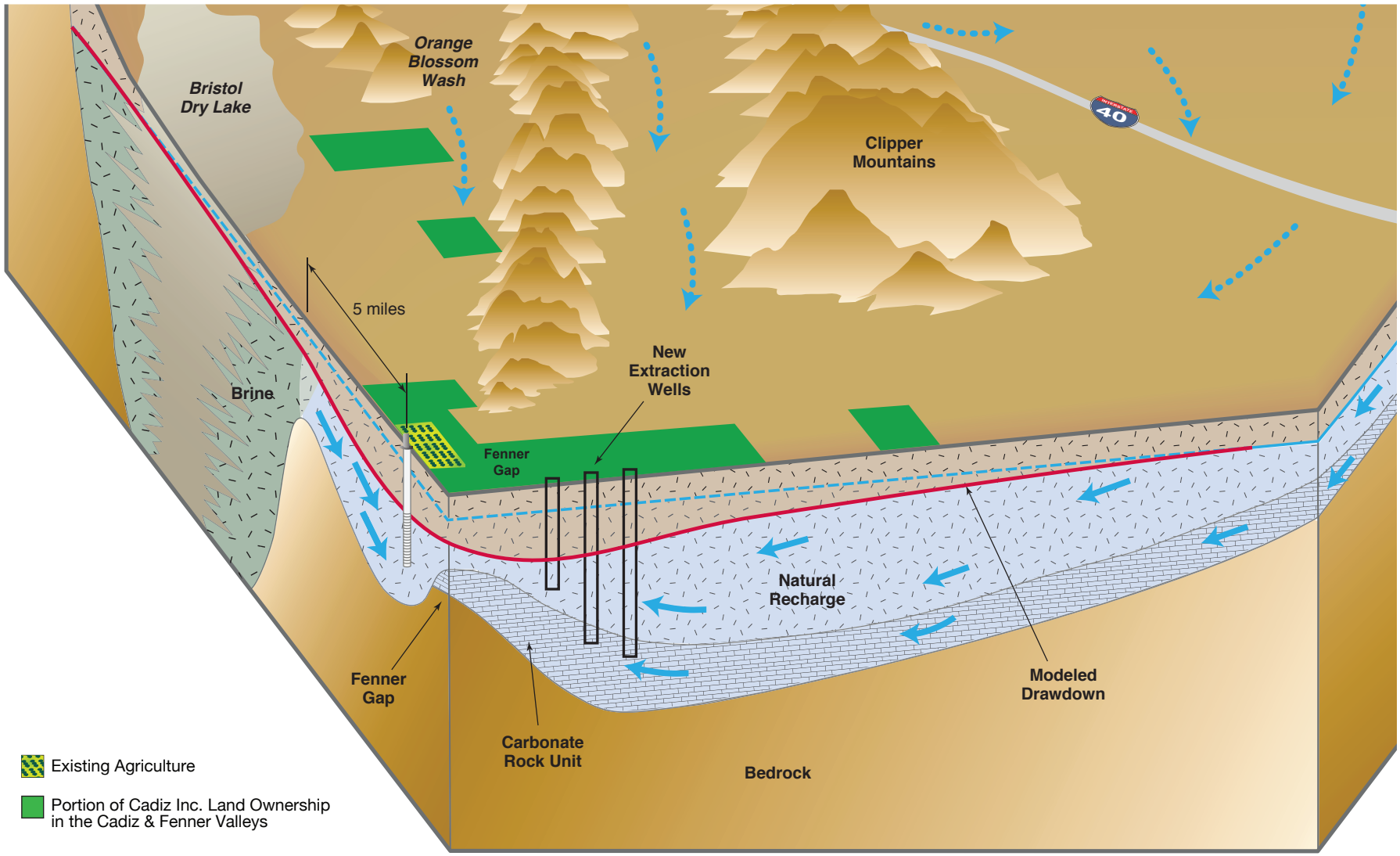


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure ES-1

Key Project Facilities



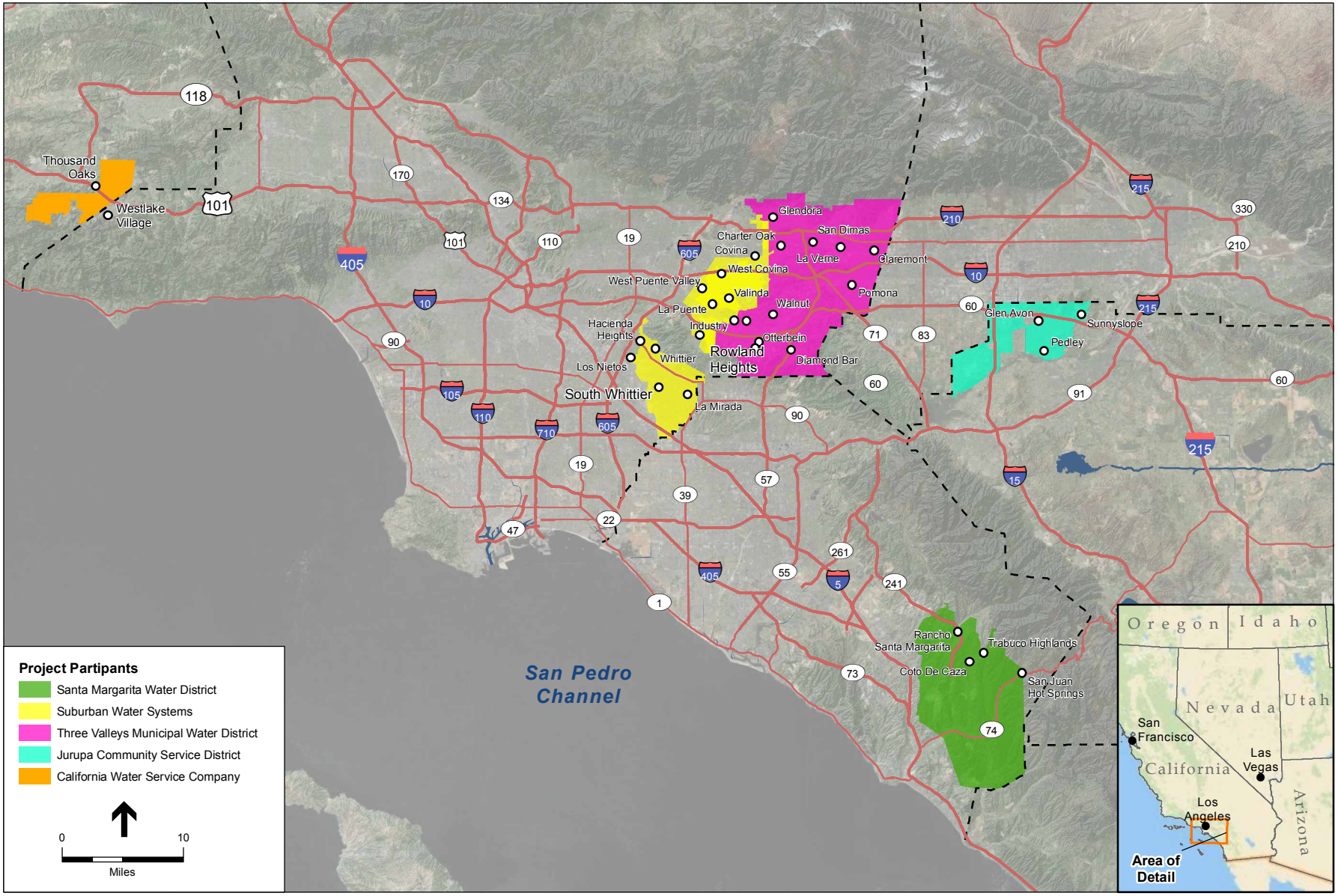
NOT TO SCALE

SOURCE: CH2M Hill, 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure ES-2

Conceptual Surface and Groundwater Flow with Project after 50 Years

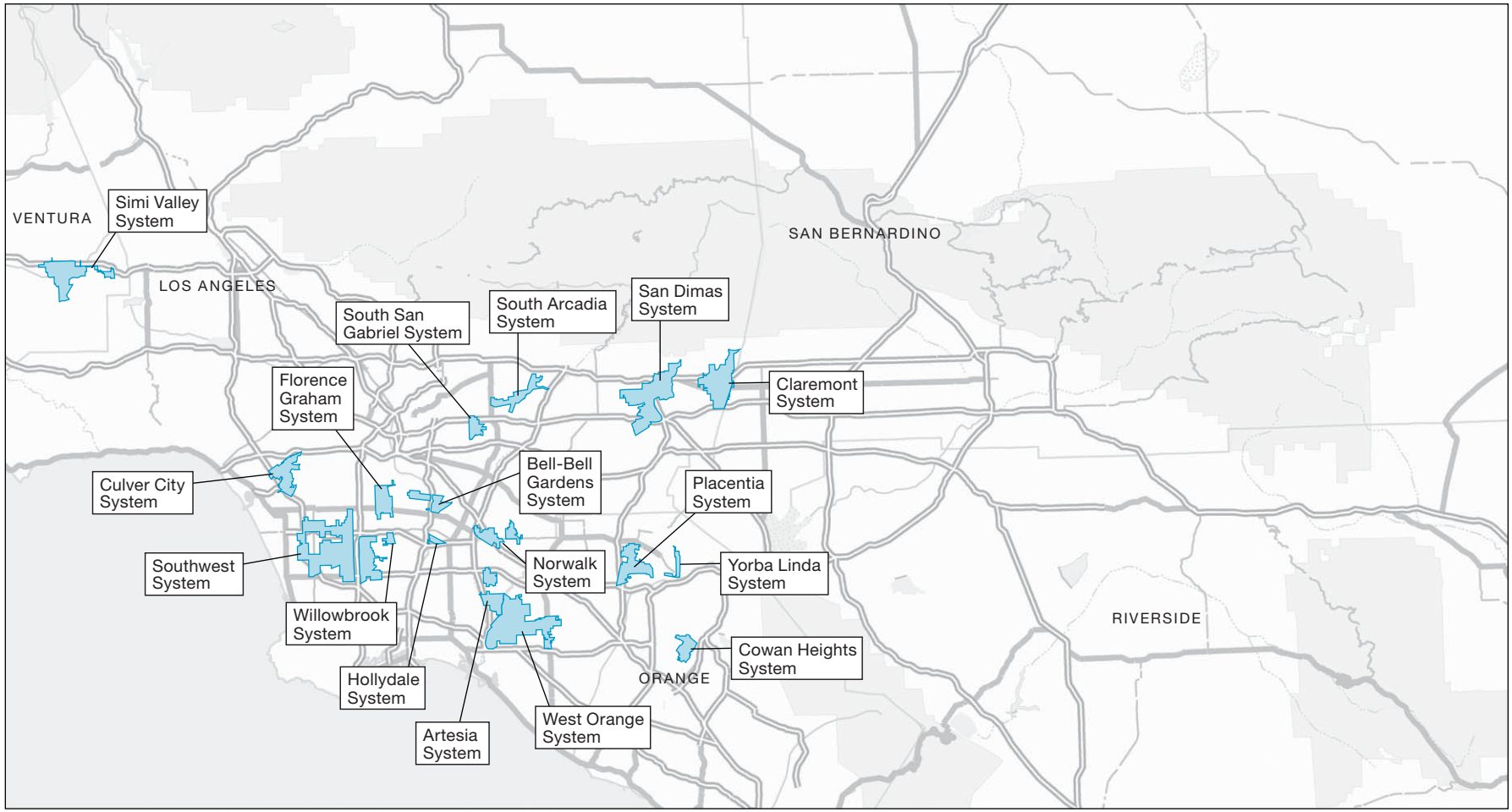


SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure ES-3

Project Participants:
SMWD, Suburban, Three Valleys, Cal Water and JCSD
(See Figure 1-4 for Golden State)



SOURCE: Golden State Water Company; ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure ES-4

Participating Water Provider:
Golden State Water Company
Southern California Service Areas

ES.4 Environmental Effects (Chapters 4, 5, 6, and 8)

Approach to Analyzing Impacts

The Draft EIR analysis of the environmental impacts of the proposed Project is divided into the following chapters:

- Environmental Setting, Impacts, and Mitigation Measures (Chapter 4)
- Evaluation of Cumulative Impacts of the Project (Chapter 5)
- Growth-Inducement Potential and Indirect Effects of Growth (Chapter 6)
- Irreversible and Irretrievable Commitment of Resources (Chapter 8)

Chapter 4 describes the environmental setting and identifies impacts of the proposed Project on environmental resource areas. Significance criteria have been developed for each environmental resource analyzed in this Draft EIR. The significance criteria are defined at the beginning of each impact analysis section. Chapter 5 describes the incremental impacts of the proposed Project when considered together with closely related past, present, and reasonably foreseeable probable future projects consistent with *CEQA Guidelines* Section 15355(b). Chapter 6 analyzes the growth inducement potential of the proposed Project and the associated secondary effects of growth, as required by *CEQA Guidelines* Section 15126.2(d). Chapter 8 evaluates irreversible and irretrievable impacts of the proposed Project (*CEQA Guidelines* Section 15126.2(c)).

Impact Significance Determinations

The level of significance of impacts is categorized as follows:

Significant and Unavoidable: Mitigation may be recommended if feasible and if it would reduce impacts but impacts would remain significant with mitigation;

Less than Significant with Mitigation: Potentially significant impact that can be mitigated to a less than significant level;

Less than Significant: Mitigation is not required under CEQA but may be recommended; or

No Impact: Mitigation not required or recommended.

Summary of Impacts

Project impacts, recommended mitigation measures, and level of significance after mitigation are summarized for the Groundwater Conservation and Recovery Component and Imported Water Storage Component in **Tables ES-1** and **ES-2**, respectively, located at the end of this chapter. These tables list impacts and mitigation measures for each issue area, as necessary. Implementation of the proposed Project would result in two significant and unavoidable impacts:

construction air emissions would exceed thresholds of significance for NOx directly and cumulatively, and growth within the Project Participants' service areas would result in significant indirect secondary effects.

ES.5 Alternatives (Chapter 7)

Chapter 7 identifies alternatives considered by the Lead Agency, but rejected as infeasible, and provides a brief explanation of the reasons for their exclusion. This Chapter identifies and compares several facilities alternatives that examine project design modifications or different facility locations to evaluate whether different variations of the Project would result in greater, similar, or lesser impacts. Chapter 7 also evaluates two No Project Alternatives, one that compares against the existing baseline condition, and one that assesses the potential future condition based on existing land use development approvals. Finally, Chapter 7 also evaluates a Reduced Project Alternative that includes a 25-year operational period for the Groundwater Conservation and Recovery Component and 25 percent less water production.

With the exception of the No Project Alternatives, alternatives were included in the Draft EIR because of their apparent ability to meet most of the Project objectives, their ability to reduce one or more of the significant impacts associated with Project implementation, their potential feasibility, and their collective ability to provide a reasonable range of alternatives to foster informed decision-making and public participation. Analysis of the No Project Alternative is included as required by CEQA.

In addition, the EIR is required to identify an environmentally superior alternative. Of the Alternatives analyzed in this Draft EIR, the No Project Alternative would be considered the environmentally superior. The No Project Alternative would avoid all construction and operational impacts associated with the proposed Project, but the No Project Alternative would not meet any of the Project objectives. Per *CEQA Guidelines* Section 15126.6(e)(2), if the No Project Alternative is determined to be the environmentally superior alternative, an environmentally superior alternative must also be identified among the remaining alternatives.

Of the Project Facility Alternatives, the Existing Natural Gas Pipeline Alternative would be the environmentally superior alternative. Of the Operational Alternatives, the Reduced Project Alternative would be the environmentally superior alternative since groundwater levels would recover more quickly than under the other Operational Alternatives. The comparison of Alternatives and identification of the environmentally superior alternative is discussed in greater detail in Chapter 7 of this Draft EIR.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.1 AESTHETICS		
Scenic Vistas Would the proposed Project have a substantial adverse effect on a scenic vista?	None required.	Less than significant.
Scenic Resources Would the proposed Project substantially damage scenic resources, including but not limited to trees, rock outcroppings, and historic buildings within a State Scenic Highway?	None required.	No impact.
Visual Character Would the proposed Project substantially degrade the existing visual character or quality of the site and its surroundings?	None required.	Less than significant.
Light and Glare Would the proposed Project create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?	**AES-1:** Construction lighting shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way, and towards the construction site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the construction site to the maximum extent feasible. **AES-2:** Outdoor lighting shall be minimized and installed for safety and security purposes only. Outdoor lighting of Project facilities and access roads shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way and towards the Project site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the Project site to the maximum extent feasible.	Less than significant with mitigation.
4.2 AGRICULTURE AND FORESTRY RESOURCES		
Farmland Conversion Would the Project convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	None required.	No impact.
Agricultural Zoning or Williamson Act Contract Would the proposed Project conflict with existing zoning for agricultural use or a Williamson Act contract?	None required.	Less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Forest Zoning Would the proposed Project conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g)?	None required.	No impact.
Forest Land Conversion Would the proposed Project result in loss of forest land or conversion of forest land to non-forest use?	None required.	No impact.
Agriculture Uses Would the proposed Project involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	None required.	Less than significant.
4.3 AIR QUALITY		
Consistency with Air Quality Management Plans Would the proposed Project conflict with or obstruct implementation of the applicable air quality plan?	Implement Mitigation Measures **AQ-1 through AQ-5.**	Less than significant with mitigation.
Air Quality Standards Would the proposed Project violate any air quality standard or contribute substantially to an existing or projected air quality violation?	**AQ-1:** Construction and operation of the proposed Project shall be conducted in compliance with applicable rules and regulations set forth by the Mojave Desert Air Quality Management District. **AQ-2:** The following dust control measures shall be implemented during construction: • All soil excavated or graded shall be sufficiently watered to prevent excessive dust. Watering shall occur as needed with complete coverage of disturbed soil areas. • Watering shall take place a minimum of twice daily on unpaved/untreated roads in areas with active operations. • Areas disturbed by clearing, earth moving, or excavation activities shall be minimized at all times. • Stockpiles of soil or other fine loose material shall be stabilized by watering or other appropriate method such as non-toxic soil binders to prevent wind-blown fugitive dust. • On-site vehicle speed on unimproved roads shall be limited to 15 miles per hour. • Streets adjacent to the Project site shall be kept clean and Project-related accumulated silt shall be removed.	Even after mitigation, NOx short-term construction emissions would remain significant and unavoidable. Long-term operational emissions, however, would be less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	AQ-3: The following measures shall be implemented during construction of the proposed Project: • All equipment shall be maintained as recommended by manufacturer's manuals. • Idling engines shall be shut down when not in use for over 30 minutes. • Electric equipment shall be used whenever possible in lieu of diesel or gasoline powered equipment. • All construction vehicles shall be equipped with proper emissions control equipment and kept in good and proper running order to substantially reduce NOx emissions. • On-road and off-road diesel equipment shall use diesel particulate filters if permitted under manufacturer's guidelines. • The Project shall develop a plan demonstrating that the off-road equipment (more than 50 horsepower) to be used in the construction Project (i.e., owned, leased, and subcontractor vehicles) would achieve a Project-wide fleet-average 20 percent NOx reduction and 45 percent PM reduction compared to the most recent CARB fleet average. Acceptable options for reducing emissions include the use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, add-on devices such as particulate filters, and/or repowering off-road engines/equipment with Tier 2 or Tier 3 engines that operate within allowable emission ranges and as a result, would achieve emission reductions. **AQ-4**: All trucks hauling dirt, sand, soil, or other loose materials are to be covered. **AQ-5:** The Project Design Feature in Chapter 6.8 of the GMMMP shall be implemented to verify air quality. If changes in air quality occur that exceed baseline conditions over a five-year moving average, the following corrective measures shall be implemented: • Modification of Project operations to re-establish baseline level air quality levels. Modifications to Project operations would include one or more of the following: – Reduction in pumping from Project wells; – Revision of pumping locations within the Project wellfield; – Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.	
Sensitive Receptors Would the proposed Project expose sensitive receptors to substantial pollutant concentrations?	None required.	Less than significant.
Objectionable Odors Would the proposed Project create objectionable odors affecting a substantial number of people?	None required.	Less than significant.
Cumulative Impact Would the proposed Project result in a cumulatively considerable air quality impact?	Implement Mitigation Measures **AQ-1 through AQ-5.**	Though operational emissions would not be cumulatively considerable, short term construction activities would

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
		exceed MDAQMD standards and would therefore result in a significant and unavoidable cumulative impact even after mitigation.
4.4 BIOLOGICAL RESOURCES		
Special-Status Wildlife Species Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any wildlife species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?	**BIO-1**: Immediately prior to construction activities, pre-construction surveys shall be conducted to document all locations of burrows and desert tortoise sightings within all proposed disturbance areas that provide potential habitat for the species. The survey protocol shall be established in coordination with USFWS. **BIO-2**: A chain-link or tortoise fence (one-inch by two-inch welded wire mesh attached to the chain-link fence, with approximately two feet above-ground and one foot buried below ground) shall be installed to exclude small wildlife species from entering the active work areas in areas of documented occurrences of special-status ground dwelling wildlife as determined during pre-construction surveys by a qualified biologist or as directed by USFWS. When crossing drainages, these temporary fences must be designed and maintained to allow storm water runoff to flow past the construction site. **BIO-3**: A Desert Tortoise Avoidance and Protection Plan shall be developed and adopted in consultation with the USFWS and CDFG prior to construction. Elements of the plan shall include, but are not limited to the following: • A step-by-step protocol to be implemented whenever a desert tortoise is observed by construction or operational personnel. • A pre-determined and pre-approved off-site relocation area if there is a need to relocate individual species during the course of Project construction. • Flagging and delineation requirements for located burrows and areas with tortoise activity. • An education program for all construction employees. • Enforcement of speed limits and checking under vehicles for tortoise prior to leaving Project areas. • Biological monitoring requirements for all ground disturbance activities. • To prevent increased use of the Project areas by common ravens and coyotes, implementation of measures such as trash management, removal of unnatural sources of standing water, and other means. Drilling mud pits and water discharges will be controlled to minimize the duration of standing water at any one drilling site. **BIO-4**: If a desert tortoise is observed in the construction zone, construction activities shall be halted in the vicinity. A pre-approved qualified biologist, authorized by USFWS and/or CDFG to handle desert tortoise, shall be contacted immediately. Work shall only continue once the authorized biologist determines there is no risk to the desert tortoise. **BIO-5**: The pipeline shall be installed within previously disturbed areas of the easement to the extent feasible. During construction, previously undisturbed areas within the pipeline alignment that are not needed for construction shall be staked and flagged to prevent	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	construction equipment access or disturbance in these areas. The cordoned off areas shall be flagged and monitored by a qualified biologist during construction activities. **BIO-6:** A special-status species and sensitive habitat restoration plan shall be prepared and approved by the USFWS and CDFG prior to construction for unavoidable temporary impacts on special-status plants and sensitive habitats. The plan would include, at a minimum, the following measures: • A salvage and replacement program for the top 12 inches of surface material and topsoil. The program shall identify soil preparation requirements, including grain size specifications that shall need to be engineered or amended on site to match to the greatest extent feasible the existing surface soil conditions. • A salvage and replanting program for perennial special-status species. • An invasive plant species maintenance, monitoring, and removal program. • Success criteria that establishes yearly thresholds for growth and reestablishment of habitat. • A five-year maintenance and monitoring plan to ensure successful implementation of the restoration plan. **BIO-7:** A habitat compensation plan would be prepared and implemented that includes at a minimum the following measure: • Purchase of compensatory mitigation lands or credits at a USFWS and CDFG approved conservation bank at a minimum 1:1 ratio for permanent habitat loss and 0.5:1 for temporary habitat loss (or that required by the USFWS and CDFG permit conditions) for preservation in perpetuity. **BIO-8:** Prior to construction, surveys for Mojave fringe-toed lizard shall be conducted by a qualified biologist within the sand dunes and sand fields habitats within the ARZC ROW. If Mojave fringe-toed lizards are identified in the construction zone, the area shall be fenced during construction as described in **BIO-2** to prevent lizards from entering the construction site. Once fenced, a qualified biologist shall trap the area for lizards and release captured lizards into adjacent suitable habitat. **BIO-9:** If construction and vegetation removal is proposed for the bird nesting period of February 1 through August 31, then pre-construction surveys for nesting bird species shall begin 30 days prior to construction disturbance with subsequent weekly surveys, the last one being no more than three days prior to work initiation. The surveys shall include habitat within 300 feet (500 feet for raptors) of the construction limits. Active nest sites located during the pre-construction surveys shall be avoided and a non-disturbance buffer zone established dependent on the species and in consultation with USFWS and CDFG. This buffer zone shall be delineated in the field with flagging, stakes, or construction fencing. Nest sites shall be avoided with approved non-disturbance buffer zones until the adults and young are no longer reliant on the nest site for survival as determined by a qualified biologist. **BIO-10:** A burrowing owl survey shall be conducted pursuant to the *Burrowing Owl Survey Protocol and Mitigation Guidelines* of the California Burrowing Owl Consortium (1993) or per the *Staff Report on Burrowing Owl Mitigation* prepared by CDFG (1995). At	

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	a minimum, this survey shall include the following: • A pre-construction survey conducted by a qualified biologist within 30 days of the start of construction. This survey shall include two early morning surveys and two evening surveys to ensure that all owl pairs have been located. • If pre-construction surveys are undertaken during the breeding season (February 1st through July 31st) active nest burrows should be located within 250 feet of construction zones and an appropriate buffer around them (as determined by the Project biologist) shall remain excluded from construction activities until the breeding season is over. • During the non-breeding season (August 15th through January 31st), resident owls may be relocated to alternative habitat. Owls shall be encouraged to relocate from the construction disturbance area to off-site habitat areas and undisturbed areas of the Project site through the use of one-way doors on burrows. If ground squirrel burrows, stand pipes, and other structures that have been documented during pre-construction surveys as supporting either a nesting burrowing owl pair or resident owl are removed to accommodate the proposed Project, these structures and burrows shall be relocated or replaced on or adjacent to the Project site. Relocated and replacement structures and burrows shall be sited within suitable foraging habitat within one-half mile of the Project area. Suitable development-free buffers shall be maintained between replacement nest burrows and the nearest building, pathway, parking lot, or landscaping. The relocation of resident owls shall be in conformance with all necessary State and federal permits. **BIO-11:** A qualified biologist shall conduct focused pre-construction surveys no more than two weeks prior to construction for potential American badger dens. If no potential American badger dens are present, no further mitigation is required. If potential dens are observed, the following measures are required to avoid potential adverse effects to the American badger: • If the qualified biologist determines that potential dens are inactive, the biologist shall excavate these dens by hand with a shovel to prevent badgers from re-using them during construction. • If the qualified biologist determines that potential dens may be active, the entrances of the dens shall be blocked with soil, sticks, and debris for three to five days to discourage use of these dens prior to Project disturbance. The den entrances shall be blocked to an incrementally greater degree over the three- to five-day period. After the qualified biologist determines that badgers have stopped using active dens within the Project boundary, the dens shall be hand-excavated with a shovel to prevent re-use during construction. • Construction activities shall not occur within 30 feet of active badger dens. **BIO-12**: Prior to construction activities, winter and spring surveys shall be conducted to determine the nature of trestle use by pallid bats. Surveys shall follow the appropriate site-specific protocol as determined in coordination with CDFG. **BIO-13:** If a special-status natal bat roost site is found within the limits of construction during pre-construction surveys, the roosts shall be staked, flagged, fenced, or otherwise clearly delineated. Roosts shall be avoided with non-disturbance buffer zones established	

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	by a qualified biologist in consultation with the USFWS and CDFG until the site is no longer in active use as a natal roost. Implement Mitigation Measures **AES-1** and **AES-2**.	
Special-Status Plant Species Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any plant species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?	**BIO-14**: Prior to construction, construction zone limits shall be marked by a qualified biologist and shall be staked, flagged, fenced, or otherwise clearly delineated to ensure that the construction zone is limited to minimize impacts on special-status plant species. These limits shall be identified on the construction drawings. No earth-moving equipment shall be allowed outside demarcated construction zones unless pre-approval is obtained from a qualified biologist.	Less than significant with mitigation.
Sensitive Habitat Would the proposed Project have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFG or USFWS?	Implement Mitigation Measures **BIO-5** and **BIO-6.**	Less than significant with mitigation.
Wetlands Would the proposed Project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	**BIO-15:** A Waters of the State Mitigation Plan shall be prepared to include with RWQCB and CDFG permit applications. Conditions of the Mitigation Plan shall include at a minimum the following measures: • measures to divert flows during construction, • measures to minimize construction footprint within washes, • measures to minimize erosion, • measures to minimize discharge of contaminants through proper storage of chemicals and vehicle maintenance, and • post-construction site restoration performance standards.	Less than significant with mitigation.
Wildlife Movement Would the proposed Project interfere substantially with the movement of any native resident or wildlife species or with established native resident or migratory native wildlife corridors, or impede the use of wildlife nursery sites?	None required.	Less than significant.
Local Policy or Ordinance Would the proposed Project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	**BIO-16:** Prior to commencement of ground disturbance activities for any component of the proposed Project, a qualified biologist/arborist shall provide an inventory of the number and size of protected species within the proposed Project's impact areas. The biologist/arborist shall mark any smoke tree (*Dalea spinosa*), mesquites (*Prosopis* spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and Joshua trees within the construction zone. Removal of these plants shall be avoided if possible. **BIO-17:** If avoidance of the species listed in **BIO-16** is not possible, these species shall	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	be moved or replanted.	
Habitat Conservation Plan Would the proposed Project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional or state habitat conservation plan?	None required.	Less than significant.
4.5 CULTURAL RESOURCES		
Historical Resources Would the proposed Project cause a substantial adverse change in the significance of a historical resource as defined in *CEQA Guidelines* Section 15064.5?	**CUL-1:** A qualified archaeologist, defined as an archaeologist meeting the Secretary of the Interior's Standards for professional archaeology,[1] shall be retained to carry out all mitigation measures related to archaeological resources. **CUL-2:** The construction zone shall be narrowed or otherwise altered to avoid all significant historical resources where feasible. Significant or unevaluated cultural resources within 50 feet of the construction zone shall be marked with exclusion markers to ensure avoidance. In the case of resources CA-SBR-3282H and CA-SBR-3233H, a 50-foot buffer shall be established outside of recorded site boundaries as an added protective measure to protect historic cemeteries. Protective fencing shall not identify the protected areas as cultural resource areas in order to discourage unauthorized disturbance or collection of artifacts. **CUL-3:** A long-term management plan shall be developed for those significant historical resources or portion(s) of resources that can be avoided during Project construction, in order to minimize future impacts during Project operation and maintenance. **CUL-4:** If avoidance of significant historical resources is not feasible, prior to any Project-related ground disturbing activities, a detailed treatment plan shall be prepared and implemented by a qualified archaeologist. The treatment plan shall include a research design and a scope of work for data recovery of the portion(s) of the significant resource(s) to be impacted by the Project. Treatment for most resources shall consist of (but would not be not limited to) sample excavation, surface artifact collection, site documentation, and historical research, with the aim to target the recovery of important scientific data contained in the portion of the significant resource to be impacted by the Project. The treatment plan shall include provisions for analysis of data in a regional context, reporting of results within a timely manner, and curation of artifacts and data at an approved facility. **CUL-5:** Prior to construction, a qualified archaeologist shall be retained to carry out a Phase 1 cultural resources survey in those portions of the Project area (including but not limited to: the wellfield, CRA tie-in Options 2a and 2b, and any access roads, staging areas, borrow areas, and any other proposed areas of potential ground disturbance) not previously surveyed within the past 5 years. The Phase 1 survey shall identify and evaluate the significance of any potentially eligible resources that may be directly or indirectly impacted by the proposed Project, and shall take Native American comments	Less than significant with mitigation.

[1] Department of the Interior, *Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (As Amended and Annotated): Professional Qualification Standards*, http://www.nps.gov/history/local-law/arch_stnds_9.htm, accessed November 2010.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	concerning viewshed impacts into consideration. The Phase 1 Survey effort shall be documented in a Phase 1 Cultural Resources Survey report. Resources determined eligible for listing shall be subject to Mitigation Measures **CUL-1 through CUL-4** and **CUL-6**. All significant cultural resources identified in the wellfield area during surveys shall be avoided. **CUL-6:** Prior to construction, an archaeological monitor shall be retained to monitor all ground-disturbing activities, including brush clearance and grubbing, within 100 feet of all significant historical resources. The monitor shall work under the supervision of the qualified archaeologist. The duration and timing of monitoring shall be determined by the qualified archaeologist in consultation with the lead agency and based on the grading plans. In the event that cultural resources are unearthed during ground-disturbing.	
Archeological Resources Would the proposed Project cause a substantial adverse change in the significance of a unique archaeological resource pursuant to *CEQA Guidelines* Section 15064.5?	**CUL-7:** If archaeological resources are encountered, all activity in the vicinity of the find shall cease until it can be evaluated by a qualified archaeologist. If the qualified archaeologist determines that the resources may be significant, he or she will develop an appropriate treatment plan for the resources. Appropriate Native American representatives shall be consulted in determining appropriate treatment for unearthed cultural resources if the resources are prehistoric or Native American in nature. In considering any suggested mitigation proposed by the archaeologist in order to mitigate impacts to archaeological resources, avoidance will be determined necessary and feasible in light of factors such as the nature of the find, Project design, costs, and other considerations. If avoidance is infeasible, other appropriate measures (e.g., data recovery) will be instituted. Work may proceed on other parts of the Project site while mitigation for cultural resources is being carried out. Implement Mitigation Measures **CUL-1 through CUL-6.**	Less than significant with mitigation.
Paleontological Resources Would the proposed Project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	**CUL-8:** Prior to construction, those portions of the Project area (including the wellfield, CRA tie-in Options 2a and 2b, access roads, staging areas, and borrow areas) not previously surveyed within the past 5 years, shall be surveyed by a qualified vertebrate paleontologist, defined as one holding an advanced degree in paleontology, biology, or a related discipline, and having at least five years of professional experience. If paleontological resources are encountered, they shall be documented or recovered, and curated, as appropriate, prior to the start of construction. The evaluation will be documented in a report to be submitted for review and approval by the lead agency prior to the start of construction. The report shall also be submitted to the San Bernardino County Museum. **CUL-9:** Prior to the start of any earth moving activity, a qualified vertebrate paleontologist shall be retained. The paleontologist shall prepare a Paleontological Mitigation and Monitoring Plan (PMMP) that shall be based on prior paleontological evaluations, including the results of the paleontological survey as described in Mitigation Measure **CUL-8**, and shall address pre-construction salvage and reporting; pre-construction contractor sensitivity training; procedures for paleontological resources monitoring including the identification of specific paleontological monitoring locations as defined by areas where Pleistocene age sediments may be impacted during construction; microscopic examination of samples where applicable; the evaluation, recovery, identification, and curation of fossils; and the preparation of a final mitigation report.	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	CUL-10: All earth-moving activities within those formations identified as sensitive within the PMMP shall be monitored on a full-time basis, unless the paleontologist determines that sediments are previously disturbed or there is no reason to continue monitoring in a particular area due to other depositional factors which would make fossil preservation unlikely or deemed scientifically insignificant. In the event fossils are exposed during earth moving, construction activities shall be redirected to other work areas until the procedures outlined in the PMMP have been implemented or the paleontologist determines work can resume in the vicinity of the find. When fossils are discovered, they and associated data shall be collected quickly and professionally. Fossil salvage procedures shall include the collection of bulk matrix samples if scientifically significant microfossils are believed to be present based on field evidence. All fossils collected during monitoring shall be transferred to a secure facility for laboratory preparation and identification. Laboratory preparation shall include stabilization, matrix removal, and conservation of individual fossil specimens, as well as screenwashing and picking of bulk matrix samples. Fossils shall be prepared to the point of curation and identified by technical specialists, as needed, to the lowest possible taxonomic level. At the end of the Project, the paleontologist shall prepare a report that includes a description and inventory list of recovered fossil materials; a map showing the location of paleontological resources found in the field; determinations of sensitivity and significance; and a statement that Project impacts to paleontological resources have been mitigated. The results of the paleontological surveys, construction monitoring, and subsequent laboratory work shall be compiled in a final paleontological mitigation report authored by the qualified paleontologist for the Project. The final report shall include all Project data and a copy of the receipt of specimens from the paleontological repository. Following preparation, the fossils and associated data and a copy of the final paleontological mitigation report shall be transferred to a public museum (paleontological repository) where they will be available for the benefit of current and future generations.	
Human Remains Would the proposed Project could disturb any human remains, including those interred outside of formal cemeteries?	**CUL-11:** If human remains are uncovered during Project construction, all work in the vicinity of the find shall be halted and the County Coroner will be contacted to evaluate the remains and follow the procedures and protocols set forth in Section 15064.5 (e)(1) of the *CEQA Guidelines*. If the County Coroner determines that the remains are Native American, the NAHC shall be contacted, in accordance with Health and Safety Code Section 7050.5, subdivision (c) and Public Resources Code 5097.98 (as amended by AB 2641). Per Public Resources Code 5097.98, the landowner shall ensure that the immediate vicinity, according to generally accepted cultural or archaeological standards or practices, where the Native American human remains are located, is not damaged or disturbed by further development activity until the landowner has discussed and conferred, as prescribed in this Section (PRC 5097.98) with the most likely descendents taking into consideration their recommendations, and developing a treatment plan, taking into account the possibility of multiple human remains. Implement Mitigation Measures **CUL-2**, **CUL-3**, and **CUL-6**.	Less than significant with mitigation.
Indian Trust Assets Would the proposed Project directly involve the use of land or sites of religious or cultural	None required.	No impact.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
importance to Native Americans? Would the proposed Project affect the use of reservation lands or sites of religious or cultural importance to Native Americans?		
4.6 GEOLOGY AND SOILS		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction Would the proposed Project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: • Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42)?; • Strong seismic ground shaking?; • Seismic-related ground failure, including liquefaction?; • Landslides?	None required.	Less than significant.
Soil Erosion and Loss of Topsoil Would the proposed Project result in substantial soil erosion or the loss of topsoil?	Implement Mitigation Measures **HYDRO-1** and **BIO-6**.	Less than significant with mitigation.
Geologically Unstable Area Would the proposed Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	**GEO-1:** The project design features in Chapter 6.3 of the GMMMP shall be implemented to address the potential impact for land subsidence. If land subsidence is observed at rates that are greater than projected by the groundwater flow simulation model for an equivalent elapsed time, or if a change in the ground surface elevation of more than 0.5 feet within the Project area occurs, or if subsidence of more than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks occurs, the following shall occur: • Implement the corrective measures that involve modification of Project operations to actively arrest subsidence through one or more of the following: – Reduction in pumping from Project wells; – Revision of pumping locations within the Project wellfield; – Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or – Repair of any structures damaged as a result of subsidence attributable to Project operations.	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Expansive or Corrosive Soils Would the proposed Project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	None required.	Less than significant.
Soil Suitability for Septic System Would the proposed Project have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of waste water?	None required.	No impact.
4.7 GREENHOUSE GAS EMISSIONS		
Greenhouse Gas Emissions Would the proposed Project generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment? Would the proposed Project conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of GHG (including AB 32, the California Global Warming Solutions Act of 2006, and the AB 32 Scoping Plan)?	**GHG-1:** Within 90 days of completion of construction of the Groundwater Conservation and Recovery Component of the Project, carbon offset credits shall be purchased from the Climate Registry, or other source that is approved by CARB as being consistent with the policies and guidelines of the California Global Warming Solution Act of 2006 (AB 32), or that is approved by a local or regional agency with jurisdiction over or within San Bernardino County as local emissions credits under a GHG reduction plan or similar program, in sufficient quantity to reduce the Project's first year total (direct plus indirect) GHG emissions below 10,000 $MTCO_2e$ per year. The first year offsets identified in the binding agreement shall be purchased and retired no later than 12 calendar months from completion of the first full year of operation. The estimated amount of offsets required is 18,153 $MTCO_2e$ per year (i.e., 28,153 – 10,000 $MTCO_2e$ per year) if the wellfield and intermediate pump station are powered by natural gas. This volume may be reduced if less power is needed, solar power is provided, or diesel powered wells are retired at the Cadiz Ranch that would count as an offset. If electricity from the grid is used, the required offsets are estimated to be 5,810 $MTCO_2e$ per year (i.e., 15,810 – 10,000 $MTCO_2e$ per year). Since offsets for off-site electricity generation is the responsibility of the energy generators, the Project may obtain verification of these offsets or purchase additional offsets as needed. A GHG inventory shall be completed which will be verified by an accredited third-party verification body and reported to the Climate Registry. The Applicant shall purchase and retire such additional carbon offset credits (due to a net increase in emissions from the first full year of operations) as may be needed each year to ensure that the Project's total (direct plus indirect) GHG emissions are offset below the benchmark of 10,000 $MTCO_2e$ above existing 2011 conditions.	Less than significant with mitigation.
4.8 HAZARDS AND HAZARDOUS MATERIALS		
Routine Transportation, Use, Disposal or Release of Hazardous Materials Would the proposed Project create a significant hazard to the public or the environment through the routine transport, use, or disposal of	**HAZ-1:** On-site materials storage, fueling, and vehicle maintenance areas shall be equipped with secondary containment and spill containment equipment. Storage, handling, and disposal of hazardous materials shall comply with applicable regulations including submittal of a Business Plan to the County Fire Department.	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
hazardous materials? Would the proposed Project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?		
Hazardous Materials Use Near Schools Would the proposed Project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	None Required.	No impact.
Hazardous Materials Sites Would the proposed Project be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment?	**HAZ-2:** If excavation uncovers contaminated materials, excavation activities shall cease in the contaminated area. Soil samples shall be collected to characterize the soils and contamination. The CUPA shall be notified of the sample results. The construction contractor shall stockpile contaminated soils on plastic sheeting as necessary to prevent releasing contamination into the ground and shall ultimately dispose of the materials in coordination with the CUPA in compliance with hazardous material regulations. **HAZ-3:** Prior to installation of the Project elements within 250 feet of the Cadiz Sonic Lake Target No. 5 and No. 9 areas, the USACE shall be requested to clear the proposed locations for the potential presence of unexploded ordnance from historical military uses. In the event that the USACE encounters unexploded ordnance, the USACE is obligated to remove the unexploded ordnance under their ongoing investigations.	Less than significant with mitigation.
Airport Hazards Would the proposed Project result in a safety hazard for people residing or working in the Project area for a project within the vicinity of a private airstrip or within an airport land use plan?	None required.	Less than significant.
Emergency Response Plans Would the proposed Project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	None required.	No impact.
Grassland and Wildland Fires Would the proposed Project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	None required.	Less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.9 HYDROLOGY AND WATER QUALITY		
Impacts to Water Quality Standards or Waste Discharge Requirements Would the proposed Project result in a significant impact by degrading water quality or violating waste discharge requirements?	**HYDRO-1:** A construction Storm Water Pollution Prevention Plan shall be prepared and included in construction specifications for the Project. At a minimum, the plan shall include the following required Best Management Practices or equivalent measures: • Install temporary sediment fences or straw waddles at stream crossings or washes to prevent erosion and sedimentation during construction, including at each ARZC railroad trestle along the pipeline alignment. • Establish designated fueling areas equipped with secondary containment, • Require drip-pans under all idle equipment on the construction sites, • Ensure that spill prevention kits are present at all construction sites. **HYDRO-2:** Project Design Feature 6.4 found in Chapter 6.4 of the GMMMP shall be implemented to address the potential impacts for the migration of the saline/freshwater water interface to adversely affect groundwater quality. If monitored increases in TDS result in impairment to beneficial uses of groundwater by overlying land owners, one or more of the following corrective measures shall be implemented: • Deepen or otherwise improve the efficiency of the impacted well(s); or • Blend impacted well water with another local source; or • Construct replacement well(s); or • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or • Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes. **HYDRO-3:** Project design features in Chapter 6.2 of the GMMMP shall be implemented to address potential impacts to Third Party wells. If a written complaint by a well owner is received regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes, following corrective measures shall be implemented: 1) Arrange for an interim water supply to the affected party as necessary. 2) Implement additional corrective measures that include one or more of the following	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	actions: • Deepen or otherwise improve the efficiency of the impacted well(s); or • Blend impacted well water with another local source; or • Construct replacement well(s); or • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells.	
Impacts to Groundwater Supplies or Groundwater Recharge Would the proposed Project result in a significant impact by substantially depleting groundwater supplies or interfering substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a significant lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	Implement Mitigation Measure **HYDRO-3.**	Less than significant with mitigation.
Impacts to Drainage Patterns Would the proposed Project result in a significant impact by altering the existing drainage patterns of the area and the courses of streams in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	**HYDRO-4:** Construction plans shall be prepared that use standard best management practices (BMPs) to control drainage around the Project infrastructure. The BMPs shall include placing well pads and above-ground appurtenant facilities outside of visible drainages; and grading well pads to disperse runoff from the site in a manner that minimizes scour potential of storm water. Additional BMPs include the use of physical barriers to prevent erosion and siltation straw wattles, hay bales, setbacks and buffers, and other similar methods that reduce the energy in surface water flow.	Less than significant with mitigation.
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?	Implement Mitigation Measure **HYDRO-4**.	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.10 LAND USE AND PLANNING		
Divide and Established Community Would the proposed Project physically divide an established community?	None required.	Less than significant.
Consistency with Land Use Plans Would the proposed Project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the General Plan, Specific Plan, Local Coastal Program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	None required.	Less than significant.
Habitat Conservation Plans or Natural Community Conservation Plans Would the proposed Project conflict with any applicable habitat conservation plan or natural community conservation plan?	None required.	No impact.
Socioeconomics Would the proposed Project cause an adverse affect on economic or socioeconomic conditions to an extent that would result in substantial physical environmental effects to the Project area (e.g. urban decay) or cause physical changes that are determined to be significant due to economic or social effects (e.g. divide a community)?	None required.	Beneficial.
Environmental Justice Would the proposed Project cause a disproportionately high and adverse human health or environmental impact on minority populations or low-income populations?	None required.	No impact.
4.11 MINERAL RESOURCES		
Loss of Availability of Known Mineral Resources Would the proposed Project result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State?	**MIN-1**: PDF 6.5 shall be implemented to address the potential impact for groundwater level drawdown on existing salt production operations. If changes in groundwater levels occur that are larger than projected by the groundwater model simulations or if changes occur in groundwater or brine water levels that are greater than 50 percent of the water column above the intake of any of salt mining companies' wells in comparison to pre-operational static levels in wells at the margins of the dry lakes, one or more of the following actions shall be implemented: • Reduction in pumping from Project wells; or	Less than significant with mitigation.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
	• Revision of pumping locations within the Project wellfield; or • Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or • Installation of injection wells to mitigate the impact, or • Compensation to mining operators for the additional costs of pumping.	
Loss of Availability of Locally Important Mineral Resources Would the proposed Project result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	None required.	No impact.
4.12 NOISE		
Sensitive Receptors Would the proposed Project expose persons to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	None required.	Less than significant.
Ground-Borne Vibrations and Ground-borne Noise Would the proposed Project expose persons to or generate excessive ground-borne vibration or ground-borne noise levels?	None required.	Less than significant.
Ambient Noise Levels Would the proposed Project create a substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project? Would the proposed Project create a substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?	None required.	Less than significant.
Exposure to Excessive Noise Levels Would the proposed Project expose people residing or working in the Project area to excessive noise levels for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport?	None required.	Less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Would the proposed Project expose people residing or working in the Project area to excessive noise levels if the Project is located in the vicinity of a private airstrip?		
4.13 PUBLIC SERVICES AND UTILITIES		
Public Services Would the proposed Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services listed below? • Fire protection; • Police protection; • Schools; • Parks; or • Other public facilities.	None required.	Less than significant.
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements Would the proposed Project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board? Would the proposed Project require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	None required.	Less than significant.
Storm Water Drainage Facilities Would the proposed Project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	**UTIL-1**: Storm water drainages traversed by the water conveyance pipeline alignment shall be returned to pre-construction conditions. Existing structures such as storm flow diversion berms, railroad facilities including bridge supports, access roads, and utility poles shall be returned to pre-construction conditions and protected from scouring by storm water flows, subject to the approval of the railroad owner. Implement Mitigation Measures **HYDRO-1** and **HYDRO-6**.	Less than significant with mitigation.
Expansion of New Water Supply Facilities Would the proposed Project require new or expanded water supply resources or	None required.	Less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
entitlements? Would the proposed Project result in a determination by the wastewater treatment provider which serves or may serve the project that it has inadequate capacity to serve the projects projected demand in addition to the provider's existing commitments?		
Solid Waste Would the proposed Project be served by a landfill with insufficient permitted capacity to accommodate the project solid waste disposal needs? Would the proposed Project comply with federal, state, and local statutes and regulations related to solid waste?	None required.	Less than significant.
Disruption of Local and Regional Utilities Would the proposed Project disrupt local or regional utility lines?	**UTIL-2:** The owner of the natural gas pipelines traversing the Cadiz Property shall be notified in advance of construction activities near the pipelines sufficient to allow for supervision and approval by the owner of construction methods and pipeline under-crossing designs. The under-crossing designs shall require approval from the pipeline owner.	Less than significant with mitigation.
Energy Usage Would the proposed Project require a substantial increase in energy usage?	**UTIL-3:** Pumps installed as part of the Project shall be rated for high efficiency to minimize energy consumption.	Less than significant with mitigation.
4.14 RECREATION		
Disruption of Recreational Facilities Would the proposed Project adversely affect the recreational experience of established recreational facilities?	None required.	Less than significant.
Deterioration of Recreational Facilities Would the proposed Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	None required.	No impact.
New Recreational Facilities Would the proposed Project include recreational facilities or required the construction or expansion or recreational facilities which might have an adverse physical effect on the environment?	None required.	No impact.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.15 TRANSPORTATION AND TRAFFIC		
Consistency with Regulations for Circulation System Performance Would the proposed Project conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?	**TR-1:** A Traffic Control Plan shall be implemented that includes the following elements: • Identify hours of construction and hours for deliveries and include a discussion of haul routes; • Identify all access restrictions, parking restrictions, and signage requirements on major roads (e.g., speed limit); • Identify signage and flag men necessary at turn-off lanes on SR-62 and US-66 to avoid traffic hazards on fast moving roads; • Include a plan to coordinate all construction activities with emergency service providers in the area at least one month in advance. Emergency service providers shall be notified of the timing, location, and duration of construction activities. All roads shall remain passable to emergency service vehicles at all times; • Arrange for a telephone resource to address public questions and complaints during Project construction. **TR-2:** The construction contractor shall submit construction plans for construction within the railroad easement to the railroad owner and operator for their review and approval. Any plans to deliver materials on the rail lines shall be reviewed and approved by the railroad owner and operator. The construction contractor shall obtain approval from the railroad operator for material delivery and staging activities within the railroad right-of-way. **TR-3:** During construction, all at-grade railroad crossings shall be clearly flagged and barricaded to ensure that all vehicular traffic comes to a full stop prior to crossing railroad tracks. **TR-4:** The construction contractor shall implement mandatory railroad safety training and implement railroad safety measures requested by the railroad operator.	Less than significant with mitigation.
Congestion Management Standard / LOS Standard Would the proposed Project conflict with an applicable congestion management program, including, but not limited to, level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	Implement Mitigation Measures **TR-1 through TR-4**.	Less than significant with mitigation.
Air Traffic Would the proposed Project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	None required.	Less than significant.

TABLE ES-1
SUMMARY OF IMPACTS AND MITIGATION MEASURES – GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Traffic Hazards Would the proposed Project substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	Implement Mitigation Measures **TR-1 through TR-4**.	Less than significant with mitigation.
Emergency Access Would the proposed Project result in inadequate emergency access?	Implement Mitigation Measure **TR-1**.	Less than significant with mitigation.
Public Transit, Bicycle, or Pedestrian Facilities Would the proposed Project conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	None required.	No impact.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.1 AESTHETICS		
Scenic Vistas Would the proposed Project have a substantial adverse effect on a scenic vista?	None required.	Less than significant.
Scenic Resources Would the proposed Project substantially damage scenic resources, including but not limited to trees, rock outcroppings, and historic buildings within a State Scenic Highway?	None required.	No impact.
Visual Character Would the proposed Project substantially degrade the existing visual character or quality of the site and its surroundings?	None required.	Less than significant.
Light and Glare Would the proposed Project create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?	Implement Mitigation Measures **AES-1** and **AES-2.**	Less than significant with mitigation.
4.2 AGRICULTURE AND FORESTRY RESOURCES		
Farmland Conversion Would the proposed Project convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	None required.	No impact.
Agricultural Zoning or Williamson Act Contract Would the proposed Project conflict with existing zoning for agricultural use, or a Williamson Act contract?	None required.	Less than significant.
Forest Zoning Would the proposed Project conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g)?	None required.	No impact.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Forest Land Conversion Would the proposed Project result in loss of forest land or conversion of forest land to non-forest use?	None required.	No impact.
Agriculture Uses Would the proposed Project involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	None required.	Less than significant.
4.3 AIR QUALITY		
Consistency with Air Quality Management Plans Would the proposed Project conflict with or obstruct implementation of the applicable air quality plan?	Implement Mitigation Measures **AQ-1 through AQ-5.**	Less than significant with mitigation.
Air Quality Standards Would the proposed Project violate any air quality standard or contribute substantially to an existing or projected air quality violation?	Implement Mitigation Measures **AQ-1 through AQ-5.**	Significant and unavoidable for NOx emissions during construction even with mitigation. Operational emissions would be less than significant.
Sensitive Receptors Would the proposed Project expose sensitive receptors to substantial pollutant concentrations?	None required.	Less than significant.
Objectionable Odors Would the proposed Project create objectionable odors affecting a substantial number of people?	None required.	Less than significant.
Cumulative Impact Would the proposed Project result in a cumulatively considerable air quality impact?	Implement Mitigation Measures **AQ-1 through AQ-5.**	Though operational emissions would not be cumulatively considerable, short term construction activities would exceed MDAQMD standards and would therefore result in a significant and unavoidable cumulative impact even after mitigation.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.4 BIOLOGICAL RESOURCES		
Special-Status Wildlife Species Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any plant species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?	**BIO-18: Imported Water Storage Component**. A habitat compensation plan for preservation in perpetuity for habitat at a 1:1 minimum ratio would be prepared and implemented for loss of habitat within a designated critical habitat area for desert tortoise. The mitigation ratios would be established by USFWS. Implement Mitigation Measures **AES-1, AES-2**, and **BIO-1 through BIO-13**.	Less than significant with mitigation.
Special-Status Plant Species Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any plant species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?	Implement Mitigation Measure **BIO-14.**	Less than significant with mitigation.
Sensitive Habitat Would the proposed Project have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFG or USFWS?	None required.	Less than significant.
Wetlands Would the proposed Project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	None required.	Less than significant.
Wildlife Movement Would the proposed Project interfere substantially with the movement of any native resident or wildlife species or with established native resident or migratory native wildlife corridors, or impede the use of wildlife nursery sites?	None required.	Less than significant.
Local Policy or Ordinance Would the proposed Project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	Implement Mitigation Measures **BIO-16** and **BIO-17.**	Less than significant with mitigation.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Habitat Conservation Plan Would the proposed Project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional or state habitat conservation plan?	Implement Mitigation Measure **BIO-18.**	Less than significant with mitigation.
4.5 CULTURAL RESOURCES		
Historical Resources Would the proposed Project cause a substantial adverse change in the significance of a historical resource as defined in *CEQA Guidelines* Section 15064.5?	Implement Mitigation Measures **CUL-1 through CUL-6.**	Less than significant with mitigation.
Archeological Resources Would the proposed Project cause a substantial adverse change in the significance of an archaeological resource pursuant to *CEQA Guidelines* Section 15064.5?	Implement Mitigation Measures **CUL-1 through CUL-7.**	Less than significant with mitigation.
Paleontological Resources Would the proposed Project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	Implement Mitigation Measures **CUL-8 through CUL-10.**	Less than significant with mitigation.
Human Remains Would the proposed Project disturb any human remains, including those interred outside of formal cemeteries?	Implement Mitigation Measure **CUL-11.**	Less than significant with mitigation.
Indian Trust Assets Would the proposed Project directly involve the use of land or sites of religious or cultural importance to Native Americans? Would the proposed Project affect the use of reservation lands or sites of religious or cultural importance to Native Americans?	None required.	No impact.
4.6 GEOLOGY AND SOILS		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction Would the proposed Project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	**GEO-2: Imported Water Storage Component.** The spreading basin berms shall be designed so that soil composition, side slopes and freeboard requirements are approved by a qualified geotechnical engineer.	Less than significant with mitigation.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
• Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42); • Strong seismic ground shaking; • Seismic-related ground failure, including liquefaction; • Landslides?		
Soil Erosion and Loss of Topsoil Would the proposed Project result in substantial soil erosion or the loss of topsoil?	Implement **HYDRO-1** and **HYDRO-4.**	Less than significant with mitigation.
Geologically Unstable Area Would the proposed project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	None required.	Less than significant.
Expansive or Corrosive Soils Would the proposed Project could be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	None required.	Less than significant.
Soil Suitability for Septic System Would the proposed Project could have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of waste water?	None required.	No impact.
4.7 GREENHOUSE GAS EMISSIONS		
Greenhouse Gas Emissions Would the proposed Project generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment? Would the proposed Project conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the	**GHG-2: Imported Water Storage Component**. Within 90 days of completion of Project construction, carbon offset credits shall be purchased from The Climate Registry, or other source that is approved by CARB as being consistent with the policies and guidelines of the California Global Warming Solution Act of 2006 (AB 32), or that is approved by a local or regional agency with jurisdiction over or within San Bernardino County as local emission credits under a GHG Reduction Plan or similar program, in sufficient quantity to reduce the Project's first year total (direct plus indirect) GHG emissions below 10,000 $MTCO_2e$ per year, and each year purchase additional carbon offset credits (due to a net	Less than significant with mitigation.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
emissions of GHG (including AB 32, the California Global Warming Solutions Act of 2006, and the AB 32 Scoping Plan)?	increase in emissions from first year operations) as may be needed to reduce emissions below 10,000 $MTCO_2e$.	
4.8 HAZARDS AND HAZARDOUS MATERIALS		
Routine Transportation, Use, Disposal or Release of Hazardous Materials Would the proposed Project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials? Would the proposed Project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	Implement Mitigation Measure **HAZ-1**.	Less than significant with mitigation.
Hazardous Materials Use Near Schools Would the proposed Project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	None Required.	No impact.
Hazardous Materials Sites Would the proposed Project be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment?	Implement Mitigation Measure **HAZ-3.**	Less than significant with mitigation.
Airport Hazards Would the proposed Project result in a safety hazard for people residing or working in the Project area for a project within the vicinity of a private airstrip or within an airport land use plan?	None required.	Less than significant.
Emergency Response Plans Would the proposed Project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	None required.	No impact.
Grassland and Wildland Fires Would the proposed Project expose people or	None required.	Less than significant.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?		
4.9 HYDROLOGY AND WATER QUALITY		
Impacts to Water Quality Standards or Waste Discharge Requirements Would the proposed Project result in a significant impact by degrading water quality or violating waste discharge requirements?	None required.	Less than significant.
Impacts to Groundwater Supplies or Groundwater Recharge Would the proposed Project result in a significant impact by substantially depleting groundwater supplies or interfering substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a significant lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	None required.	No impact.
Impacts to Drainage Patterns Would the proposed Project result in a significant impact by altering the existing drainage patterns of the area and the courses of streams in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	**HYDRO-5: Imported Water Storage Component.** Project operators shall prepare a drainage analysis of the recharge basin and access road locations to ensure that diverted stormwater runoff does not affect downstream railroad crossings, roads, or other infrastructure. Recharge basins shall be located outside of major drainages, such as Schuyler Wash. The recharge basins shall be designed using BMPs to divert sheet flow storm water around the basins and redistribute the flow downstream without increasing velocity or scour potential.	Less than significant with mitigation.
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?	Implement Mitigation Measure **HYDRO-4.**	Less than significant with mitigation.
4.10 LAND USE AND PLANNING		
Divide an Established Community Would the proposed Project physically divide an established community?	None required.	No impact.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Consistency with Land Use Plans Would the proposed Project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the General Plan, Specific Plan, Local Coastal Program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	None required.	Less than significant.
Habitat Conservation Plans or Natural Community Conservation Plans Would the proposed Project conflict with any applicable habitat conservation plan or natural community conservation plan?	None required.	No impact.
Socioeconomics Would the proposed Project cause an adverse affect on economic or socioeconomic conditions to an extent that would result in substantial physical environmental effects to the Project area (e.g. urban decay) or cause physical changes that are determined to be significant due to economic or social effects (e.g. divide a community)?	None required.	Beneficial.
Environmental Justice Would the proposed Project cause a disproportionately high and adverse human health or environmental impact on minority populations or low-income populations?	None required.	No impact.
4.11 MINERAL RESOURCES		
Loss of Availability of Known Mineral Resources Would the proposed Project result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State?	None required.	No impact.
Loss of Availability of Locally Important Mineral Resources Would the proposed Project result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	None required.	No impact.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
4.12 NOISE		
Sensitive Receptors Would the proposed Project exposed persons to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	None required.	Less than significant.
Ground-Borne Vibrations and Ground-borne Noise Would the proposed Project expose persons to or generate excessive ground-borne vibration or ground-borne noise levels?	None required.	Less than significant.
Ambient Noise Levels Would the proposed Project could create a substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project. Would the proposed Project create a substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?	None required.	Less than significant.
Exposure to Excessive Noise Levels Would the proposed Project expose people residing or working in the Project area to excessive noise levels for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport? Would the proposed Project expose people residing or working in the Project area to excessive noise levels if the Project is located in the vicinity of a private airstrip?	None required.	Less than significant.
4.13 PUBLIC SERVICES AND UTILITIES		
Public Services Would the proposed Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant	None required.	Less than significant.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services listed below? • Fire protection; • Police protection; • Schools; • Parks; or • Other public facilities.		
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements Would the proposed Project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board? Would the proposed Project require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	None required.	No impact.
Storm Water Drainage Facilities Would the proposed Project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	**UTIL-4: Imported Water Storage Component.** Spreading basins shall be designed to avoid or minimize encroachment into major surface drainages. The Project participants shall conduct a drainage study to evaluate the potential impact of the spreading basins to surface drainages and to develop design parameters to minimize storm flow detention, velocity, and scouring downstream from the new basins. These recommendations shall be included in final designs to ensure that downstream improvements, including railroad lines and the agricultural operations, are not adversely affected. Implement Mitigation Measures **HYDRO-1** and **HYDRO-6**.	Less than significant with mitigation.
Expansion of New Water Supply Facilities Would the proposed Project require new or expanded water supply resources or entitlements? Would the proposed Project result in a determination by the wastewater treatment provider which serves or may serve the project that it has inadequate capacity to serve the projects projected demand in addition to the provider's existing commitments?	None required.	Less than significant.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
Solid Waste Would the proposed Project be served by a landfill with insufficient permitted capacity to accommodate the project solid waste disposal needs? Would the proposed Project comply with federal, state, and local statutes and regulations related to solid waste?	None required.	Less than significant.
Disruption of Local and Regional Utilities Would the proposed Project disrupt local or regional utility lines?	Implement Mitigation Measure **UTIL-2.**	Less than significant with mitigation.
Energy Usage Would the proposed Project require a substantial increase in energy usage?	None required.	Less than significant.
4.14 RECREATION		
Disruption of Recreational Facilities Would the proposed Project adversely affect the recreational experience of established recreational facilities?	None required.	Less than significant.
Deterioration of Recreational Facilities Would the proposed Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	None required.	No impact.
New Recreational Facilities Would the proposed Project include recreational facilities or require the construction or expansion or recreational facilities which might have an adverse physical effect on the environment?	None required.	No impact.
4.15 TRANSPORTATION AND TRAFFIC		
Consistency with Regulations for Circulation System Performance Would the proposed Project conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant	Implement Mitigation Measures **TR-1 through TR-4.**	Less than significant with mitigation.

TABLE ES-2
SUMMARY OF IMPACTS AND MITIGATION MEASURES – IMPORTED WATER STORAGE COMPONENT

Environmental Impact	Mitigation Measures	Significance Conclusion
components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?		
Congestion Management Standard / LOS Standard Would the proposed Project conflict with an applicable congestion management program, including, but not limited to, level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	Implement Mitigation Measures **TR-1 through TR-4**.	Less than significant with mitigation.
Air Traffic Would the proposed Project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	None required.	Less than significant.
Traffic Hazards Would the proposed Project substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	Implement Mitigation Measures **TR-1 through TR-4**.	Less than significant with mitigation.
Emergency Access Would the proposed Project result in inadequate emergency access?	Implement Mitigation Measure **TR-1**.	Less than significant with mitigation.
Public Transit, Bicycle, or Pedestrian Facilities Would the proposed Project conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	None required.	No impact.

CHAPTER 1
Introduction

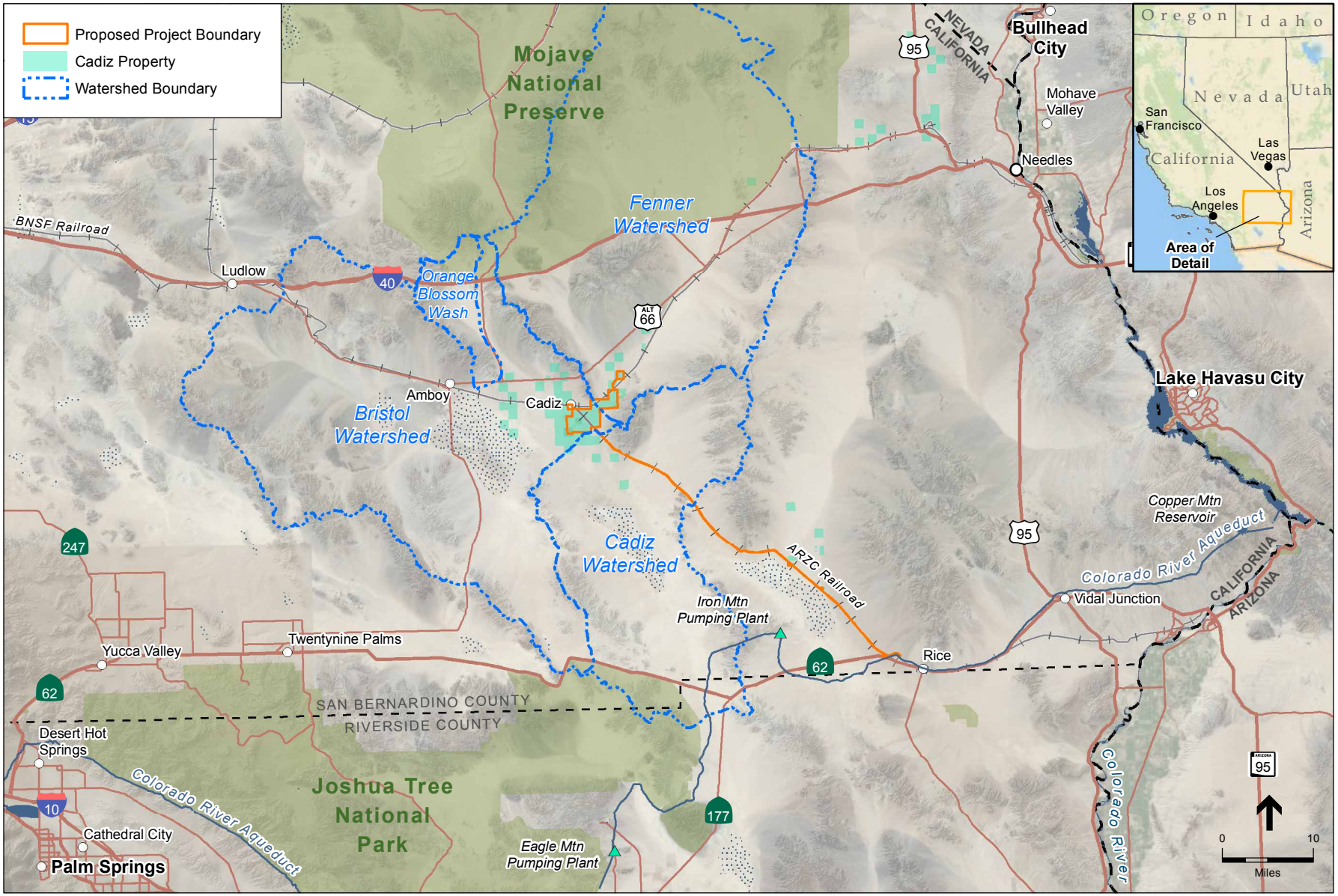
1.1 Purpose of the EIR

Santa Margarita Water District (SMWD) has prepared this Draft Environmental Impact Report (Draft EIR) to provide the public and responsible and trustee agencies with information about the potential effects on the local and regional environment associated with construction and operation of the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). This Draft EIR has been prepared pursuant to the California Environmental Quality Act (CEQA) of 1970 (as amended), codified at California Public Resources Code Sections 21000 et. seq., and the *CEQA Guidelines* in the Code of Regulations, Title 14, Division 6, Chapter 3.

This Draft EIR describes the environmental impacts of the proposed Project and suggests mitigation measures to reduce any significant impacts to a less than significant level. The impact analyses are based on a variety of information sources, including agency consultation, technical studies, and field surveys. As Lead Agency under CEQA, SMWD may use this EIR to approve the proposed Project, make Findings regarding identified significant impacts, and if necessary, adopt a Statement of Overriding Considerations regarding these impacts.

1.2 Project Overview

The proposed Project is designed to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California (**Figure 1-1**). The Project would be developed in two phases, the first being the Conservation and Recovery Component and the second phase being the Imported Water Storage Component. The purpose of the Project is to maximize beneficial uses of the groundwater in the Fenner Valley for SMWD and other entities participating in the Project (Project Participants). SMWD, along with other Project Participants, is proposing to implement the Project in partnership with Cadiz Inc. (Cadiz), a Delaware corporation that owns approximately 34,000 contiguous acres of land in the Cadiz and Fenner Valleys (Cadiz Property), and the Fenner Valley Mutual Water Company (FVMWC), a non-profit California mutual water company that would be formed to deliver water to its shareholders which are comprised of the Project Participants (see Section 1.2.3 in this chapter). Cadiz would make available its land, easements, and appurtenant rights for the operation of the Project.



SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 1-1

Watershed Boundaries

Substantial quantities of percolating groundwater underlie the Cadiz Property and the surrounding Fenner, Orange Blossom Wash, Cadiz, and Bristol Watersheds (Watersheds). The total volume of groundwater in storage in the Fenner and Orange Blossom Wash Watershed has been estimated to be between 17 and 34 million acre-feet (MAF).[1] Figure 1-1 shows the boundaries of the Watersheds. Within this closed basin system, groundwater percolates and migrates downward from the higher elevations in the Watersheds and eventually flows to Bristol and Cadiz Dry Lakes. Once the fresh groundwater reaches the Dry Lake areas, it mixes with the highly saline groundwater zone under the Dry Lakes and ultimately evaporates. The proposed Project intercepts this flow and extracts groundwater for beneficial uses before it is wasted to the brine zone. The Project would prevent up to 2 MAF from mixing with the brine and evaporating over the 50-years of pumping an annual average of 50,000 acre feet (AF).

The Project has two components that would be implemented by the FVMWC. The first component—the Groundwater Conservation and Recovery Component—is ready for detailed analysis and implementation. The second component—the Imported Water Storage Component—is under development and would be implemented following completion of the first component. The first Component, analyzed in this Draft EIR at a "project-level," is required to set the stage for proceeding with the second Component, which is analyzed at a "program-level."

1.2.1 Groundwater Conservation and Recovery Component

In the first phase of the proposed Project, the Groundwater Conservation and Recovery Component, an annual average of 50,000 AF of groundwater would be pumped from the basin over a 50-year period and delivered to the Project Participants in accordance with the Cadiz Groundwater Management, Monitoring and Mitigation Plan (GMMMP) that has been developed to guide long-term groundwater management for the Project. The level of groundwater pumping proposed under the Groundwater Conservation and Recovery Component is designed specifically to extract and conserve groundwater that would otherwise migrate to the brine zone below the Dry Lakes where its beneficial use is lost before it evaporates. To implement the Project, extraction wells (wellfield) would be built on the Cadiz Property and a 43-mile underground water conveyance pipeline would be constructed within an active railroad right-of-way (ROW) that originates in Cadiz, California and intersects with the Colorado River Aqueduct (CRA) (Figure 1-1). The pipeline would convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to the CRA and then on to SMWD and other Project Participants, for a period of 50 years. In accordance with *CEQA Guidelines* Sections 15161 and 15378(a), the Groundwater Conservation and Recovery Component is being analyzed at a project level in this Draft EIR.

1.2.2 Imported Water Storage Component

The second phase of the Project, the Imported Water Storage Component, would make available up to 1 MAF of groundwater storage space in the basin to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects

[1] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.

(California Water Code § 79170 et. seq.). Under the Imported Water Storage Component, water would be conveyed to recharge basins in the Fenner Valley to percolate into the ground for storage and future withdrawal as a dry-year supply (Figure 1-1). The Imported Water Storage Component is being evaluated in this Draft EIR at a programmatic level in accordance with *CEQA Guidelines* Section 15168, because the potential quantity and schedule for spreading, storage, and extraction is still under conceptual development, the participants have not yet been identified, and it would be implemented at a later date. A similar project proposed by the Metropolitan Water District of Southern California (Metropolitan) called the "Cadiz Groundwater Storage and Dry-Year Supply Program" was analyzed in detail in 2001. The analysis from this previously proposed project supports the programmatic analysis provided here.

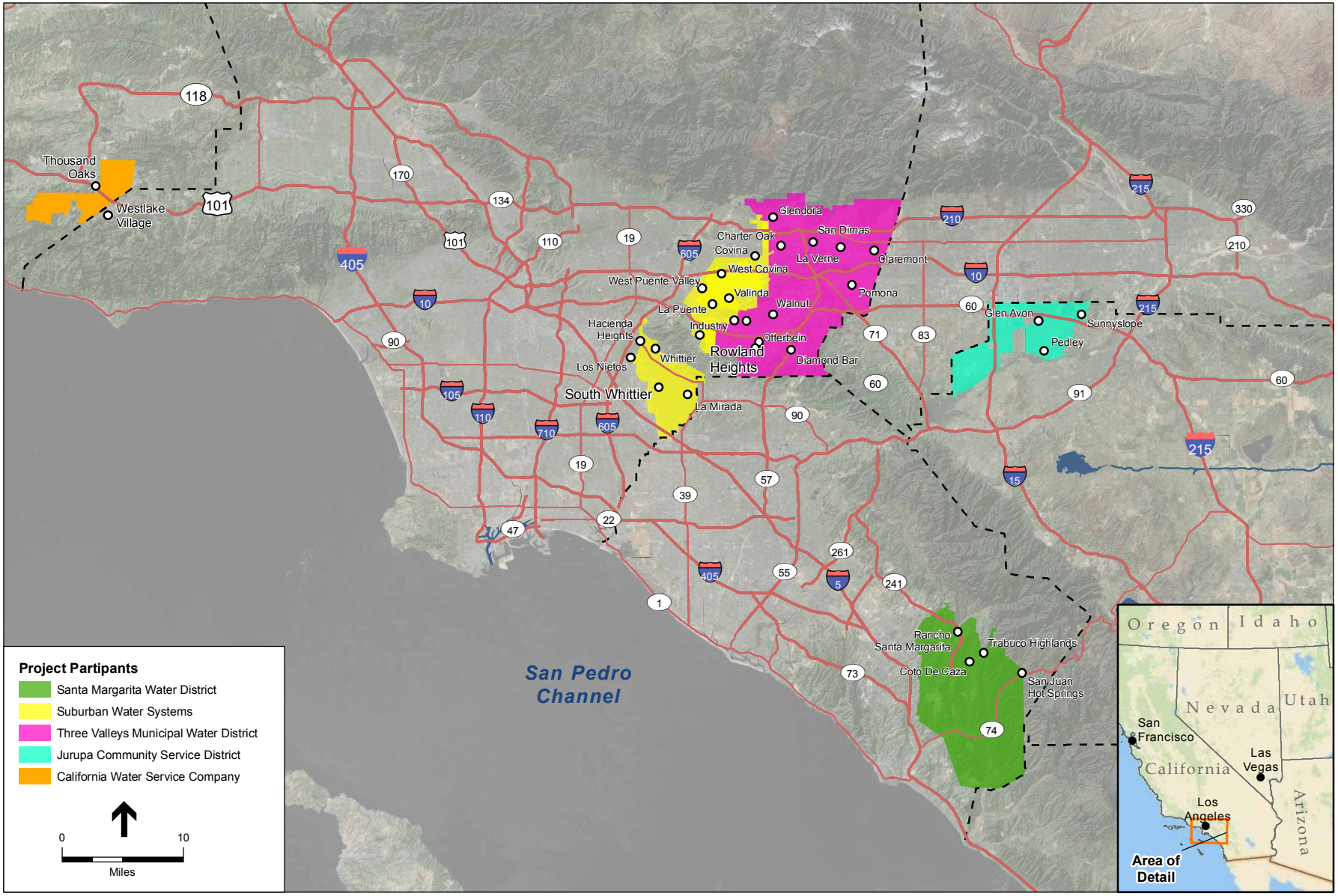
1.2.3 Project Participants

The following water providers and railroad company have entered into agreements with Cadiz Inc. to be Project Participants. Each Project Participant would receive water from the Project in accordance with the GMMMP that has been developed to guide the long-term groundwater management for the Project. Other participating entities may join the Project at any time until the established Project capacity is reached. The full term of the Project would be 50 years. In the event that circumstances beyond the control of the Project operator required additional time to complete contracted water deliveries, the Project term may be extended for a limited time under the terms of the agreements. If Project Participants elect to extend the Project for an additional term, new agreements and a new environmental analysis would be required.

Santa Margarita Water District – Lead Agency

SMWD is Orange County's second-largest water district, with a 97-square-mile service area that includes residents and businesses in southern Orange County, California. SMWD is divided into eight improvement districts that allow SMWD to meet the diverse needs of specific portions of its service area, factoring in land use, topography, property ownership, water supply, and wastewater treatment needs. SMWD is a member agency of the Municipal Water District of Orange County (MWDOC), which is a member agency of Metropolitan.[2] With limited local water supplies available within its service area, significant portions of SMWD's water supply are purchased from Metropolitan, which delivers to its customers water imported to the region from Northern California via the State Water Project (SWP) and from the Colorado River via the CRA. SMWD also delivers limited local groundwater reuse and recycled water supplies to its customers (see **Figure 1-2**).[3] As described in further detail in Section 1.3, SMWD is acting as Lead Agency for CEQA review of the Project.

[2] Santa Margarita Water District, *2010 Urban Water Management Plan*, July 2011, page 2-10.
[3] Santa Margarita Water District, *About Us: Operations*, www.smwd.com/operations.htm, accessed December 2010.



SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 1-2

Project Participants:
SMWD, Suburban, Three Valleys, Cal Water and JCSD
(See Figure 1-3 for Golden State)

Three Valleys Municipal Water District

Three Valleys Municipal Water District (Three Valleys) is a California Municipal Water District and a public water agency that distributes water for beneficial uses within Eastern Los Angeles County and provides imported water to 14 member agencies, serving a total population of over 600,000.[4] Three Valleys' service area spans over 133 square miles. Three Valleys is a member agency of Metropolitan and delivers water purchased from Metropolitan to its member agencies (see Figure 1-2). Three Valleys service area receives approximately 50 percent of its water supplies from Metropolitan. The majority of the remaining 50 percent is provided by local groundwater sources, and smaller percentages are provided by local surface water and recycled water.[5] Three Valleys would act as a Responsible Agency for purposes of evaluating environmental impacts of the proposed Project within its service area.

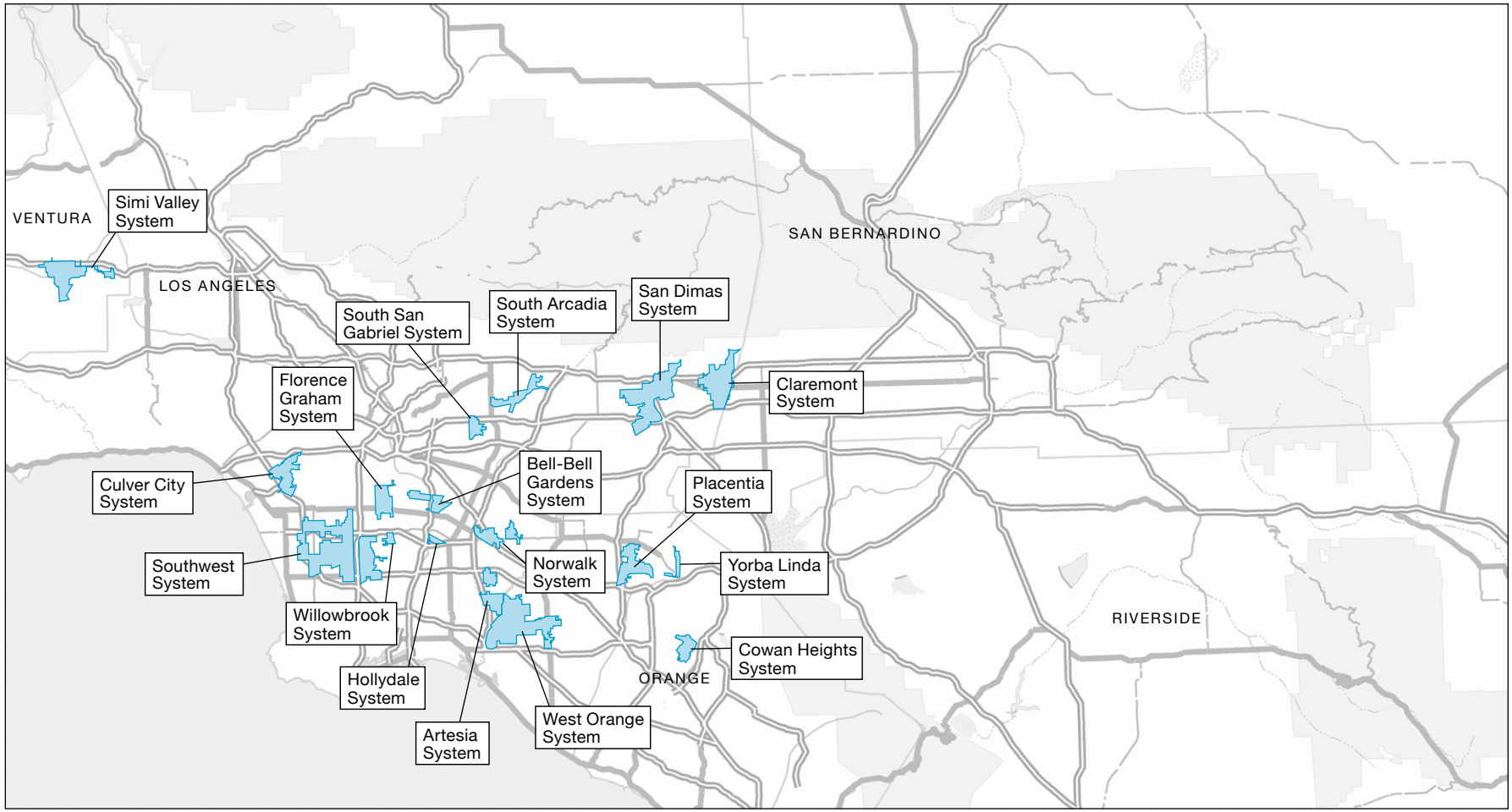
Golden State Water Company

Golden State Water Company (Golden State) is California's second-largest investor-owned water utility and a wholly-owned subsidiary of American States Water Company (NYSE: AWR). Golden State is engaged in the distribution and sale of water and power to over 275,000 customers in 10 counties across California. In Southern California, Golden State serves customers in cities throughout San Bernardino, Riverside, Los Angeles, Orange and Ventura counties (see **Figure 1-3**). Golden State's customers receive water from several sources, including imported water purchased from Metropolitan; surface water obtained from local rivers, lakes, and streams; groundwater pumped from local underground aquifers; and recycled or reclaimed water.[6] Golden State is regulated by the California Public Utilities Commission (CPUC).

Suburban Water Systems

Suburban Water Systems (Suburban) is an investor-owned water utility that provides water and water service to a population of approximately 300,000 people in Los Angeles and Orange Counties. Suburban is a wholly-owned subsidiary of SouthWest Water Company. Suburban's 42-square-mile service area is divided into two regions: the San Jose Hills Service Area and the Whittier/La Mirada Service Area (see Figure 1-2). The two service areas are about three miles apart, separated by the La Puente Hills. Suburban's water supply comes primarily from local groundwater (80 percent); the remaining 20 percent is provided by surface water from Metropolitan, Covina Irrigating Company and California Domestic Water Company.[7] Suburban's water distribution system includes 18 wells, 32 reservoirs and more than 800 miles of pipeline. Suburban is regulated by the CPUC.

4 Metropolitan Water District of Southern California, *Member Agencies: Three Valleys Municipal Water District*, www.mwdh2o.com/mwdh2o/pages/memberag/agencies/threevalleys.htm, accessed February 2011.
5 Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011, page 3.
6 Golden State Water Company, *2010 Urban Water Management Draft Plan, Multiple Water Systems*, 2010.
7 SouthWest Water Company, *Suburban Water Systems*, www.swwc.com/suburban/about-our-water/, accessed February 2011.



SOURCE: Golden State Water Company; ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 1-3

Project Participant:
Golden State Water Company
Southern California Service Areas

Jurupa Community Services District

Jurupa Community Services District (JCSD) is a public agency responsible for providing potable water, sewer and street lights to over 101,000 people located throughout 48 square miles in the Jurupa area of Riverside County (see Figure 1-2). JCSD utilizes a combination of wells and water treatment plants to deliver highly treated groundwater to customers throughout the service area. The treatment plants in use are the Chino I and II Desalters, which are owned and operated by Chino Basin Desalter Authority. Currently, JCSD operates 16 wells, 8 booster stations, and 16 reservoirs, providing a 46.2 million-gallon capacity.[8] JCSD would act as a Responsible Agency for purposes of evaluating environmental impacts of the proposed Project within its service area.

California Water Service Company

California Water Service Company (Cal Water) is California's largest investor-owned water utility. Cal Water is the largest subsidiary of the California Water Service Group, which also includes Washington Water Service Company, New Mexico Water Service Company, Hawaii Water Service Company, and CWS Utility Services. Cal Water distributes and sells water to 1.7 million Californians through 435,000 connections. Its 24 separate water systems serve 63 communities from Chico in Northern California to the Palos Verdes Peninsula in Southern California.[9] Cal Water's customers receive water from several sources, including imported water purchased from Metropolitan; surface water obtained from local rivers, lakes, and streams; groundwater pumped from local underground aquifers; and recycled or reclaimed water. Cal Water is regulated by the CPUC. Project water would be used to serve its Westlake District service area within the City of Thousand Oaks in Ventura County. (See Figure 1-2)

Arizona & California Railroad Company

The Arizona & California Railroad Company (ARZC) is the owner and operator of the shortline railroad that runs from Cadiz, California to Parker, Arizona. Cadiz Inc. has entered into an agreement with the ARZC to utilize a portion of its ROW for installing the proposed water conveyance pipeline from the Cadiz Property to the CRA. ARZC is also participating in the Project to meet railroad water demands along the ROW including fire suppression and future needs of the railroad.

1.3 CEQA Lead Agency and Responsible and Trustee Agencies

According to CEQA, when a project is to be carried out by more than one public agency, the public agency with the greatest responsibility for supervising or approving a project or the first public agency to make a discretionary decision to proceed with a proposed project should act as the Lead Agency (*CEQA Guidelines* §§ 15051(a) and 15051(b)). The term Responsible Agency

[8] Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011, page 5.
[9] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011.

includes all public agencies other than the Lead Agency which have discretionary approval power over a project (*CEQA Guidelines* §§ 15096 and 15381). The Lead Agency is responsible for preparing the appropriate CEQA document and has primary responsibility for approving or carrying out the project (*CEQA Guidelines* § 15050(a)). The decision-making bodies of the Lead Agency and Responsible Agencies consider the EIR prior to acting upon or approving a project (*CEQA Guidelines* § 15050(b)).

As the first public agency with a discretionary decision regarding the proposed Project and because the Project would be owned in part and operated by SMWD, SMWD is acting as Lead Agency. SMWD was the first Project Participant to enter into an Option Agreement for the largest portion of water supply and carry-over storage from the Project and is sharing CEQA costs with Cadiz. SMWD has prepared this Draft EIR in accordance with its responsibility as Lead Agency to evaluate the potential environmental impacts of the proposed Project. SMWD has the discretion to certify the EIR and to approve or reject the Project.

Trustee Agencies are defined in *CEQA Guidelines* Section 15386. Trustee Agencies are state agencies having jurisdiction by law over natural resources affected by a project which are held in trust for the people of the State of California. The California Department of Fish and Game (CDFG), which is responsible for fish and wildlife, is the only Trustee Agency defined in *CEQA Guidelines* Section 15386, with jurisdiction over the Project. CDFG would be reviewing the Draft EIR during its review of the proposed Project pursuant to the permitting authority under the California Fish and Game Code Sections 2081 and 1602.

1.4 Organization of the Draft EIR

This Draft EIR describes the proposed Project and the existing environmental setting, identifies short-term, long-term, and cumulative environmental impacts, identifies mitigation measures for impacts found to be significant, and provides an analysis of Project alternatives. The Notice of Preparation (NOP) for the proposed Project was published on February 28, 2011.

This Draft EIR has been organized into the following chapters:

ES. Executive Summary. This chapter contains an overview of the Draft EIR, as well as a summary of environmental impacts, proposed mitigation measures, level of significance after mitigation, and a description of significant but unavoidable impacts.

1. Introduction. This chapter discusses the purpose of CEQA, the purpose and format of this Draft EIR, the environmental review process, and the intended uses of this document, and describes the difference between a project level of analysis and a programmatic level of analysis.

2. Project Background. This chapter describes the Project history and background, including the relationship between the proposed Project and the former "Cadiz Groundwater Storage and Dry-Year Supply Program" (Cadiz Program) for which an EIR/EIS (environmental impact statement) was prepared in 2001.

3. **Project Description.** This chapter provides an overview of the proposed Project, describes the Project objectives, and identifies the Project Participants. It also describes the construction and operation of the two phases of the Project: the Groundwater Conservation and Recovery Component analyzed at the project level, and the Imported Water Storage Component analyzed at the programmatic level.

4. **Environmental Setting, Impacts, and Mitigation Measures.** This chapter describes the environmental setting and identifies impacts of the proposed Project on each of the following environmental resource areas: Aesthetics; Agriculture and Forestry Resources; Air Quality; Biological Resources; Cultural Resources; Geology and Soils; Greenhouse Gas Emissions; Hazards and Hazardous Materials; Hydrology and Water Quality; Land Use and Planning; Mineral Resources; Noise; Public Services and Utilities; Recreation; and Transportation and Traffic. Significance criteria have been developed for each environmental resource analyzed in this Draft EIR. The significance criteria are defined at the beginning of each impact analysis section.

   Impacts are categorized as follows:

   - **Significant and Unavoidable:** Mitigation may be recommended if feasible and if it would reduce impacts but impacts would remain significant with mitigation;
   - **Less than Significant with Mitigation:** Potentially significant impact that can be mitigated to a less than significant level;
   - **Less than Significant:** Mitigation is not required under CEQA but may be recommended; or
   - **No Impact:** Mitigation not required or recommended.

5. **Cumulative Impacts.** This chapter describes the incremental impacts of the proposed Project when considered together with closely related past, present, and reasonably foreseeable probable future projects consistent with *CEQA Guidelines* Section 15355(b).

6. **Growth Inducement.** This chapter describes the potential for the proposed Project to induce growth.

7. **Analysis of Alternatives**. This chapter presents an overview of the alternative development processes, describes the alternatives to the proposed Project that are being considered, and compares the impacts of the proposed Project to those of the Project alternatives.

8. **Irreversible and Irretrievable Commitment of Resources.** This chapter indentifies elements of the proposed Project that could result in irreversible and irretrievable commitment of resources and described the Project's long-term benefits and how these benefits offset the irretrievable commitment of resources.

9. **Report Preparers.** This chapter identifies the report preparers, including persons and organizations consulted.

10. **Acronyms.** This chapter defines the acronyms used throughout the Draft EIR.

11. **References.** This chapter provides the references for information in the Draft EIR.

1.5 Level of CEQA Analysis in this Draft EIR

1.5.1 Geographic Context

This Draft EIR considers potential environmental effects to the Project area and broader region. Localized impacts of Project construction and operation are analyzed in detail for the property that is proposed to be affected. The analysis expands in scope depending on the resource area potentially affected. For example, the groundwater basin underlying the Project area and the air basin extend for miles in every direction and public lands and utilities that could be affected by the Project extend even further from the local Project construction footprint. Finally, this Draft EIR includes an assessment of water demands in the context of the entire Southern California region, and particularly within Project Participant service areas and the greater Metropolitan service area. **Figure 1-4** provides a schematic overview of the geographic context of the environmental analysis contained in this Draft EIR.

1.5.2 Project-Level Analysis

This Draft EIR evaluates the first phase of the proposed Project, the Groundwater Conservation and Recovery Component, at a site-specific "project level" consistent with *CEQA Guidelines* Section 15161 and 15378(a). Project-level analyses examine all phases of a proposed project, including planning, construction, and operation, at a site-specific level.

1.5.3 Programmatic-Level Analysis

Because it could be implemented at a later date and the potential quantity and schedule for spreading, storage, and extraction of water is still under conceptual development, the Draft EIR evaluates the second phase of the proposed Project, the Imported Water Storage Project, at a programmatic-level providing more of a general level of analysis consistent with *CEQA Guidelines* Section 15168. Further appropriate environmental review would be conducted as determined appropriate pursuant to CEQA and when specific Project Participants that would access and utilize the storage space are identified. For example, additional information regarding the specific location and design of the proposed wellfield expansion could be necessary to fully evaluate groundwater quality impacts associated with the Imported Water Storage Component. This Draft EIR would provide the basis for any future project-level CEQA analyses.

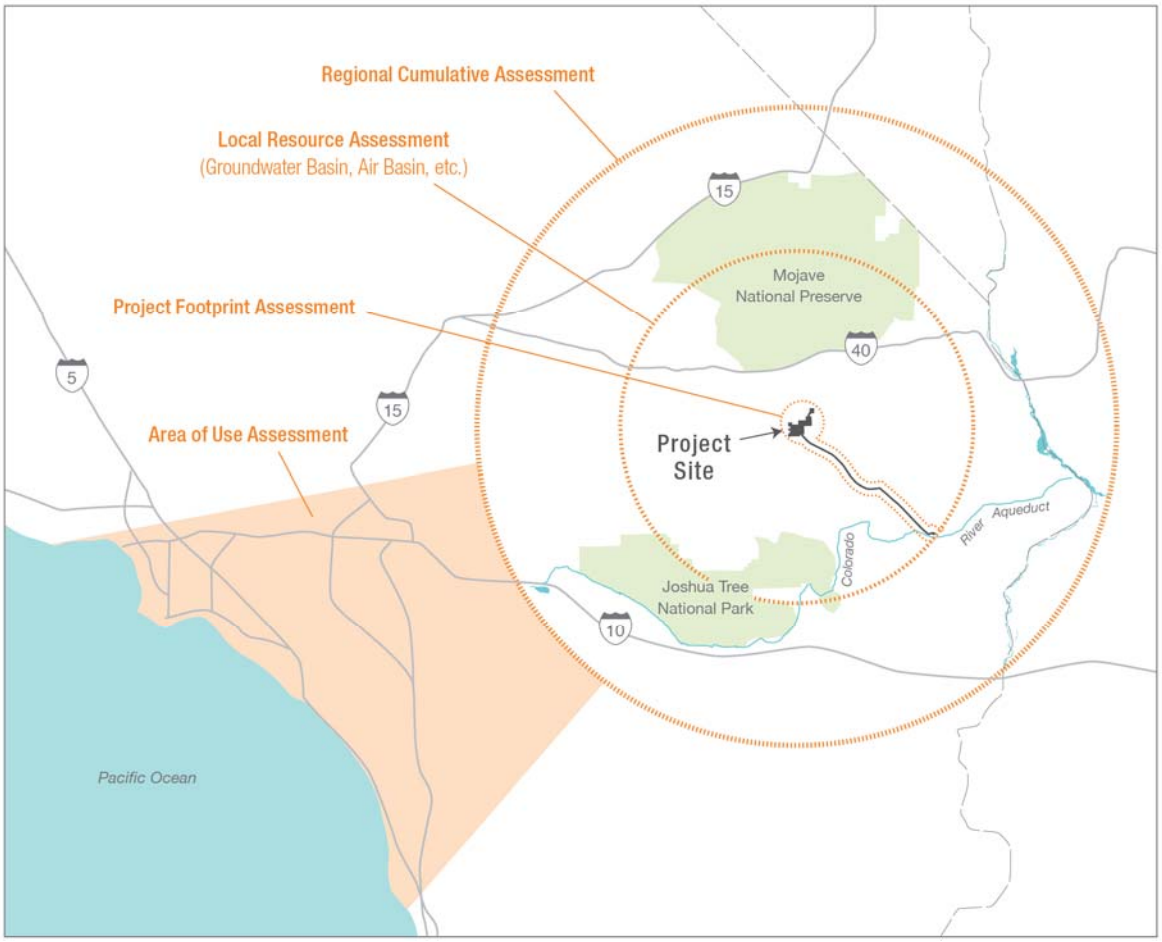


Figure 1-4
Geographic Context of Project Assessment

1.6 EIR Review Process

1.6.1 Notice of Preparation

In accordance with *CEQA Guidelines* Sections 15063 and 15082, SMWD prepared a NOP of a Draft EIR (see Appendix A) that was circulated to and available for comment by local, state, and federal agencies and other interested parties between February 28, 2011 and March 30, 2011. The NOP included the Project location and setting, the Project description for the first and second components, the Project approvals that would be required, the Project history, and a list of the potential environmental impacts to be discussed in the Draft EIR. As indicated in the NOP, this Draft EIR addresses all topics listed in Appendix G of the *CEQA Guidelines* regardless of whether the potential impact may be significant, so that information regarding this Project is available in a single document to facilitate public review.

Written comments were received during the 30-day public review period for the NOP. Comment letters received are included in Appendix A.

1.6.2 Public Scoping Meeting

CEQA recommends conducting early coordination with the general public, appropriate public agencies, and local jurisdictions to assist in developing the scope of the environmental document. Pursuant to *CEQA Guidelines* Section 15083, public scoping meetings were held on March 16, 2011 at the Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, California and on March 24, 2011 at the Joshua Tree Community Center, 6171 Sunburst Street, Joshua Tree, California to allow agency consultation and public involvement in defining the scope and content of the Draft EIR. Public notices were placed in local newspapers (The Press Enterprise, Orange County Register, Hi-Desert Star, and The Desert Trail) to inform the public of the scoping meetings and the availability of the NOP. The purpose of the proposed Project and its potential environmental impacts were presented at the scoping meetings. Attendees were provided an opportunity to voice comments or concerns regarding the scope and content of the environmental information to be examined and included in the EIR for the proposed Project. Written comments and summaries of verbal comments received during the scoping meeting are included in the scoping report in Appendix A.

1.6.3 Public Review of the Draft EIR

SMWD has filed a Notice of Availability (NOA) of the Draft EIR with the Governor's Office of Planning and Research. The NOA is being circulated to local, state, and federal agencies and to organizations and individuals that have expressed interest in reviewing and commenting on the Draft EIR. Publication of this Draft EIR marks the beginning of a 70-day public review period. During this 70-day public review period, comments may be made on the Draft EIR either in writing or at the public informational meetings on the Draft EIR. Written comments may be sent to the following address and may be submitted via mail or via email:

Attn: Tom Barnes
ESA | Southern CA Water Group
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017
Email: tbarnes@esassoc.com

The Draft EIR is available for public review at the following locations:

- Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688
- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd., Twentynine Palms, CA 92277
- Joshua Tree Library, 6465 Park Blvd., Joshua Tree, CA 92252
- San Bernardino County Library, 104 W. 4th St., San Bernardino, CA 92415

The Draft EIR may also be reviewed on SMWD's website: www.smwd.com.

1.6.4 Final Environmental Impact Report Publication

Following the 70-day public review period of this Draft EIR, SMWD will prepare responses to comments received on the Draft EIR, which it will provide in a Final EIR on the Project. When considering the proposed Project for approval, SMWD will review and consider the information presented in the Final EIR and will certify that the Final EIR has been adequately prepared in accordance with CEQA (*CEQA Guidelines* §§ 15089 and 15090). If it approves the Project, SMWD shall make Findings regarding any significant, unavoidable environmental effects identified in the Final EIR, and if necessary, adopt a Statement of Overriding Considerations regarding these impacts (*CEQA Guidelines* §§ 15091, 15092, and 15093). If SMWD certifies the Final EIR and approves the Project, SMWD will file a Notice of Determination (NOD) with the State Clearinghouse and the county clerk of the county in which the Project will be located (*CEQA Guidelines* § 15094(d)). The Responsible Agencies also will review the Final EIR prior to considering relevant discretionary approvals for the proposed Project.

1.6.5 Mitigation Monitoring and Reporting Plan

CEQA requires lead agencies to adopt a mitigation monitoring and reporting program for mitigation measures or conditions of project approval that are necessary to mitigate or avoid significant effects on the environment (California Public Resources Code § 21081.6; *CEQA Guidelines* § 15097). A Mitigation Monitoring and Reporting Plan (MMRP) for the proposed Project will be prepared based on the mitigation measures and Project design features included in the Final EIR and will be included in the Findings made by SMWD and the Responsible Agencies.

1.7 References and Citations

Throughout this Draft EIR, technical citations are provided as footnotes and also listed in alphabetical order in Chapter 11, References. The material cited in each Chapter has been relied upon to substantiate the analysis. In addition, a substantial amount of technical data has been generated in evaluating the Project. Original technical reports prepared for this analysis are appended in Volumes 2, 3, and 4.

CHAPTER 2
Project Background

2.1 Introduction

This Chapter presents background for the Project including a brief history of the Project, a summary of relevant existing agreements and easements/rights-of-way, and an overview of the water supply issues in Southern California that led to this Project.

2.2 Overview of Cadiz Properties

Cadiz owns 45,000 acres (approximately 70 square miles) of land in three areas of the Mojave Desert portion of eastern San Bernardino County, California. The primary property is located in the Cadiz and Fenner Valleys (Cadiz Property) on approximately 34,000 acres of largely contiguous land. Cadiz's additional properties, located in the Piute Wash (Piute Property) and near Danby Dry Lake (Danby Property), are 8,500 acres and 1,500 acres respectively. All three properties are underlain by groundwater supplies. The proposed Project would be sited on a portion of the Cadiz Property and involves the Cadiz, Fenner, Bristol, and Orange Blossom Wash Watersheds.

2.2.1 Agricultural Operations

Over the last 20 years, Cadiz has maintained an agricultural operation at its Cadiz Property consisting of approximately 1,600 acres of table grapes, dried-on-the-vine raisins, citrus, and various row crops. The agricultural operation utilizes groundwater for irrigation of all crops in production through a network of seven existing water-production wells.

In 1993, the County of San Bernardino approved a General Plan Amendment and Conditional Use Permit authorizing Cadiz to expand its agricultural operations, to include the withdrawal of groundwater to irrigate agricultural uses on up to 9,600 acres and the construction of worker housing, crop storage, and cooling facilities on adjacent Cadiz-owned lands.[1] The County certified an EIR in 1993 evaluating potential impacts associated with the proposed agricultural expansion including the extraction of 30,000 AFY of groundwater. The County also adopted a Statement of Overriding Considerations, and adopted a Mitigation Monitoring Program (MMP) under CEQA for the Cadiz Agricultural Program. The 1993 EIR included estimates of groundwater drawdown of approximately 200 feet in the wellfield and approximately 10 feet at the edge of Bristol Dry Lake.

[1] County of San Bernardino, *Final Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development*, October 1993, page 1.

As a condition of the application approved in 1993, the County worked with Cadiz to prepare a Groundwater Monitoring Plan (GWMP) in 1997. As required by the GWMP, Cadiz provides annual reports to the County that includes water levels, extraction amounts, electric conductivity sample results, and observed subsidence due to ground water withdrawal. As reported in its annual filings with the County, between 1986 and 1998, Cadiz used an average of 5,000 to 6,000 AFY of groundwater[2] for its agricultural operations. Most recently it has been using approximately 1,800-1,900 AFY of groundwater due to changes in crop cultivation and increased irrigation efficiency. No land subsidence or any other impact to the environment has been observed since reporting began.[3]

In addition, on January 31, 2000, the County of San Bernardino approved a Conditional Use Permit (CUP) 95-0015 (as revised) for the Cadiz Agricultural Program. Among the conditions to the CUP, and included in the 1993 MMP is Condition/Mitigation Measure WR6, which sets forth the requirements for groundwater monitoring. In accordance with Measure WR6, Cadiz has filed annual reports every year and also began filing a more extensive five-year monitoring report for the Cadiz Agricultural Program in 2003.

2.2.2 Cadiz Storage and Supply Program with Metropolitan

Cadiz recognized the potential for developing a conjunctive use groundwater storage and supply program on its property in the early 1990s and reached out to water providers, including Metropolitan, seeking project partners. At the same time, forecasted conditions showing dry-year supplies from all existing sources within the Metropolitan service area were projected to fall short of dry-year demands by 2020, even with full implementation of water conservation. To meet this projected demand, Metropolitan and its member agencies developed an integrated approach to obtaining additional dry-year supplies that included water conservation, recycling, groundwater banking, water transfers, and other programs. The Cadiz Program, a joint effort between Metropolitan and Cadiz, was intended to be one element of these efforts to meet dry-year demand.[4] Between 1999 and 2001, Metropolitan, the lead agency for the Cadiz Program under CEQA, and the U.S. Bureau of Land Management (BLM), the lead agency for the Cadiz Program under the National Environmental Policy Act (NEPA), prepared a joint EIR/EIS that evaluated the feasibility of operating the Cadiz Program.[5] The Cadiz Program would have transported surplus Colorado River water to the Cadiz site, recharging it through a series of spreading basins, storing it, and then extracting the stored water during times of drought. The Cadiz Program also proposed to extract native groundwater from the groundwater basin underlying part of the Cadiz and Fenner Valleys for transfer to Metropolitan during dry years.

---

2 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163,* November 1999, page 43.

3 Cadiz Inc., *12th Annual Groundwater Monitoring Report, January-December 2009, Cadiz Valley Agricultural Development,* June 2010, page 14.

4 PCR Services Corporation, *Technical Memorandum: Assessment for CEQA Compliance – Cadiz Valley Aquifer Storage Project,* October 2006, page 3.

5 Metropolitan Water District of Southern California and Bureau of Land Management, Final *Environmental Impact Report and Final Environmental Impact Statement for the Cadiz Groundwater Storage and Dry-Year Supply Program,* September 2001.

The Final EIR/EIS for the Cadiz Program was completed in September 2001. After determining that the Cadiz Program would not cause any significant environmental harm, the United States Department of the Interior (DOI) approved the Final EIS, authorized an amendment to the California Desert Conservation Area (CDCA) Plan, and authorized an ROW grant and temporary use permit for the construction, operation, and maintenance of the water conveyance pipeline and related facilities in a Record of Decision that was issued by the DOI on August 29, 2002.[6] However, although the feasibility studies completed under the partnership demonstrated a significant potential for water supply development, Metropolitan decided not to pursue the Cadiz Program in October 2002 and declined to accept the ROW grant that had been authorized by the DOI. As a result of Metropolitan's decision, the amendment to the CDCA Plan was not processed and the ROW grant and temporary use permit were not issued.

Following Metropolitan's 2002 decision, Cadiz continued its efforts to implement a groundwater project, given the sustained need for a more reliable, local source of water and groundwater storage in Southern California. Since 2002 the region has confronted an historic drought, an historic wet year, and regulatory restrictions on imported supplies, all of which has led to decreased reliability in the region's water supplies.[7] The proposed Project evaluated in this EIR is the result of the interest expressed by Southern California water providers in developing a local, reliable water supply in Southern California.

2.3 Existing Agreements and Permits

2.3.1 San Bernardino County Groundwater Management Ordinance

On October 29, 2002, the Board of Supervisors for San Bernardino County adopted Ordinance No. 3872, Groundwater Management Ordinance, in order to provide for the management of groundwater in the unincorporated, un-adjudicated desert region of San Bernardino County. The Desert Groundwater Management Ordinance (Title 3, Division 3, Chapter 6, Article 5, Section 33.06551 of the San Bernardino County Code of Ordinances) imposes permitting requirements and procedures for certain new groundwater extraction wells in the Desert Region of the County. The ordinance requires any new wells to obtain a permit from the County, which is a discretionary action subject to CEQA. The stated purpose of the ordinance is to ensure safe yield and health of aquifers in the relatively undeveloped Desert Region of the County.

The ordinance does not apply to entities that have prepared a County-Approved Groundwater Management, Mitigation and Monitoring Plan (GMMMP) and that have entered into a Memorandum of Understanding (MOU) with the County that "requires the parties to share groundwater monitoring information and data and to coordinate their efforts to monitor groundwater resources in the County;" and "ensures that the measures identified in the AB 3030

6 PCR Services Corporation, *Technical Memorandum: Assessment for CEQA Compliance – Cadiz Valley Aquifer Storage Project*, October 2006, page 4.

7 California Department of Water Resources, *California Water Plan Update 2009, Integrated Water Management*, December 2009.

Plan or County-approved groundwater management, monitoring and mitigation plan are fully implemented and enforced." [8]

In November 2002, Cadiz entered into a MOU with the County that exempted its existing Agricultural Operations — including construction of worker housing and related facilities and the withdrawal of groundwater to irrigate agricultural uses on up to 9,600 acres (30,000 AFY of groundwater) — from permitting under the County's Ordinance. To meet the exemption requirements, the County relied on Cadiz's existing 1993 and 2000 Agricultural Development Project MMP and GWMP (described above) that provided that Cadiz would monitor its annual groundwater pumping and submit annual and five-year monitoring reports to the County.[9]

The Project includes the approval of a GMMMP developed to guide the long-term groundwater management for the Project consistent with the County's Ordinance. Pursuant to an additional MOU with the County, the GMMMP will be submitted to the County for approval and will satisfy the requirements for an exclusion from the scope of the Ordinance.

2.3.2 ARZC Lease

Cadiz has acquired a 99-year ROW (longitudinal lease) agreement with ARZC to construct, operate, and maintain a subsurface water-conveyance pipeline and a power line between the Cadiz Property and the CRA within a portion of the ARZC railroad ROW.[10] This segment of the ARZC ROW is 200-feet-wide and runs between mile post 189.0 at Cadiz, California and mile post 144.0 at Freda, California in San Bernardino County. The ARZC ROW extends approximately 100 feet on each side of the railroad centerline.

The agreement between ARZC and Cadiz also provides for ARZC's use of Project water and facilities as follows:

1. Fire hydrants placed along railroad tracks;
2. Access road to be constructed on leased area for railroad company for maintenance purposes or in case of emergencies such as rail car derailment;
3. Access to 10,000 gallons of water per day for vegetation control, washing rail cars, offices, and other contemplated improvements;
4. Access to power at meters located along the railroad tracks and emergency access to power at any location;
5. Accommodations for passenger terminals and water service associated with the steam-powered locomotives that ARZC is contemplating operating in the future; and

8 County of San Bernardino, San Bernardino County Code, Title 3, Division 3, Chapter 6, Article 5, § 33.06552.
9 Cadiz Inc., *Cadiz Valley Agricultural Development Project Mitigation Monitoring and Compliance Program*, December 2000.
10 Cadiz Inc., *Memorandum of Lease Agreement between Cadiz Real Estate, LLC and Arizona & California Railroad Company*, September 2008, page 1.

6. Right to connect and deliver water to any future water production facilities within the ROW to the pipeline and facilities (future delivery of water would be subject to permitting and require monitoring).

A recent opinion from the Solicitor of the DOI holds that as long as new activities derive from or further a railroad purpose, even if those activities have both railroad and commercial purposes, authorization is within the purview of the railroad.[11]Accordingly, no federal authorization is required for the construction of the pipeline along the ARZC ROW, because the proposed pipeline (and corresponding water service), access roads, and safety design features would serve both railroad and commercial purposes.

2.3.3 Natural Heritage Institute Agreement

On May 14, 2009, Cadiz and the Natural Heritage Institute (NHI) signed a Memorandum of Understanding for Land Stewardship, referred to as the "Green Compact," to ensure sustainable management of approximately 70 square miles of Cadiz Property within the Cadiz, Fenner, and Piute Valleys of eastern San Bernardino County.[12] NHI is a non-governmental, non-profit organization founded by a group of conservation lawyers and scientists whose mission it is to restore and protect ecosystems and the services they provide for public benefit and to sustain and enrich human life. Cadiz had committed to manage their property and develop projects in accordance with the Stewardship Principles identified in the Green Compact; NHI has committed to assist Cadiz in designing groundwater banking projects, identifying Project Participants, and auditing the management of Cadiz-owned property in keeping with the Green Compact. The Stewardship Principles are summarized below:

Long-term Sustainability. The property will be managed holistically with due regard for long term sustainability.

Renewable energy. Cadiz will make reasonable best efforts to use renewable energy supplies to support operations.

Protection of Species. Any take of endangered species will be offset through habitat conservation planning.

Conservation Easement. Cadiz will implement conservation easements to offset operational effects.

Groundwater Banking. Cadiz will pursue groundwater banking to support beneficial uses.

Resource Evaluation. Cadiz will conduct technical studies of its properties prior to implementing major projects.

Priority of Use. Cadiz will maintain highest priority of use as beneficial uses for overlying properties.

11 U.S. Department of the Interior, Office of the Solicitor, *Memorandum of Opinion M-37025 Partial Withdrawal of M-36964*, November 2011.

12 Cadiz Inc., *Memorandum of Understanding for Land Stewardship Between the Natural Heritage Institute and Cadiz*, May 2009, page 1-6.

2.4 Overview of Southern California Water Supply

Southern California receives two-thirds of its water supplies from the Sacramento-San Joaquin Bay Delta (via the SWP), the Colorado River (through the CRA), and the Owens Valley and Mono Basin (through the Los Angeles Aqueduct). The balance of Southern California's demand is supplied by local surface water, groundwater, and recycled water and partly managed through conservation.

Two of these water sources—the SWP and the Colorado River—are subject to a number of challenges, including competing demands, aging infrastructure, regulatory restrictions, and climatic fluctuations, all of which have caused the availability of water supplies to vary from year to year.[13]

The 2010 California Department of Water Resources (DWR) California Water Plan Update, Integrated Water Management found that reliability of supplies of water historically used by water providers in Southern California will continue to vary in the future.[14] Given the inconsistencies in water deliveries, Southern California is continuing to look for more reliable supplies. Southern California water providers are currently seeking ways to overcome these projected supply deficiencies to meet existing and future demand such as through supply diversification.

2.4.1 The State Water Project

The SWP began in 1960 with California voter approval for a statewide distribution system to meet growing water needs south of the Sacramento-San Joaquin River Delta (also known as the Bay Delta). The SWP is the nation's largest state-built water conveyance system and includes reservoirs, lakes, and storage tanks; canals, tunnels and pipelines; and pumping and power plants. The system conveys water to 29 State Water Contractors (contractors). The contractors deliver water directly to agricultural and urban water users or to water wholesalers and retailers.

The amount of water available to the SWP fluctuates widely each year due to factors such as hydrologic conditions, flood management needs, the capacity of SWP storage and conveyance facilities, changing weather-temperature conditions, water quality, and environmental requirements. Water deliveries are based on long-term water supply contracts that DWR has with each of the 29 contractors. The total water supply for each year is estimated based on a variety of factors including storage reservoir levels, surface water flow levels, Delta conditions, contractor delivery requests, environmental conditions, and legal considerations. **Figure 2-1** shows the State Water Project and Colorado River Aqueduct.

13 California Department of Water Resources, *The State Water Project Reliability Report 2009,* August 2010; California Department of Water Resources, *California Water Plan Update 2009, Integrated Water Management,* December 2009.

14 California Department of Water Resources, *California Water Plan Update 2009, Integrated Water Management,* December 2009.

SOURCE: ESRI 2011; State of California GIS; ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 2-1

California State Water Project and Colorado River Aqueduct

Each contractor can request water in an amount not to exceed a previously established ceiling referred to as the "Table A" amount. From 1980 to 1989, DWR was able to meet 100 percent of the contractors' Table A requests. Between 1990 and 1994, DWR had greater difficulty meeting demand because several years were very dry. Contractors received less than 50 percent of their requests in 1991 and 1992. In recent years, the SWP has been able to deliver full amounts only in wet years; during dry years, SWP deliveries can be substantially less than the full amounts requested. This has been the result of a rise in contractors' demand levels, more stringent water quality requirements, and environmental constraints. DWR's most recent reliability estimates indicate the system will have 60 percent reliability for delivering Table A requests, depending on hydrologic and environmental factors.[15] DWR currently estimates 60 percent reliability in the future. This reduced system reliability has incentivized local water providers to identify new water supply sources to make up for water they previously assumed would be supplied by the SWP per their contractual Table A amount agreements.

2.4.2 Metropolitan Water District of Southern California and the Colorado River Aqueduct

Metropolitan is a public agency that was organized in 1928 for the purpose of developing, storing, and distributing water to the residents of Southern California. The first function of Metropolitan was building the CRA to convey water from the Colorado River. Deliveries through the aqueduct began in the early 1940s and supplemented the local water supplies of the original Southern California member cities. In 1960, to meet growing water demands in its service area, Metropolitan contracted for additional water supplies from the SWP via the California Aqueduct, which is owned and operated by DWR. SWP deliveries began in 1972. Metropolitan currently receives imported water from the SWP and the Colorado River via the CRA.

Metropolitan is the primary supplier of water to approximately 19 million people in a six-county Southern California area that includes portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties. Metropolitan's 5,200-square-mile service area covers the Southern California coastal plain; it extends about 200 miles along the Pacific Ocean from the city of Oxnard on the north end to the international boundary with Mexico to the south, and it reaches as far as 70 miles inland from the coast. Metropolitan is composed of 26 member agencies, including 14 cities, 11 municipal water districts, and one county water authority. Metropolitan's member agencies serve residents in 152 cities and 89 unincorporated communities.[16]

The CRA, owned and operated by Metropolitan, has a capacity of 1,800 cubic feet per second, or 1.25 million AFY.[17] California's allotment of Colorado River water is 4.4 million AFY, plus

[15] California Department of Water Resources, *The 2009 State Water Project Delivery Reliability Report*, August 2010, Table 7.1.
[16] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-6.
[17] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page A2-13.

available surplus water.[18] Of this amount, Metropolitan's full basic entitlement is 550,000 AFY. Historically, the amount of water conveyed annually through the CRA has varied depending on wet and dry years and local demands, but has always included the basic entitlement plus additional unused or transferred water available in the system. However, as a result of increased diversions by Arizona and Nevada, Metropolitan's diversion of Colorado River water has been substantially reduced compared with historic diversions. Since 2003, Metropolitan has developed agreements with other Colorado River water rights holders to convey water through the CRA. Metropolitan approved the Quantification Settlement Agreement (QSA) in 2003 that provided for additional transfers from agricultural agencies that use Colorado River Water such as the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD) to San Diego.[19]

Table 2-1 summarizes water supplies within Metropolitan's service area since 1980. As shown in Table 2-1, the CRA has operated under its 1.25 million AFY capacity for most years and water deliveries from the Los Angeles Aqueduct to the Metropolitan service area are affected by dry year restrictions as well as reductions due to environmental restoration programs at Owens Lake.

TABLE 2-1
SOURCES OF WATER SUPPLY FOR THE METROPOLITAN SERVICE AREA (acre-feet)

Calendar Year	Local Supplies	L.A. Aqueduct	Colorado River Aqueduct	State Water Project	Total
1980	1,452,000	515,000	791,000	560,000	3,317,000
1985	1,535,000	496,000	1,018,000	728,000	3,776,000
1990	1,470,000	106,000	1,183,000	1,458,000	4,217,000
1995	1,590,000	464,000	933,000	451,000	3,438,000
2000	1,768,000	255,000	1,217,000	1,473,000	4,714,000
2005	1,590,000	369,000	685,000	1,525,000	4,168,000
2010	1,832,000	243,000	1,150,000	1,500,000	4,725,000

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan*, November 2010, page A. 2-3, Table A. 2-1.

Metropolitan's 2010 *Regional Urban Water Management Plan* (RUWMP) states that as new water banking and transfer programs are developed, water deliveries through the CRA will increase. The RUWMP identifies programs under development that could provide water in excess of the CRA's 1.25 million AFY capacity by the year 2015. However, on a year-to-year basis, actual deliveries will depend on water availability and the successful implementation of the

[18] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, page 3-4.

[19] Twelve of the QSA agreements are currently the subject of an appeal pending in the Third District Court of Appeal for which oral argument will occur on November 21, 2011. In January 2010, the Sacramento Superior Court found that one of the agreements was invalid because it violated the State constitutional debt limitation. The Superior Court also held that 11 other agreements, including the QSA agreement and various transfer agreements, were invalid because they were inextricably linked to the agreement that the Superior Court found was unconstitutional. The QSA agreements continue to be implemented while the appeal is being decided.

conceptual programs outlined in the RUWMP. The RUWMP recognizes the need to develop storage programs and groundwater management systems within the Southern California region.

2.5 Purpose of the Cadiz Valley Water Conservation, Recovery, and Storage Project

The overall purpose of the Project is to make available a reliable water supply for Southern Californian Project Participants, to supplement or replace existing supplies and enhance dry-year supply reliability. The Project serves as one of several water supply options for Project Participants as documented in their Urban Water Management Plans (UWMPs).

Both the SWP and Colorado River water supplies are experiencing reductions from historic deliveries. As a result, Southern California water providers are looking for affordable new supplies to replace or augment current supplies and enhance dry-year supply reliability. Cadiz recognizes that the groundwater beneath its Cadiz Property is confined within a closed basin that ultimately flows to two saline groundwater sinks (Bristol and Cadiz Dry Lakes) with salinity levels close to ten times greater than that of sea water. Groundwater that flows past the Cadiz Property joins with the saline groundwater where it is wasted to evaporation. The Project would optimize the reasonable and beneficial use of water within the aquifer system in a sustainable fashion—conserving water that would otherwise be wasted—to create a local water supply alternative for Southern California water providers.

Project Participants would also be able to use a flexible water delivery schedule that would make possible the delivery of water only when actually needed, such as in dry years. Water designated for delivery would be stored in what is called carry-over storage, remaining in the aquifer until the Project Participant needs it.

The second phase of the Project, being examined at the programmatic level in this EIR, would create needed water-storage space for Southern California water providers. Given the varying reliability of imported water in Southern California, the ability to store up to 1 million AF of water would greatly enhance water supply reliability. In wet years, when there is more water than is needed, water would be diverted into storage at the Imported Water Storage Component to be used in future dry years. This phase is at the concept development stage and there are no participants at this time.

CHAPTER 3
Project Description

3.1 Project Overview

This chapter is organized in the following sections:

3.1 Project Overview

3.2 Project Objectives

3.3 Groundwater Basin Overview

3.4 Project Components

- 3.4.1 Groundwater Conservation and Recovery Component
- 3.4.2 Imported Water Storage Component
- 3.4.3 Groundwater Management, Monitoring, and Mitigation Plan

3.5 Project Participants

3.6 Proposed Project Facilities

3.7 Project Construction

3.8 Required Project Approvals

3.1.1 Introduction

Cadiz Inc., in collaboration with Santa Margarita Water District and other Project Participants, has developed the Cadiz Valley Water Conservation, Recovery and Storage Project to implement a comprehensive, long-term groundwater management program for the closed groundwater basin underlying its property that would allow for both the beneficial use of some of the groundwater and storage of imported surface water in the groundwater basin. The Project would provide a new, reliable water supply source and water storage local to the Southern California region, both contributing to improved water supply reliability for the region.

Cadiz Inc. is a private corporation that owns approximately 34,000 mostly contiguous acres in the Cadiz and Fenner Valleys, which are located in the Mojave Desert portion of eastern San Bernardino County, California (see Figure 1-1). Underlying the Cadiz and Fenner Valleys and the adjacent Bristol Valley is a vast groundwater basin that holds an estimated 17 to 34 MAF of fresh groundwater.[1] The freshwater aquifers here consist of saturated alluvial materials, carbonate rocks, metamorphic rocks, and igneous rocks with a depth to groundwater consistently more than 180 feet below ground surface (bgs) and reaching over 400 feet bgs in many areas.[2] In recent

1 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.
2 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figures 2-23 and 2-16.

studies, groundwater has been found in the alluvium as well as the carbonate and crystalline rocks. In parts of the Bristol, Cadiz, and Fenner Valleys, the groundwater extends to depths of nearly 2,000 feet bgs.[3]

Within this closed basin system, groundwater percolates and migrates downward from the higher elevations in the watersheds surrounding the Project area and eventually flows to Bristol and Cadiz Dry Lakes. Figure 1-1 shows the boundaries of the surrounding Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds. These Watersheds span over 2,700 square miles, see Section 3.3.1 below. The Dry Lakes represent the low point in the closed watershed basin, meaning that all surface and groundwater within the Watersheds eventually flows down gradient to these Dry Lake areas and not beyond. Once the fresh groundwater reaches the Dry Lake areas, it evaporates, first mixing with the highly saline groundwater zone under the lake beds and getting trapped in the salt sink, no longer fresh, suitable, or available to support freshwater beneficial uses. The portion that evaporates is lost from the groundwater basin and is therefore also unable to support beneficial uses.

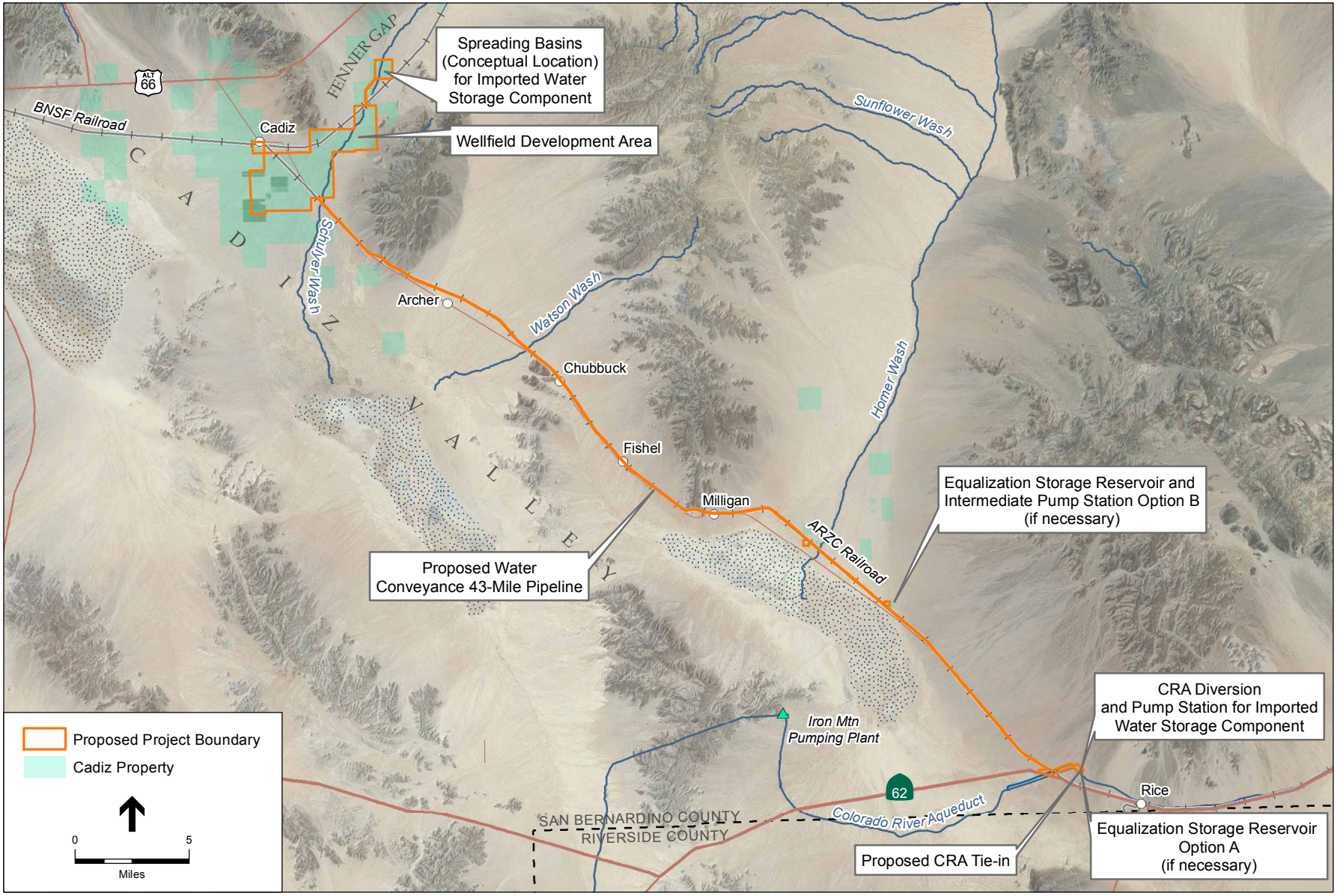
The proposed Project includes two distinct but related components:

1. Groundwater Conservation and Recovery Component
2. Imported Water Storage Component

In the Groundwater Conservation and Recovery Component, an annual average of 50,000 AF of groundwater would be pumped from the basin over a 50-year period for delivery to Project Participants (see Chapter 1, Section 1.2.3) in accordance with agreements with Cadiz Inc. and with the GMMMP. The GMMMP has been developed to guide the long-term groundwater management of the basin (for the Project). As described further in Section 3.3 below, the level of groundwater pumping proposed under the Groundwater Conservation and Recovery Component is designed specifically to extract and conserve groundwater that would otherwise migrate to the Dry Lakes, enter the brine zone, and evaporate. In addition, Project Participants could, in wet years, forego their annual groundwater delivery and instead "store" some or all of their annual share of water in the aquifer system for a future dry year. This is called carry-over storage.

The facilities proposed for this Component of the Project include a wellfield, manifold (piping) system, a 43-mile water conveyance pipeline, monitoring features, other appurtenances and fire suppression mechanisms. The wellfield and manifold (piping) system would be constructed on Cadiz Property to carry pumped groundwater to the conveyance pipeline, which would be constructed along the ARZC ROW and tie into the CRA. Water would be distributed to Project Participants via the CRA. A power conveyance system would be installed that would convey energy to the wellfield from natural gas engines or from electricity from the grid. In addition, to meet ARZC's fire suppression and operational water needs, fire hydrants would be installed along the conveyance pipeline at strategic locations along the railroad tracks (e.g., at bridge trestles). Withdrawal of water for this Project component would be limited to a maximum of 75,000 AFY of water in any given year and a total of 50,000 AFY on average over the 50-year term of the Project. These proposed Project facilities are identified in **Figure 3-1** and are described in more detail below in Section 3.6.

[3] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figure 2-16.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-1

Key Project Facilities

The Groundwater Conservation and Recovery Component is intended to be consistent with the State's constitutional requirement that all waters of the State be put to their fullest, beneficial use and not be wasted. In relevant part, Article X, Section 2 of the California Constitution states:

> "[B]ecause of the conditions prevailing in this State *the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable*, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. …" (emphasis added) (California Constitution Article X, Section 2).

The Imported Water Storage Component allows Project Participants to send surplus surface water supplies, when available, to the Project area to be recharged via spreading basins and held in storage until needed in future years. When needed, the stored surface water would be pumped out of the groundwater basin and returned to the appropriate Project Participant. The Imported Water Storage Component proposes to store up to 1 MAF, at any given time.

The facilities proposed for the Imported Water Storage Component of the Project include expansion of the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply, and distribution facilities; and a CRA diversion structure and pump station. This Project component would utilize the pipeline constructed for the Groundwater Conservation and Recovery Component to convey stored water back to any Project Participants.

As part of the Imported Water Storage Component, one or more of the unused natural gas pipelines that exist in the Project area may be converted for use as a water conveyance facility. The purpose of this would be 1) to intertie the Project system to the SWP or other potential sources of surface water supply for import and storage at the Project site and/or 2) to connect to other potential Project Participants interested in storing water at the Project area. Initial study indicates that existing natural gas pipelines in the area could be converted for use as water conveyance pipelines with a maximum capacity of 30,000 AFY.

The importation of surplus water from the CRA to the Cadiz area was evaluated in an EIR/EIS published in 2001 by the BLM and Metropolitan. The BLM certified the Final EIS and offered a right of way grant to Metropolitan in 2002. Although the program considered by the 2001 EIR/EIS was not approved by Metropolitan, extensive technical review, modeling and evaluation of impacts was undertaken concerning the storage and recovery of imported water.

Participants for the Imported Water Storage Component of the Project have not yet been identified. Withdrawal and return of groundwater upon implementation of the Imported Water Storage Component would be limited to a combined maximum of 105,000 AFY, which reflects the capacity of the 43-mile conveyance pipeline and the potential additional 30,000 AFY capacity of any converted natural gas pipelines. In accordance with *CEQA Guidelines* Sections 15161 and 15378(a), the Groundwater Conservation and Recovery Component is being analyzed at a project level in this Draft EIR. Where possible, the Imported Water Storage Component is also analyzed at a project level (i.e., select facilities that are sufficiently defined), but because participants have

not been identified and certain elements of the design are still under conceptual development, including the potential quantity and schedule for surface water import, spreading, storage, and extraction, the Imported Water Storage Component of the proposed Project is analyzed primarily at a programmatic level in this Draft EIR in accordance with *CEQA Guidelines* Section 15168. At a time when the Imported Water Storage Component is to be implemented, additional review will be conducted pursuant to Section 15168 and the technical work, studies and modeling previously undertaken will be updated to account for, among other things, proposed project parameters, newly developed information and modeling.

The Project would be operated by the FVMWC, which would be formed as a non-profit California mutual water company to deliver water at cost to its shareholders. Shareholders of FVMWC would include the Project Participants and Cadiz Inc. The full term of the Project's operation, including the first and second phases, would be limited to 50-years. In the event that circumstances beyond the control of the Project operator required additional time to complete contracted water deliveries, the Project term may be extended for a limited time under the terms of the agreements. If Project Participants elect to extend the Project for an additional term, new agreements and a new environmental analysis would be required.

3.1.2 Project Location

The facilities to be constructed for the Project would be located at the confluence of the Fenner, Orange Blossom Wash, Cadiz, and Bristol Watersheds (see Chapter 1, Figure 1-1) approximately 220 miles east of Los Angeles, 75 miles southwest of Needles, and 65 miles northeast of Twentynine Palms (see Figure 3-1). The water would be conveyed from the Project area to the service areas of the Project Participants shown on Figures 1-2 and 1-3 via the CRA.

The proposed wellfield and observation wells described in the GMMMP would be located on private property. The proposed 43-mile conveyance pipeline would be located within the ARZC ROW and extend from the wellfield on Cadiz Property southwest to the CRA. Two of the observation wells in the proposed 17-well monitoring network are proposed to be located on Cadiz Property in the Danby and Piute Valleys which lie adjacent to and east of Fenner Valley respectively; the other proposed observation wells and equipment most likely would be located at the main Project site. All Project facilities would be built on private land, with the entire pipeline and some of the wells on pre-disturbed land. Specific facility site location maps for proposed Project facilities are provided in subsequent sections. The Project location considered in this Draft EIR also includes the broader region within which the water supply provided by this Project would be used. Thus, the service areas of the water provider Project Participants are included as well as the broader service area of Metropolitan, since the Groundwater Conservation and Recovery Component still has capacity for other water providers to elect to participate.

3.2 Project Objectives

The California Constitution mandates maximizing the reasonable and beneficial use of water and the avoidance of waste. *The fundamental purpose of the Project* is to save substantial quantities of groundwater that are presently wasted and lost to evaporation by natural processes. In the absence

of this Project, approximately 3 MAF of groundwater presently held in storage between the proposed wellfield and the Dry Lakes will become saline and evaporate over the next 100 years. By strategically managing groundwater levels, the Project would conserve up to 2 million AF of this water, retrieving it from storage before it is lost to evaporation. The conservation opportunity is unique and garners special emphasis. The proposed conservation is not dependent upon future rainfall, snow pack or the needs and demands of others: the groundwater is already in storage. Moreover, the conservation and resulting water supply augmentation can be achieved independently from the environmental and regulatory conditions that generally constrain the importation of water to Southern California. The geographic isolation of the groundwater makes it non-tributary to the Colorado River system, and therefore eligible for distinctive treatment under federal regulations that may unlock additional complementary storage opportunities, both within the Basin and in Lake Mead.

The Project makes available a reliable water supply for Southern California Project Participants, to supplement or replace existing supplies and enhance dry-year supply reliability. Both the SWP and Colorado River water supplies are experiencing reductions from historic deliveries. As a result, Southern California water providers are looking for affordable new supplies to replace or augment current supplies and enhance dry-year supply reliability. The Project would optimize the reasonable and beneficial use of water within the aquifer system in a sustainable fashion—conserving water that would otherwise be wasted—to create a local water supply alternative for Southern California water providers.

The objectives for this Project are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation;
- Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought;
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;
- Enhance dry-year water supply reliability within the service areas of SMWD and other Southern California water provider Project Participants;
- Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of carry-over storage and, for Phase II, imported water storage;
- Support operational water needs of the ARZC in the Project area;
- Create additional water storage capacity in Southern California to enhance water supply reliability;
- Locate, design, and operate the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

3.3 Groundwater Basin Overview

3.3.1 Watersheds

The overall drainage basin in which the proposed Project would be constructed consists of the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds (collectively, the Watersheds) (see Figure 1-1). The Watersheds are considered one topographically-closed drainage system because all surface water and groundwater drain to the interior of the overall drainage basin. In summary, the total area of the combined Fenner (including Orange Blossom Wash), Bristol and Cadiz groundwater basin system is approximately 2,710 square miles and consists of the Fenner Watershed (1,100 square miles), the Orange Blossom Wash Watershed (160 square miles), Bristol Watershed (1,170 square miles), and the Cadiz Watershed (540 square miles).[4]

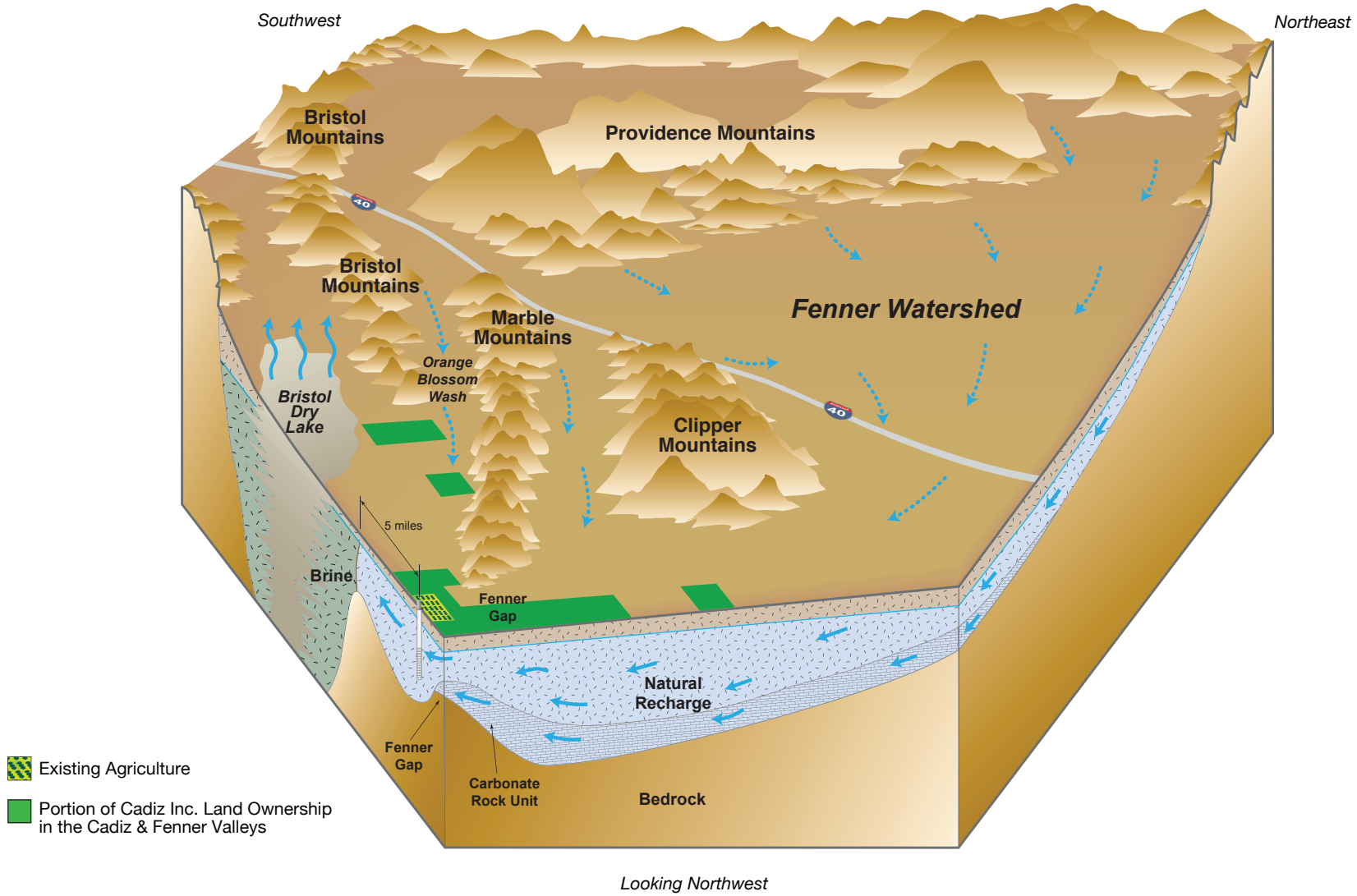
The Fenner Watershed is located in the northern portion of the Project area. Generally, the Fenner Valley slopes south to southwest toward the Fenner Gap at an elevation of about 900 feet National Geodetic Vertical Datum (NGVD). The Fenner Gap occurs at the southern end of the Fenner Watershed between the Marble and Ship Mountains. At this location, surface water drainage and groundwater flow from the Fenner Watershed and enter the Bristol and Cadiz Watersheds to the south. The Orange Blossom Wash Watershed comprises approximately 160 square miles and drains to the southeast into the Bristol Watershed. For the purposes of the proposed Project, the Orange Blossom Wash Watershed is generally assumed to be included in references to the Fenner Watershed because both watersheds provide the proposed production source and storage capacity for the Project.

Since the Watersheds are part of a closed drainage system, the only natural outlet for surface water and groundwater is through evaporation at the Bristol and Cadiz Dry Lake surfaces. These surfaces are normally dry but flash flooding from high intensity rain storms can result in standing water that can remain for weeks before evaporating.

3.3.2 Aquifer Properties

The alluvial sediments of the groundwater basin underlying the northern Bristol, Cadiz, and Fenner Valleys are underlain by igneous and metamorphic rocks, forming a rock-bounded basin overlain with sands and gravels many hundreds of feet thick. Groundwater can be found in significant quantities not only in the alluvium, but also in the caverns of the carbonate and fractures of the crystalline rock. Groundwater ranges from approximately 270 to 400 feet bgs in the northeastern portion of the Project area to 180 feet bgs in the southwest, becoming shallower with increasing proximity to the Dry Lakes. **Figure 3-2** provides a schematic cross section of the Fenner Gap and Bristol Dry Lake.

[4] GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project Phase I – Conservation Scenarios,* August 2011, page 2.



NOT TO SCALE

SOURCE: CH2M Hill, 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-2

Conceptual Surface and Groundwater Flow

Evaporation of groundwater and surface water from the Dry Lakes over the past several million years has resulted in thick deposits of salt (primarily calcium chloride and sodium chloride) and brine-saturated sediments.[5] Two surface soil samples taken from Bristol Playa show that it is high in sodium and chloride with sulfate in small quantities increasing from the playa edge.[6]

The primary sources of recharge to the aquifer system in the Project area include: 1) direct infiltration of precipitation (both rainfall and snowfall) into fractured bedrock that is exposed in mountainous terrain, and 2) infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the watershed. The source of much of the groundwater recharge occurs at higher elevations.[7]

The natural recharge in the Watersheds has been the subject of several studies since 1970. The most recent estimate, presented in 2010 by CH2M Hill, is 32,000 AFY. The 32,000AFY estimate is calculated from newly compiled data bases and publicly available data, based on the 2008 U.S. Geological Survey (USGS) INFIL3.0 model. The USGS INFIL3.0 model is a comprehensive model that computes a wide-range of daily, monthly, and annual average water-balance components for multi-year simulations.[8]

3.3.3 Groundwater Movement and Storage

In general, groundwater within the Watersheds flows down gradient in the same direction as the slope of the land surface. In the Fenner Valley, groundwater flows southward and discharges through Fenner Gap toward the Bristol and Cadiz Dry Lakes. In Orange Blossom Wash, located between the Marble and Bristol mountains, groundwater flows southeast from the Granite Mountains and then turns south into the Bristol Dry Lake.[9]

Total fresh groundwater in storage within the Watersheds is estimated to range from 17 to 34 MAF. Groundwater water levels in the Fenner Valley are found at elevations above 610 feet at the Fenner Gap, while groundwater levels at the Cadiz and Bristol Dry Lakes are as low as 545 feet in elevation. This groundwater elevation difference between the Fenner Gap and the Dry Lakes drives groundwater downslope toward the Dry Lakes. It is estimated that between 4 and 10 MAF of groundwater exists in the freshwater zone south of the Fenner Gap.[10]

3.4 Project Components

The Project would be constructed in two phases. This section first explains how each of the two Project components, Groundwater Conservation and Recovery and Imported Water Storage, would be developed and operated and then summarizes the monitoring and management program that would be implemented as a design feature of the Project.

5 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.
6 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Play, San Bernardino, California*, January 2011, page 9.
7 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.
8 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page ES 3.
9 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-9.
10 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010.

3.4.1 Groundwater Conservation and Recovery Component

Groundwater Pumping Operations

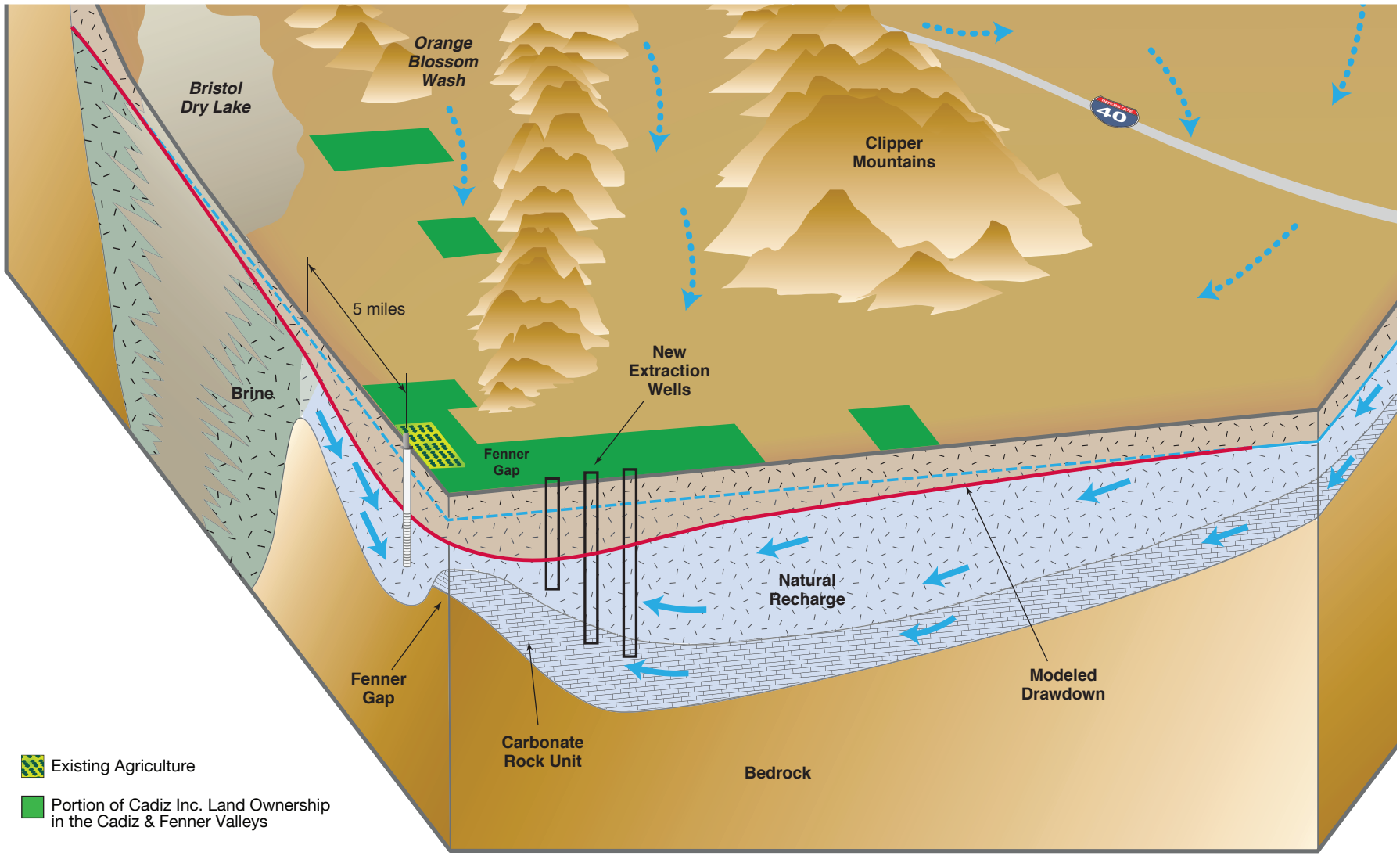
For the Groundwater Conservation and Recovery Component, a wellfield would be installed near the narrow Fenner Gap area and spread south and southwest toward Bristol Dry Lake to extract groundwater from the basin and prevent the loss to high-salinity and evaporation.

Groundwater pumping would be coordinated to lower the water table in the wellfield so that: (1) annually replenished groundwater that naturally flows through the Fenner Valley and the Orange Blossom Wash can be intercepted and conserved for use before it naturally migrates to the hyper-saline Bristol and Cadiz Dry Lakes; and (2) groundwater in storage south of the proposed wellfield and presently migrating towards Bristol and Cadiz Dry Lakes can be retrieved and conserved for beneficial use.

Groundwater modeling and associated studies completed to develop the proposed Project operations determined that in order to (1) intercept groundwater that is upstream of the wellfield before it flows down past the wellfield to the Dry Lakes and (2) to pull back and recover the fresh groundwater that is already down gradient of the proposed wellfield and on its way to the Dry Lakes area, sufficient groundwater pumping in excess of the natural recharge rate must be implemented. This pumping would lower the groundwater levels at the wellfield to create a pumping depression, referred to as a cone of depression, and establish hydraulic control of the local groundwater flow. The modeling evaluated the extent of retrieval and conservation that would occur from the fresh water zone. **Figure 3-3a** illustrates the drawdown effect of the proposed wellfield showing how lowering the groundwater table enough at the wellfield would induce some of the groundwater to flow towards the wells rather than continue its down gradientmigration to the salt sink under the Dry Lakes and eventual evaporation. **Figure 3-3b** provides a schematic view of the relationship of pumping over time and evaporation off the Dry Lakes. As illustrated in Figure 3-3b, the planned strategic groundwater pumping of 50,000 AFY on average and lowering of the groundwater table in the targeted area near the Fenner Gap, establishes hydraulic control of the groundwater flow and allows the conservation of groundwater that without such control would continue to migrate to the Dry Lakes. This would potentially conserve 1.36 MAF of groundwater that otherwise would have evaporated over the 50-year operational period of the Project. This amount increases to 2 MAF after 100 years, since evaporation would increase slowly over time as groundwater levels recover once pumping stops.[11]

In addition to identifying the existence of a substantial conservation opportunity, the modeling work suggests a strong correlation between the quantity of groundwater pumped in the earlier years and the ability to efficiently retrieve groundwater from evaporation. Over the Project's 50-year operational period, greater pumping rates in excess of natural recharge are expected to generally result in higher conservation benefits.

[11] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010.



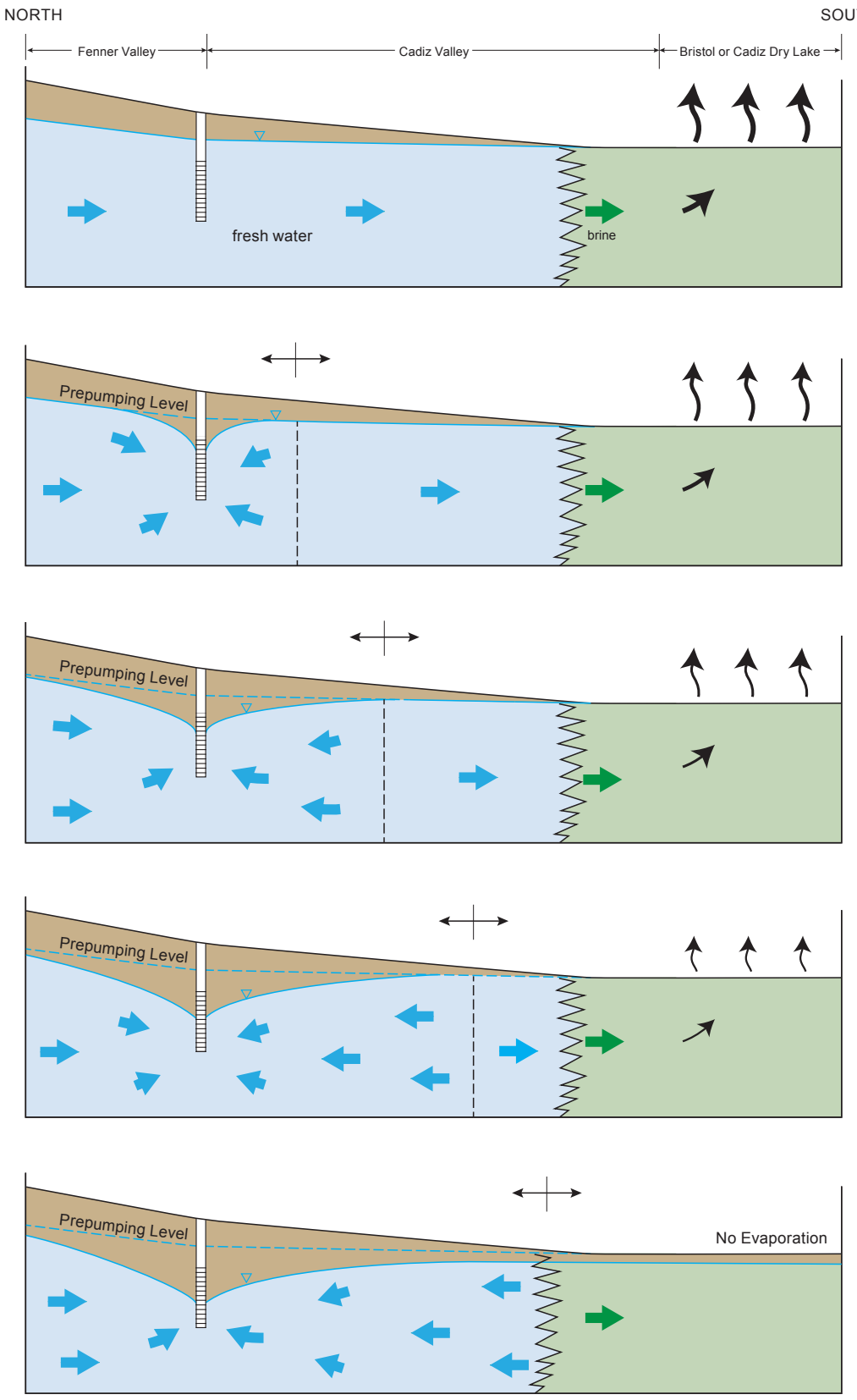
NOT TO SCALE

SOURCE: CH2M Hill, 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-3a

Conceptual Surface and Groundwater Flow with Project after 50 Years



Time 0
No pumping. Groundwater flows equal to rate of natural recharge (southeast) toward the dry lake and evaporates.

Time 1
Pumping begins. Groundwater near well is captured, but most groundwater downgradient (southeast) of well continues to flow toward the dry lake and evaporates.

Time 2
Pumping continues. Groundwater is captured further from the well, but a significant volume of groundwater downgradient (southeast) of the well continues to flow toward the dry lake and evaporates.

Time 3
Pumping continues. Most groundwater is captured and now only a small volume of groundwater downgradient (southeast) of the well flows toward the dry lake and evaporates.

Time 4
Pumping continues. All groundwater is now captured downgradient (southeast) of the well and no groundwater flows toward the dry lake or evaporates. Some of the brine near the dry lake moves slightly toward the pumping well.

SOURCE: CH2M HILL, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-3b
Conceptual Cross Section Showing Groundwater Flow and Evaporation

Modeling suggests that the most effective method of operating for the single purpose of groundwater retrieval is to maximize groundwater pumping in the first years of Project operation and to curtail extractions in the last years, resulting in a 50-year average of 50,000AFY. There is an estimated 4 to 10 MAF of groundwater in the area south and downgradient of the Fenner Gap that is moving towards the Dry Lakes. The greater the pumping in excess of natural recharge, the more effective and successful the retrieval and conservation of this stored groundwater.

Proposed groundwater pumping for the 50-year operational period for the Project would recover a fraction of the 17-34 MAF presently in storage to create the lowered water table and would enable the interception of the natural recharge and the retrieval of groundwater from that portion of groundwater in storage south of the wellfield (4-10 MAF) conserving it for beneficial use.

Establishing hydraulic control of the groundwater at the wellfield allows Project Participants flexibility in determining the actual annual quantity of groundwater that they would remove from the Project in any year. If they do not need their full contracted allotment in a given year, it can remain in groundwater storage (carry-over storage) south of the Fenner Gap protected through the hydraulic control mechanism from being lost to the Dry Lakes and evaporation. This emulates groundwater management practices in many basins in Southern California and would give Project Participants some operating flexibility by allowing them to maximize conjunctive use of Project water with other supplies in their portfolios, further improving the management and reliability of their water supply.

Under the Groundwater Conservation and Recovery Component of the Project, groundwater from the Project, which is non-tributary to the Colorado River, would be introduced into the CRA as "new" water. For potential participants who have contracts with the Bureau of Reclamation for Colorado River water, this creates the opportunity for establishing Intentionally Created Surplus

Credits on that system. This opportunity could allow a participant to further leverage its water supplies and improve supply reliability. Such a request would require compliance with a separate administrative process.

Annual Pumping Scenarios

The annual average groundwater pumping under the Groundwater Conservation and Recovery Component of the Project over the 50-year operating period would be 50,000 AFY. Actual total pumping in a given year would vary depending on Project Participant supply needs and may range from 25,000 AFY up to 75,000 AFY in any one year. In certain wet years, Project Participants may opt to decrease or forego their contracted annual groundwater deliveries and instead store their water in the aquifer system at the Project site. This stored water, or "carry-over water," could then be conveyed in a future dry-year as a supplement to the contracted annual supply. As previously stated, the Project would be limited to a maximum of 75,000 AFY in any given year and a long-term annual average of 50,000 AFY over the 50-year term of the Project. Pumping would be conducted over a period of 10 months each year.

Relationship of Groundwater Operations for the Groundwater Conservation and Recovery Component and the Imported Water Storage Component

One of the benefits of the Groundwater Conservation and Recovery Component is that it would prepare the groundwater basin to safely and efficiently store imported water. Lowering the water table to retrieve and intercept groundwater as part of the Groundwater Conservation and Recovery Component would allow for the subsequent storage and retention of imported surface water in the groundwater basin for the second phase of the Project. Thus, the Project promotes the fullest beneficial use of water, as mandated by the California Constitution, in three ways: (1) conservation and recovery of approximately 50,000 AFY of groundwater supply, (2) avoidance of loss of water to salinity and evaporation, and (3) the resultant creation of space in the groundwater basin to store imported water that can be held behind the hydraulic control to minimize loss and evaporation.

This approach is greatly preferred to a strategy of implementing the Imported Water Storage Component alone, for the following reasons. First, there is already a natural gradient driving groundwater toward the Dry Lakes. Without the initial dewatering, storing additional water in the groundwater basin would increase this downslope pressure (by mounding) toward the Dry Lakes, accelerating the potential loss of groundwater which would operate at cross-purposes with the conservation objective. Second, implementation of the Imported Water Storage Component once groundwater levels have been drawn down and after a hydraulic gradient can be established would also allow Project Participants the opportunity to put conserved water from Phase 1 to beneficial use. Third, this approach avoids the practical concern of finding a short-term beneficial use for vast quantities of groundwater simultaneous with the initiation of recharge activity that aims to put imported water in the ground.

Role of the Fenner Valley Mutual Water Company

The FVMWC would operate the Project and implement the GMMMP. The FVMWC would be formed as a non-profit California mutual water company to deliver water at cost to its shareholders, which would be comprised of the participating water providers, Cadiz Inc., and the ARZC. Mutual water companies are unregulated, non-profit, private corporations organized for the purpose of acquiring water rights and distributing water to shareholders (*Consolidated People's Ditch Co. v. Foothill Ditch Co*. [1928] 205 Cal. 54, 63). They are administered by a board of directors and incorporated pursuant to the California Corporations Code, Sections 14300 et seq. Mutual water companies are allowed to provide water to a limited set of non-shareholders, such as schools and public agencies, but if they offer water service to the public at large, then they become regulated public utilities (see California Public Utilities Code § 2705). While the CPUC regulates privately owned and operated for-profit water services that provide water to the public, they do not regulate non-profit mutual water companies.

3.4.2 Imported Water Storage Component

The Imported Water Storage Component of the Project would allow for storage of imported surface water from the Colorado River or the State Water Project in the aquifer system at the

Project area. When water is available by direct delivery or exchange, such as surplus water in wet years, a Project Participant could convey water from the CRA to the Project site via the water conveyance pipeline that would be constructed under the first phase of the Project. This water would be recharged into the aquifer system via proposed spreading basins that would be constructed on Cadiz Property. A pump station would be constructed to convey the water from the CRA to the spreading basins. Existing unused natural gas pipelines in the Project area may also be converted for water conveyance and employed to deliver water from the State Water Project system to the Project spreading basins.

The Project participants for the second phase of the Project may include Colorado River rights holders located in Southern California and potentially providers with rights to water from the State Water Project. Whether the imported water comes from the Colorado River or the State Water Project, when needed, previously stored surface water would be withdrawn from storage, conveyed to the CRA and delivered through the CRA delivery system to Project participants. Existing unused natural gas pipelines that traverse the Cadiz Property converted for water conveyance also could be used to convey water to Project Participants.

Provided that groundwater extractions proceed as planned in the first phase of the Project with an annual average of 50,000 AFY, then the aquifer system could ultimately accommodate 1 MAF of imported water without unreasonable mounding. There is an existing natural downward gradient between the proposed wellfield and the Dry Lakes that causes groundwater to flow downward to the west and south to the Dry Lakes, where it evaporates. Without the benefit of the drawdown in the proposed wellfield and the resulting hydraulic control, the Storage and Recovery phase would face the challenge of incurring substantial losses.

Based on the available storage capacity in the Fenner Valley, withdrawal of groundwater stored in the aquifer, should the Imported Water Storage Project Component be implemented, would be limited to a combined maximum of 105,000 AFY as compared to the 150,000 AFY that was evaluated previously in 2001 by Metropolitan. This reflects the capacity of the 43-mile conveyance pipeline to the CRA and, potentially, an additional 30,000 AFY that could be conveyed through a converted natural-gas pipeline. The wellfield would be expanded so that a total of 105,000 AFY of imported water could be returned to the CRA and, potentially, the SWP.

The Imported Water Storage Component could also provide storage opportunities with in-lieu arrangements between FVMWC, Metropolitan and the Project Participants. Water could be delivered through the CRA to Project Participants in lieu of extracting groundwater from the basin. Although the storage and recovery of water imported from the CRA was reviewed at a project level in the 2002 EIR/EIS, the Imported Water Storage Component is still under conceptual development. Because the sources of the imported water, the possibility of banking both Colorado River and other water, and the potential quantity and schedule for spreading, storage, and extraction are all unknown, the Imported Water Storage Component will be analyzed at a programmatic level in this Draft EIR, pursuant to *CEQA Guidelines* § 15168 (14 California Code of Regulations § 15168). Further environmental review will be conducted as appropriate and required under CEQA when specific Project participants are identified and express an interest in accessing the basin storage. For example, additional information regarding the specific location

and design of the proposed wellfield expansion will be necessary to fully evaluate groundwater quality impacts associated with the Imported Water Storage Component.

3.4.3 Groundwater Management, Monitoring, and Mitigation

Overview

The GMMMP establishes a monitoring protocol and oversight authority to ensure that operation of the Project is managed effectively to optimize beneficial uses and avoid adverse impacts for the life of the Project. The FVMWC would implement the GMMMP, including installation of observation features and data collection, as an integral part of the Project. It is attached to this Draft EIR as Appendix B1.

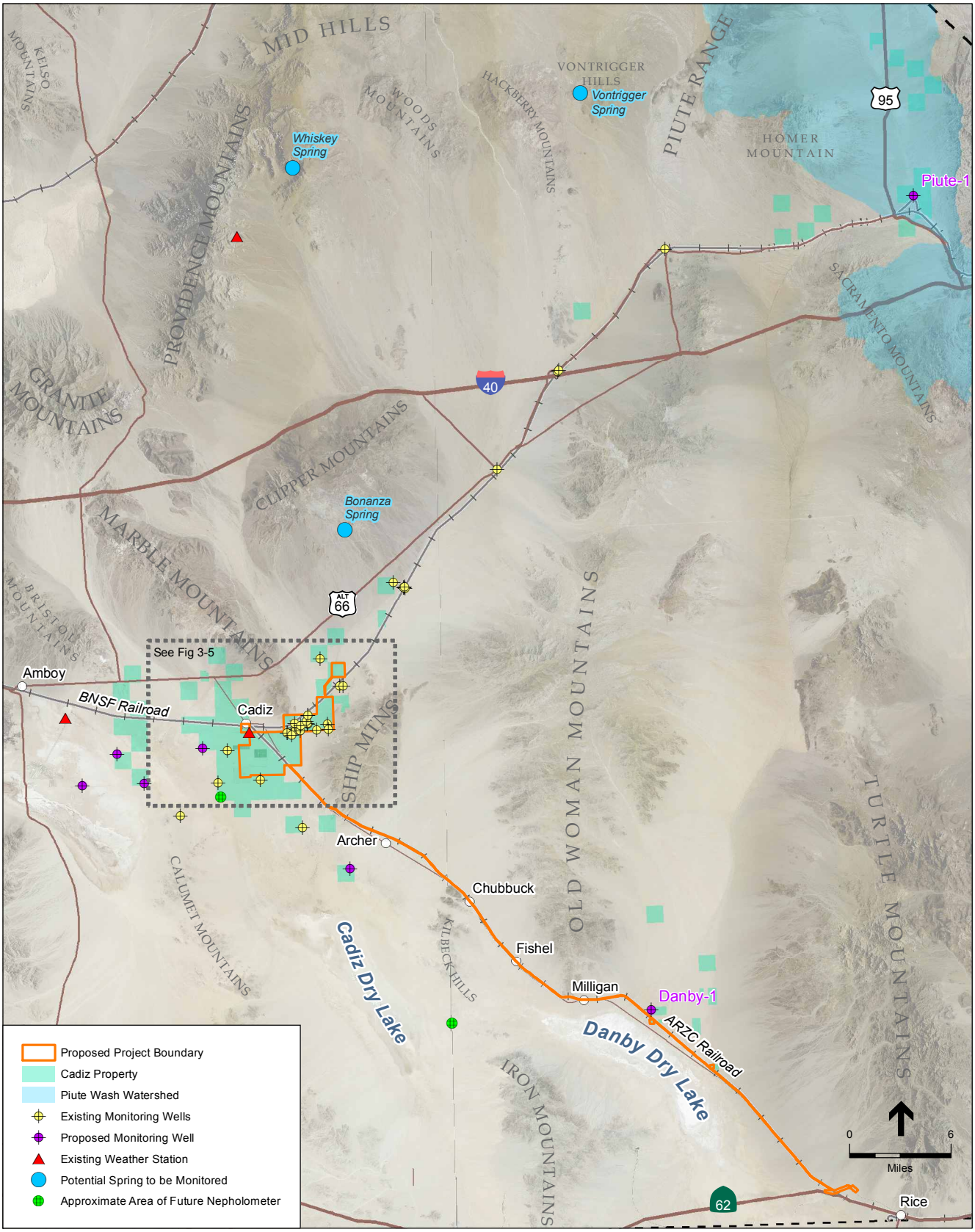
The GMMMP includes a detailed monitoring and mitigation response program for the first phase of the Project, the Groundwater Conservation and Recovery Component. When the Imported Water Storage Component of the Project is developed and ready for project-level environmental review, the GMMMP would be updated to incorporate a detailed monitoring and response program for that phase of the Project, as appropriate.

The GMMMP evaluated Project operations with respect to critical resources that include the following:

- Groundwater aquifer system (including groundwater quality, subsidence, and existing users)
- Natural springs in the watershed
- Brine resources
- Air Quality
- Adjacent watersheds

In order to monitor potential effects to these critical resources, the GMMMP integrates the use of monitoring equipment in the field, routine visual inspection, and the ongoing use of the groundwater model to track Project operations. The monitoring program would make use of a network of observation wells (both existing and new) to monitor both groundwater levels and water quality; a series of land survey benchmarks and extensometers to evaluate land subsidence; and nephelometers to assess airborne dust. These monitoring facilities and activities are described below. **Figures 3-4 and 3-5** show the locations of the monitoring facilities (wells, extensometers, and nephelometer stations).

For each critical resource, the GMMMP establishes specific action criteria (trigger levels) and corrective measures, to be implemented if necessary, to address potential adverse impacts resulting from the Project. The GMMMP establishes a defined protocol for scientific review and decision-making processes. All data collected by the GMMMP would be in the public record available for public review. A Technical Review Panel (TRP) would be established to review data reports and propose management refinements to the Lead Agency over the life of the Project.

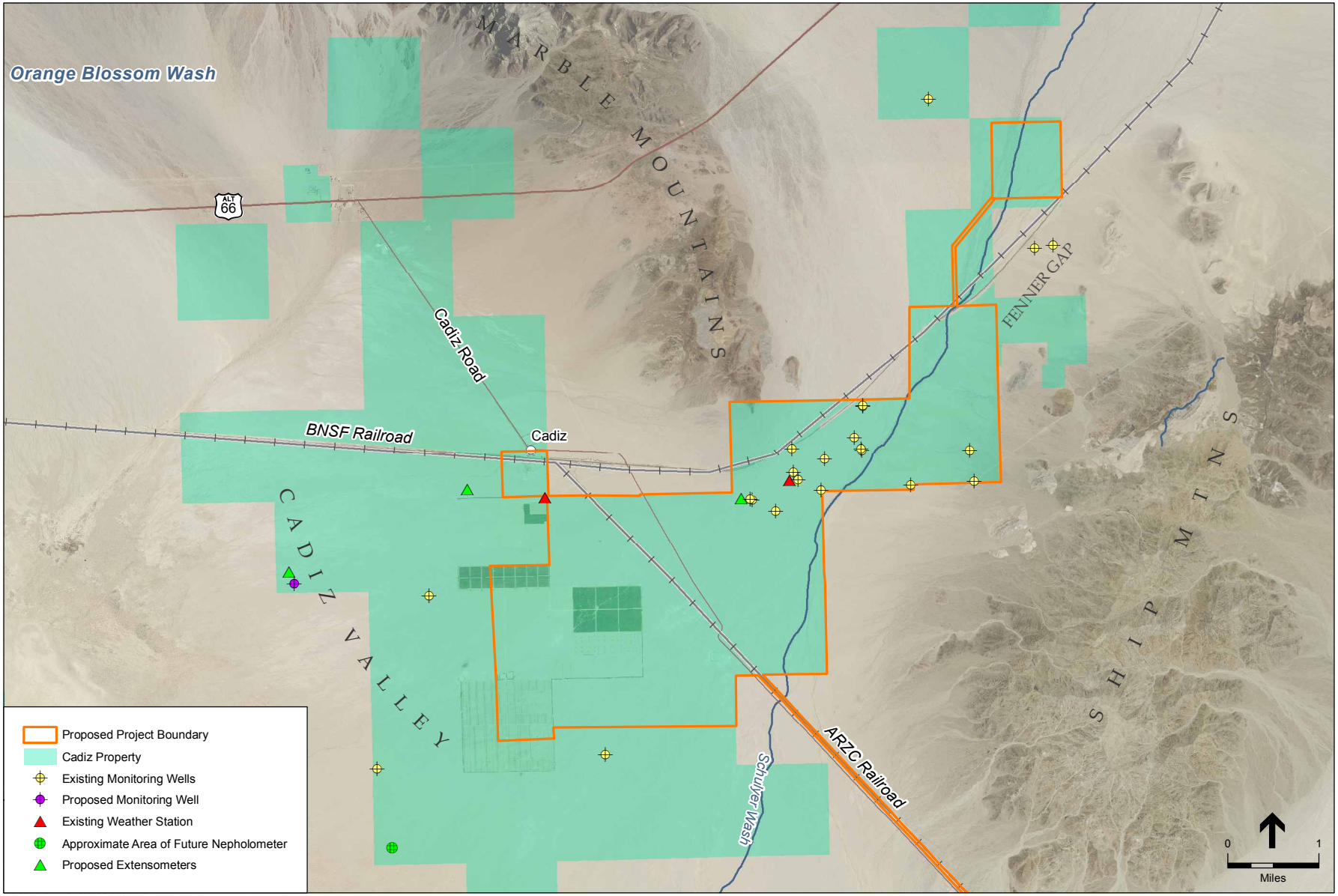


SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-4

Regional Monitoring Facilities (Wells, Nephelometer Station)



SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-5

Monitoring Facilities
(Wells, Extensometers, Nephelometer Station)

Groundwater Monitoring – Water Levels and Water Quality

A total of approximately 15 existing observation wells would be used to monitor groundwater levels and water quality during Project operations. Two additional observation wells would be installed outside the Project area, one in the Piute Wash Watershed tributary to the Colorado River, and one in the Danby Watershed to the southeast of the wellfield. In addition, four observation well clusters would be installed consisting of 2-3 wells each: one within the wellfield using existing wells, one between the wellfield and Bristol Dry Lake, one on Bristol Dry Lake, and one at Cadiz Dry Lake. Each well cluster would be installed on private land.

Springs Monitoring

The monitoring program includes quarterly inspection of select springs throughout the Project operation period. Proposed monitoring consists of visual observation and flow estimates to be performed at the Bonanza Spring in the Clipper Mountains, the Whisky Springs in the Providence Mountains (near Colton Hills), and Vontrigger Spring in the Vontrigger Hills, east of the Hackberry Mountains.

Land Subsidence Monitoring

A network of approximately 22 land survey benchmarks would be installed at the approximate locations shown on Figure 3-4 to monitor changes in land surface elevation. Each benchmark would be established and surveyed by a California licensed land surveyor. Benchmark surveys would be conducted on an annual basis during the term of the Project. To monitor the effects of Project operations, three extensometers would be installed in the area of the highest potential for subsidence (see Figure 3-5). These extensometers would measure non-recoverable compaction of fine-grained materials interbedded within the alluvial aquifer systems.

Dust Monitoring

One nephelometer would be installed downwind of Bristol Dry Lake and one would be installed downwind of Cadiz Dry Lake to measure visibility. In addition, the GMMMP would record annual observations of surface soils on the Dry Lakes to verify that no changes in soil characteristics have occurred.

3.5 Project Participants

3.5.1 Groundwater Conservation and Recovery Component

Project Participants

As of the publication date of this Draft EIR, Project Participants include SMWD, Three Valleys Municipal Water District, Golden State Water Company, Suburban Water Systems, Jurupa Community Services District, and California Water Service Company, which cover some or all of the following five counties: San Bernardino, Riverside, Orange, Ventura, and Los Angeles (see Figures 1-2 and 1-3). These Project Participants are “public water systems” which is defined as a system for the provision of water for human consumption through pipes or other constructed

conveyance that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.[12]

The ARZC is also a Project Participant. The Project would serve railroad water demands along the ROW including fire suppression and would also provide ARZC access to certain facilities, including the road along the pipeline that will be constructed as part of the Project. The Project will also serve as additional railroad purposes that have been identified by ARZC but which would be the subject of additional and subsequent environmental review.[13] These Project Participants are described in Chapter 1, Introduction. They are briefly identified below.

Santa Margarita Water District Service Area

The SMWD service area encompasses 97 square miles at the southern end of Orange County, California and includes Rancho Santa Margarita, Coto de Caza, Las Flores, Ladera Ranch, Talega, and portions of Mission Viejo (see Figure 1-2).

Three Valleys Municipal Water District Service Area

The area served by Three Valleys covers 133.3 square miles in Los Angeles County, California, and includes Azusa, City of Industry, Covina, Claremont, Diamond Bar, Glendora, Hacienda Heights, La Puente, La Verne, Pomona, Rowland Heights, San Dimas, Walnut, and West Covina (see Figure 1-2).

Golden State Water Company Service Area

Golden State's operations are organized into three water service regions and one electric customer service region, representing 21 customer service areas in 75 communities within 10 California counties. Region I consists of 7 customer service areas in northern and central California and Ventura Counties; Region II consists of 4 customer service areas located in Los Angeles and Orange Counties; and Region III consists of 10 customer service areas in eastern Los Angeles County and in Orange, San Bernardino, and Imperial Counties (see Figure 1-3). Golden State would utilize conserved Project water to serve 17 customer service areas primarily in Regions II and III but including one (Simi Valley) in Region I.

Suburban Water Systems Service Area

Suburban serves an approximately 42-square-mile area that covers all or portions of Glendora, Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, Buena Park, and unincorporated portions of California's Los Angeles and Orange Counties. The service area is divided into two regions which are 3 miles apart and separated by the La Puente Hills (see Figure 1-2).

Jurupa Community Services District Service Area

JCSD is a public agency responsible for providing water, sewer, and street lights to over 101,000 people located throughout 48 square miles in the Jurupa area of Riverside County. JCSD serves

[12] California Health and Safety Code, §116275(h).
[13] The total quantity of groundwater pumped for all users for all purposes will not exceed 50,000 AFY.

unincorporated areas of Riverside County as well as the communities of Jurupa Valley and Eastvale (see Figure 1-2).

California Water Service Company Service Area

Cal Water distributes and sells water to 1.7 million Californians through 435,000 connections. Its 24 separate water systems serve 63 communities from Chico in Southern California to the Palos Verdes Peninsula in Southern California. Cal Water would utilize conserved Project water to serve one of its water systems, the Westlake District, which is an 8,200 acre community located in the eastern section of Ventura County within the City of Thousand Oaks (see Figure 1-2), and may also use Project water to serve its Dominguez and East Los Angeles Districts.

Arizona & California Railroad Company

The Arizona & California Railroad Company operates the ARZC, a 259-mile short line railroad. The ARZC begins at an interchange with the BNSF in Cadiz, California and continues southeast across the Mojave Desert.

Project Water Subscriptions

Table 3-1 lists the Project Participants and their contracted water subscriptions. SMWD is the CEQA Lead Agency, and was the first Project Participant to enter into an Option Agreement for water supply, carry-over storage, and sharing CEQA costs with Cadiz Inc. The other water provider Project Participants have entered into similar Option Agreements for water supply, carry-over storage, and sharing CEQA costs with Cadiz Inc.

TABLE 3-1
PROJECT WATER SUBSCRIPTIONS FOR
THE GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Project Participants	Contracted Annual Amount (AF)
Santa Margarita Water District	5,000 – 15,000[a]
Three Valleys Municipal Water District	5,000
Golden State Water Company	5,000
Suburban Water Systems	5,000
Jurupa Community Services District	5,000
California Water Service Company	5,000
ARZC rail operations support supply	10 – 100
Total Annual Project Water Subscribed	**30,100 – 40,100**
Project Supply Available for Subscription	**9,900 – 19,900**
TOTAL PROJECT SUPPLY	**50,000**

a SMWD has an option to take an additional 10,000 AFY for a total of up to 15,000 AFY. If SMWD exercises this option then the total Project water subscribed out of the 50,000 AFY available would be 40,100 AFY and the total remaining supply available for additional participants would be 9,900 AFY.
b. ARZC has reserved rights to conserved water from Project for identified railroad purposes that may require additional environmental review. However, the total quantity of groundwater pumped for all uses for all purposes will not exceed 50,000 AFY.

SOURCE: ESA, 2011.

Upon completion of the environmental review and permitting process, each water agency would have the right to acquire 5,000 AFY at a pre-determined formula competitive with their incremental cost of new water. SMWD also has the added option to purchase an additional 10,000 AFY. Additional Project Participants may join the Project at any time until the established Project capacity is reached. In addition, ARZC has requested up to 10,000 gallons per day in Project water supply to support its current and future operations.

3.5.2 Imported Water Storage Component

The participants for the Imported Water Storage Component of the Project have not yet been identified. Given the strategic location of the Project and the proposed interties with the CRA system and possibly the SWP system, potential participants might be located throughout the broad southern California region or beyond. For purposes of providing programmatic-level review of this future component of the Project, it is assumed that participants in the Imported Water Storage component would be located in Southern California within Metropolitan's service area. Once specific participants are identified and specific operations for the Imported Water Storage Component are developed, additional project-level environmental review, documentation, and permitting will be completed as appropriate.

3.6 Proposed Project Facilities

Under the Groundwater Conservation and Recovery Component of the proposed Project, Cadiz would construct a wellfield and manifold system (including connecting piping and natural gas supply), an approximately 43-mile underground water conveyance pipeline between Cadiz Property and the CRA, and a tie-in to the CRA. In addition, an observation well system would be installed throughout the Bristol, Cadiz, and Fenner Valley Watersheds with additional observation wells located in the adjacent Danby and Piute Wash Watersheds. The Project would be constructed under a design-build type of contract where one contractor would be retained to design and construct the facilities.

The proposed Project would utilize approximately 150 acres of Cadiz Property in the Cadiz and Fenner Valleys to construct the wellfield and related facilities, approximately 450 linear acres of pre-disturbed land within the ARZC ROW to build the conveyance pipeline as well as approximately 300 acres of Cadiz Property near Danby Dry Lake for construction staging areas. In comparison with Cadiz Inc.'s total land position at the Project area of 25,000 acres, the total land disturbance of the Groundwater Conservation and Recovery Component's proposed facilities would be less than 2 percent.

The Imported Water Storage Component would utilize the facilities of the Groundwater Conservation and Recovery Component and also require the expansion of the Project wellfield, construction of spreading basins to the northeast of the Project wellfield, and construction of a CRA diversion and pump station at the CRA. In addition, if determined feasible, an existing unused natural gas pipeline would be converted for the conveyance of water between the Project and the SWP. Such a line would likely run northwest from the Cadiz Property to Kern County. Facilities are described in more detail below.

3.6.1 Groundwater Conservation and Recovery Component

Facilities associated with the Groundwater Conservation and Recovery Component include the following:

- Wellfield with approximately 34 wells.
- Interconnecting access road with underground utilities and manifold system.
- Power distribution system.
- 43-mile water conveyance pipeline.
- Tie-in to the CRA.
- Equalization storage reservoir and pump station near CRA (if necessary).
- ARZC rail operations' support, supply, and access.

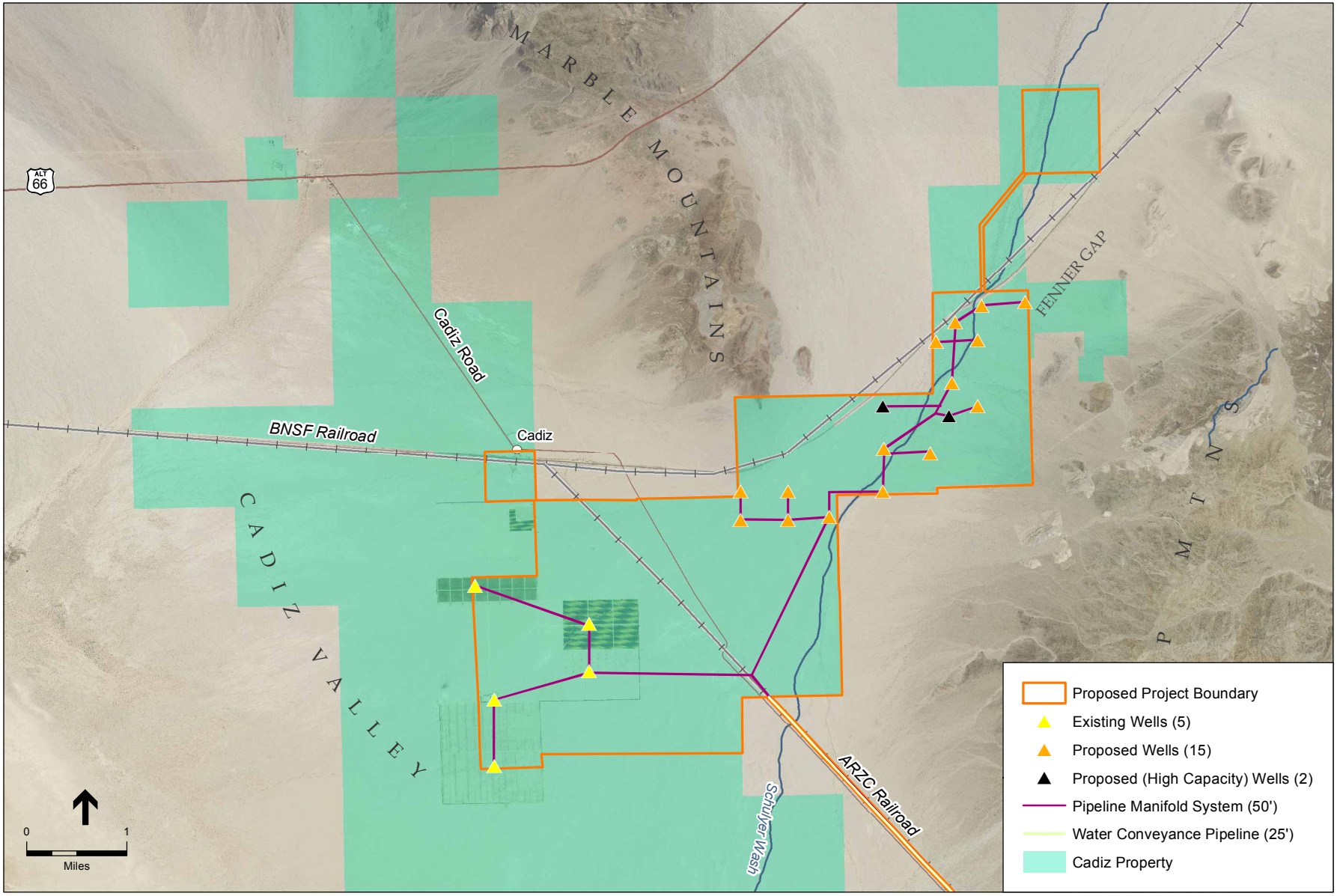
Project Wellfield

Under the Groundwater Conservation and Recovery Component, extraction wells would be constructed on Cadiz Property in the vicinity of the Fenner Gap to draw an average of 50,000 AFY from the groundwater basin, over the 50-year term of the Project, and place this water into a pipeline for conveyance to the CRA (see Figure 3-1). This Draft EIR assumes that the wellfield constructed under the Groundwater Conservation and Recovery Component would consist of approximately 34 wells, because 34 wells would be required to provide Project deliveries over the anticipated 10-month delivery schedule. Although the actual number of wells constructed under this phase of the Project is likely to be far fewer (i.e., 22 wells, including 2 high capacity wells[14]), depending on the yield of each well and the target annual maximum yield (see Section 3.5, Operations Plan), this Draft EIR evaluates two wellfield configurations (A and B), which ensures that all potential Project elements are evaluated at a project-level.

Figure 3-6a represents wellfield Configuration A and **Figure 3-6b** represents wellfield Configuration B. Both figures conceptually depict the proposed wellfield and manifold system, which would include extraction wells, pumps and electric motors, a natural gas or electricity supply system, individual well piping and control valves, collector piping, Supervisory Control and Data Acquisition (SCADA) system, and appurtenant facilities. The total wellfield disturbance area needed to install the wells and interconnecting manifold systems would be approximately 120 acres.

As shown in Figure 3-6a and 3-6b, the Project wellfield would incorporate into the manifold system five existing agricultural irrigation wells that would be upgraded to meet Project requirements, including conversion from the use of diesel engines to natural gas and/or solar powered engines. Power lines would either be underground or overhead, connecting to each well head following the access road network. Please note that the piping diagrams depicted in Figure 3-6a and 3-6b are conceptual; the final well locations and piping design for the Groundwater Conservation and Recovery Component wellfield is subject to change as Project design details are finalized, but such changes, if any, are not expected to affect analysis of impacts of the piping.

[14] High capacity wells yield 15,000 AFY compared to 2,250 AFY for other wells.

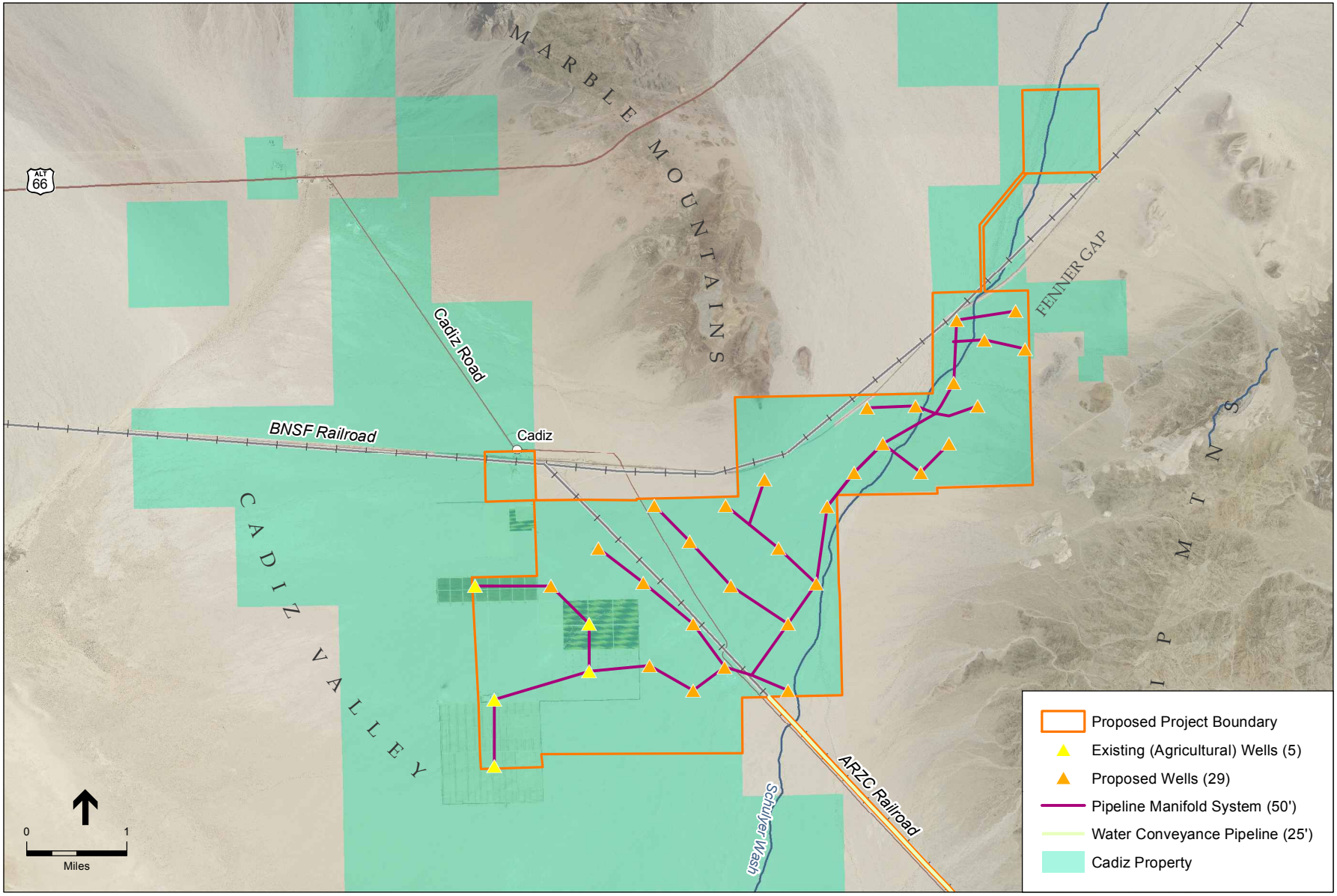


SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-6a

Proposed Wellfield and Manifold System:
Groundwater Conservation and Recovery Component
Wellfield Configuration A



SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-6b

Proposed Wellfield and Manifold System:
Groundwater Conservation and Recovery Component
Wellfield Configuration B

A typical well schematic is shown in **Figure 3-7**. Each new well would have an approximately 16 to 20-inch diameter casing and a design capacity of approximately 4.5 cubic feet per second (cfs) per well for a nominal wellfield design capacity of 100 to 125 cfs. Several high capacity wells, up to 30 cfs would be installed in the highly productive carbonate aquifers in the Fenner Gap.[15] The wells would be drilled to depths of approximately 1,000 feet bgs. There would be an electric motor installed at each well that would use between 350 and 500 horsepower (hp). Well pumps are assumed to operate 24 hours a day, 365 days a year.

Each well would be situated within a fenced wellpad area encompassing up to 1,000 square feet. The wellpads would be connected by service roads approximately 25 feet in width. Connecting utilities including electric, gas, data cables, and the water manifold system would be buried underground within the roadway easements. Wellpads may be equipped with lighting that would not be used except during infrequent nighttime maintenance activities. An electric control system would monitor pump discharge flow allowing for coordinated staging of pumps based on pumped flow and drawdown.

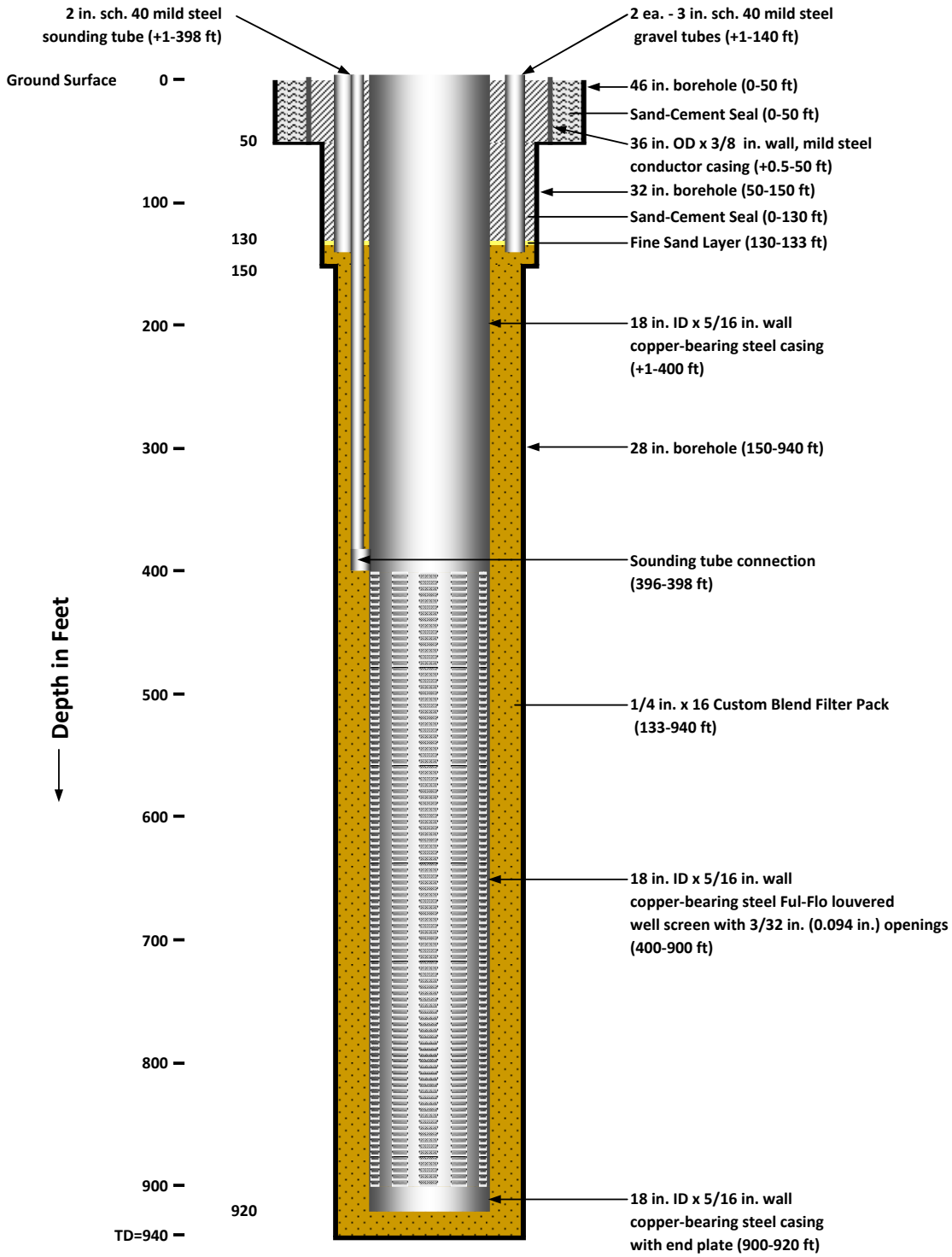
Water Conveyance Facility to Colorado River Aqueduct

Under the Groundwater Conservation and Recovery Component, an approximately 43-mile-long underground water conveyance pipeline would be constructed to deliver water extracted from the Project wellfield to the CRA for delivery to Project Participants through the existing CRA delivery system. The water conveyance pipeline would be constructed entirely within (and parallel to) the privately-owned ARZC ROW that runs north-south between the Cadiz Property and the CRA (see Figure 3-1). In 2008, Cadiz Inc. acquired a 99-year lease with the ARZC, that allows a conveyance pipeline and related facilities to be constructed and buried beside the railroad tracks within the segment of the railroad ROW that runs between mile post 189.0 at Cadiz, California and mile post 144.0 at Freda, California.[16] The ARZC ROW is 200 feet wide (approximately 100 feet on either side of the track centerline).[17] Appendix C includes a map book of the proposed pipeline alignment from the wellfield to the CRA.

From the connection point at the CRA, the proposed pipeline would extend approximately 43 linear miles from the CRA to a location where the ARZC ROW intersects the Cadiz Property within Section 36 Township 5N, Range 14E (see Figure 3-1), at which point the pipeline alignment would join with the wellfield manifold system described above. The pipeline would be constructed parallel to and predominantly southwest of the railroad tracks. A typical pipeline section and trench is shown in **Figure 3-8.**

The water conveyance facility would consist of a single barrel, pressurized pipeline with nominal design flow of up to 250 cfs, which would provide capacity to allow for implementation of the Imported Water Storage Component. This Draft EIR assumes that the pipe diameter would be 84 inches, although the pipe diameter could be anywhere between 54 and 84 inches, depending

[15] Scenario I (Wellfield A) includes two high capacity wells; Scenario 2 (Wellfield B) does not include high capacity wells.
[16] Longitudinal Lease Agreement between ARZC and Cadiz, September 17, 2008.
[17] Tetra Technologies, *Draft Preliminary Study: ARZC Railroad Alignment*, 2008, page 1.

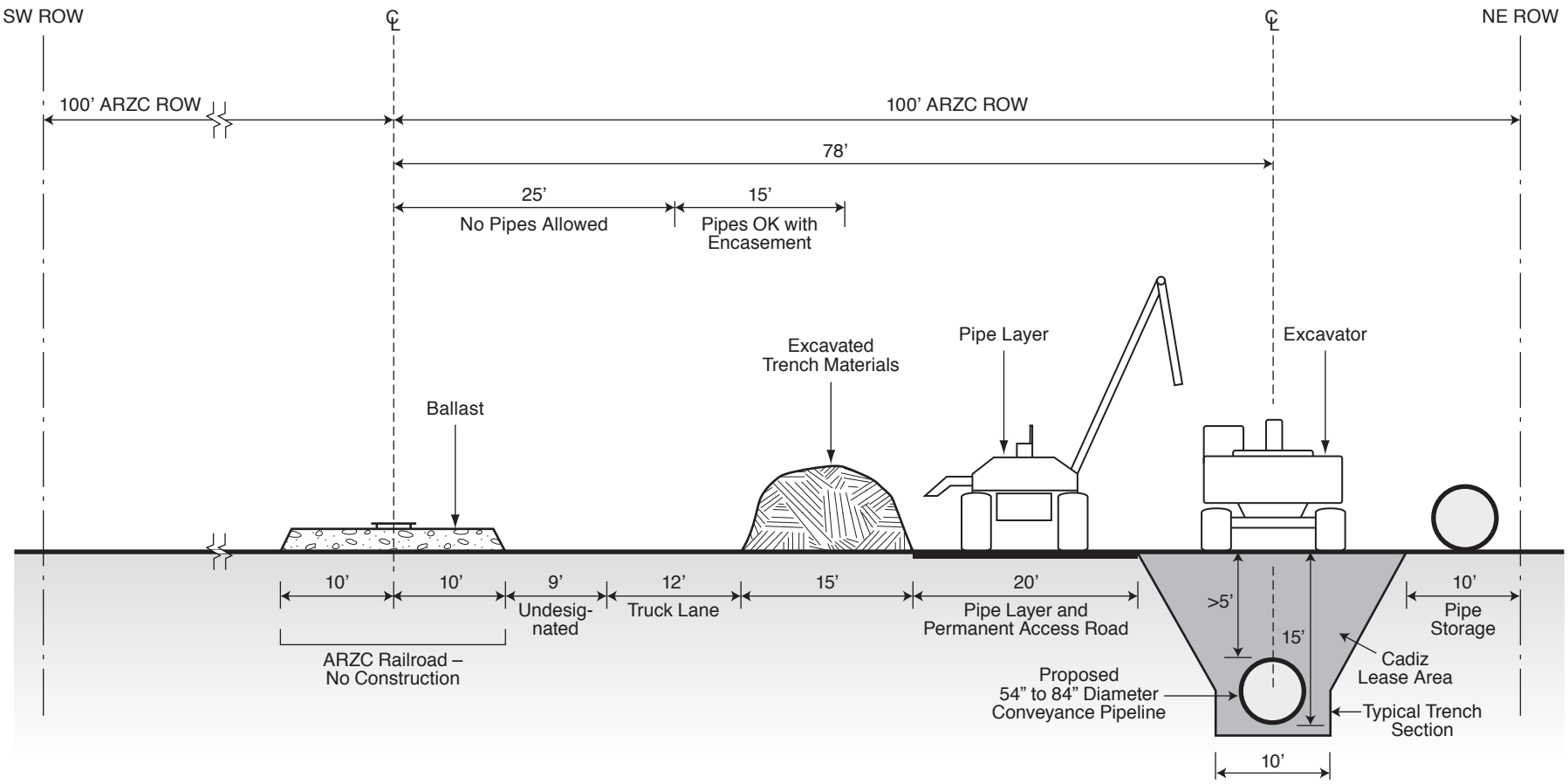


SOURCE: Geoscience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-7

Typical Well Conceptual Diagram



NOTES:

1. Layout is based on typical trench section shown and 5’ of cover on the proposed pipe.
2. Layout does not show existing railroad sidings.
3. Layout assumes the width of the railroad ballast as 20’ wide.
4. A crane will be needed on site to complete the initial unloading of pipe off of the railroad cars and place the pipe on the far edge of the right-of-way as indicated in the cross section.
5. Typical section looking north/west.

SOURCE: Tetra Tech, 2008.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-8

Typical Pipeline Section / Trench

on the operational needs of the Project. Ultimately, pipe diameters would be finalized with pipe manufacturers during final design. The material of choice for the pipeline would be steel. The water conveyance pipeline would require pipeline appurtenances visible on the surface, including air relief/vacuum relief valves, blow-off facilities, and access manholes. The exact location of these facilities would be determined during final design. These appurtenances would be accessed periodically for maintenance. Air relief valves would be installed approximately every ½ mile. These appurtenant structures would encompass less than 500 square feet and be located directly over the pipeline. A five-foot tall "goose-neck" pipe on a concrete pad would be visible at the surface. **Figure 3-9** shows an example of a typical air valve of the type to be installed. The pipeline profile would be designed to minimize high points needing air relief valves, and low points needing blow-off valves. The highest point near Chubbuck would require installation of a series of air relief valves.

At each drainage crossing, the pipeline would be either encased in concrete or protected with an underground concrete apron. This reinforcement would protect against future scouring in the washes.

Construction and operation of Project facilities within the ARZC ROW would occur without affecting the operation of the railroad. The conveyance pipeline would be installed at a depth of 15 feet and would be installed more than 50 feet from the centerline of the existing track.[18] The pipeline may need to cross under the railroad tracks to avoid sensitive areas or geologic constraints. Such crossings would be subject to written approval by the ARZC and installed, maintained, renewed, and repaired at a depth of not less than 5 feet below the base of the rail.[19] Construction, staging, and laydown would occur entirely within the railroad ROW or on private lands abutting the railroad ROW. A 25-foot wide maintenance road would be constructed parallel to and within the railroad ROW adjacent to the pipeline along the entire alignment. **Figures 3-10a** through **3-10c** show potential staging areas.

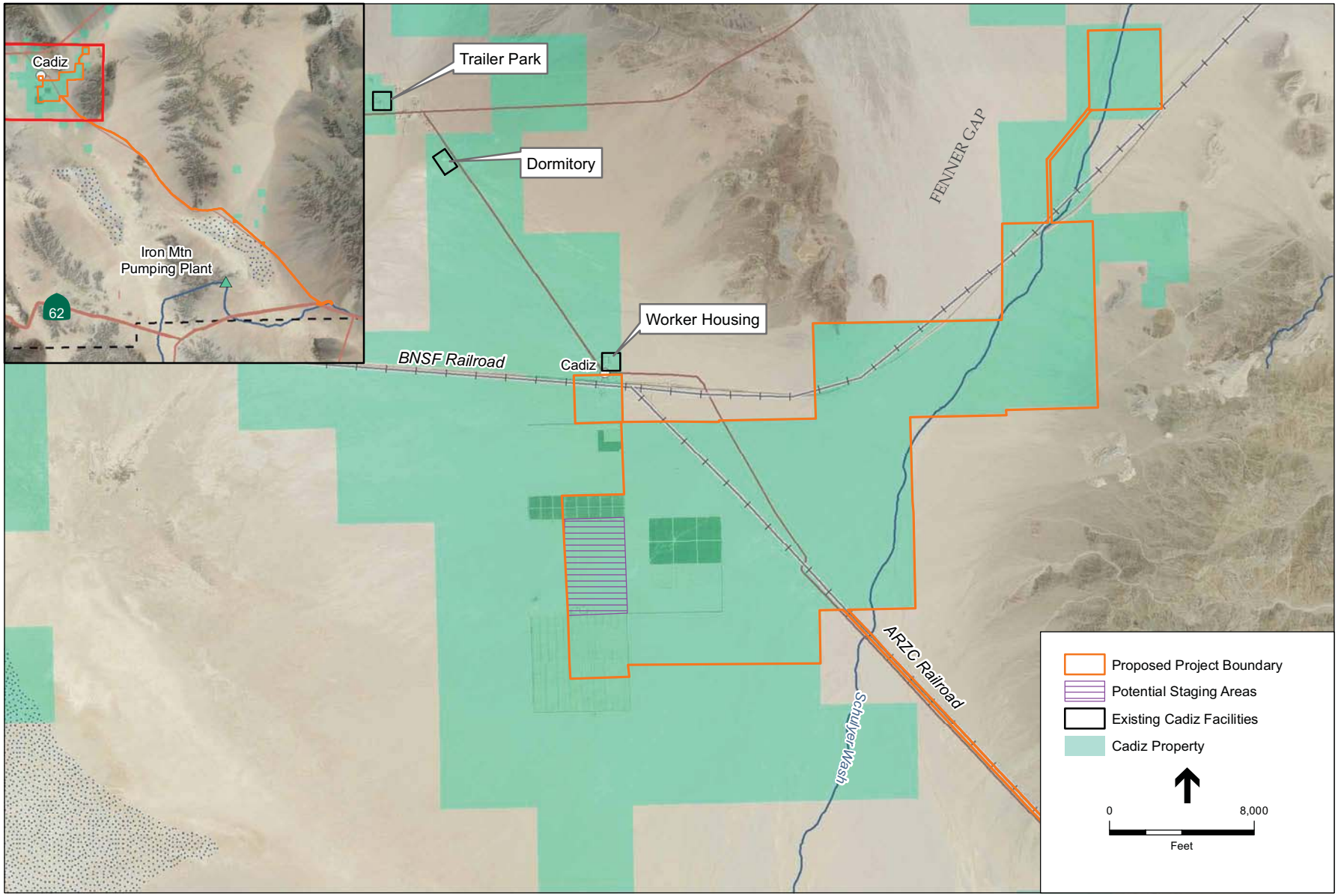
[18] Memorandum of Lease Agreement between Cadiz Real Estate, LLC and Arizona & California Railroad Company, dated September 17, 2008, page 1.

[19] Cadiz Inc., *Communication entitled "Cadiz RE pipeline project"* to RailAmerica Inc., September 17, 2008.

SOURCE: CCWD, 2008.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-9
Example of Typical
Air Relief Valve Structure

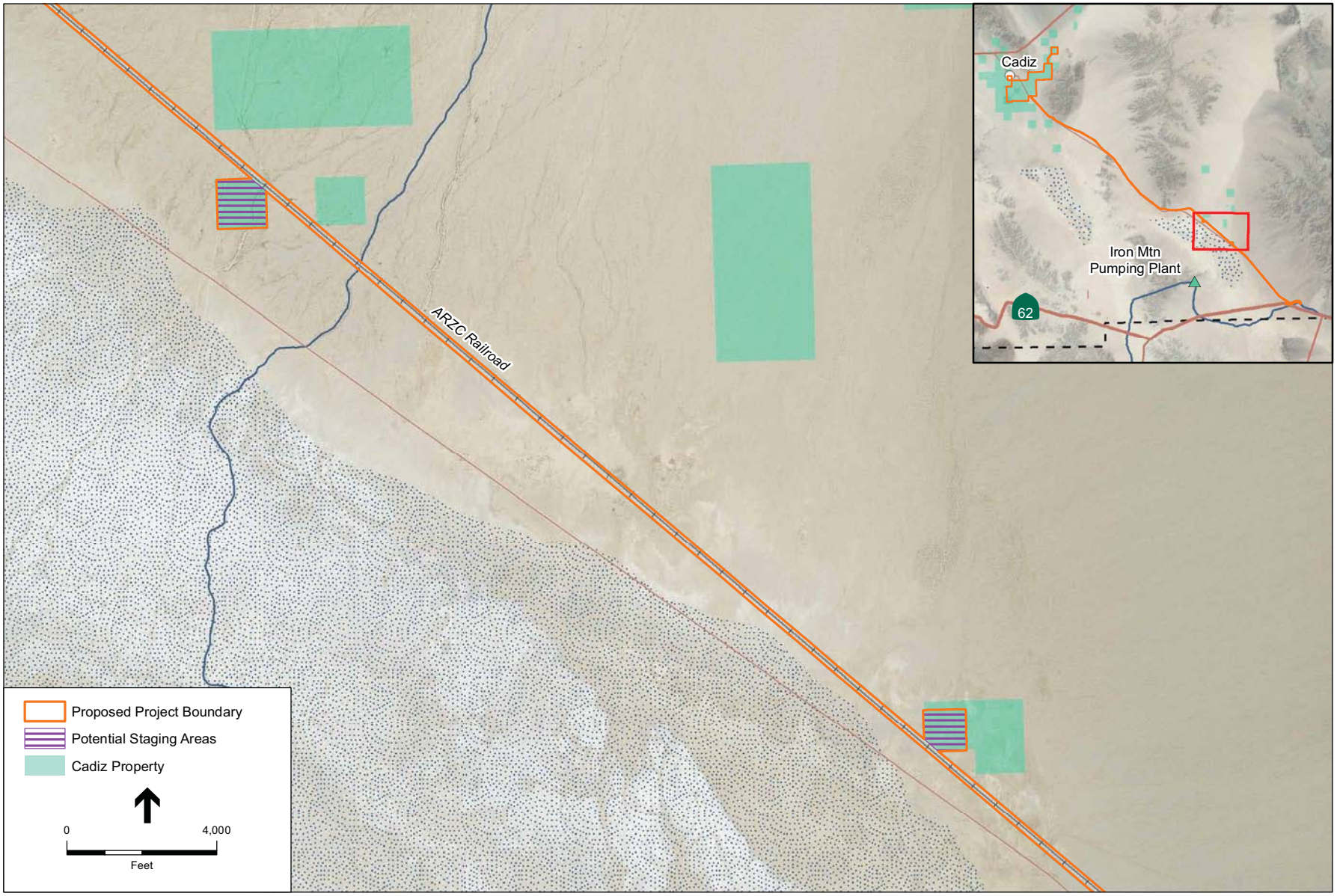


SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-10a

Potential Staging Areas: Near the Proposed Wellfield Area

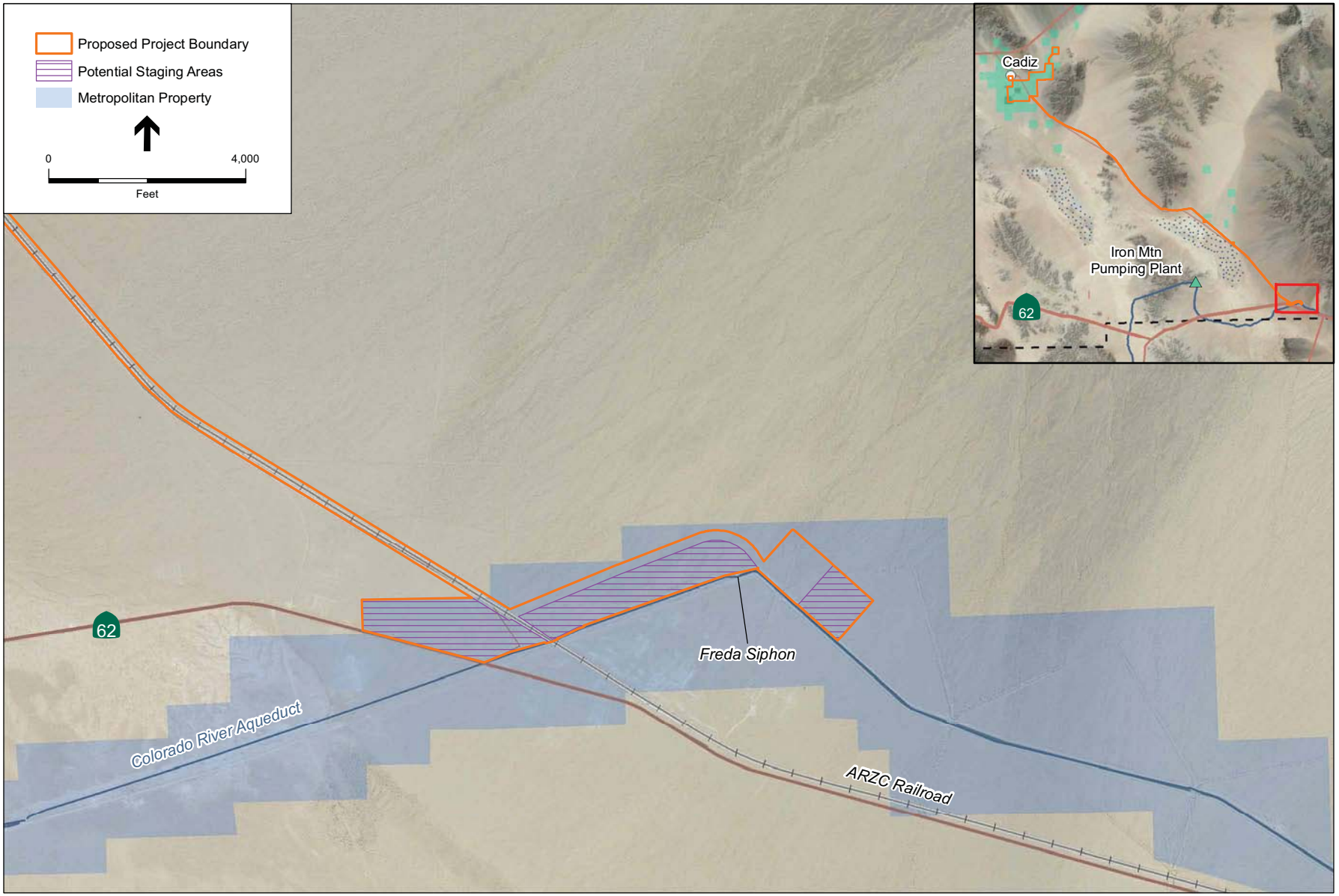


SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-10b

Potential Staging Areas: Along the ARZC Railroad



SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-10c

Potential Staging Areas: Near the CRA Tie-In

Colorado River Aqueduct Tie-in

The water conveyance pipeline would terminate at the CRA, a 242-mile water conveyance facility that delivers water from the Colorado River at Parker Dam to water suppliers in Southern California. The CRA is owned and operated by Metropolitan. Operation of the CRA is complex; it involves advance annual planning of water deliveries from the Colorado River and continuous changes in the operation of the facilities along the aqueduct in order to convey water to terminal storage at Lake Mathews. In general, water can be introduced into the CRA in increments of 215 cfs to 235 cfs to account for the CRA's pumping capabilities, although some flexibility may exist and would be determined by Metropolitan.[20]

This Draft EIR evaluates two CRA tie-in options, Option 1 and Option 2, each containing sub-options. Under Option 1, a direct tie-in to the CRA would be constructed at the intersection of the water conveyance pipeline and the CRA. Various operational strategies could be employed to deliver water to the CRA.

CRA Tie-in Option 1

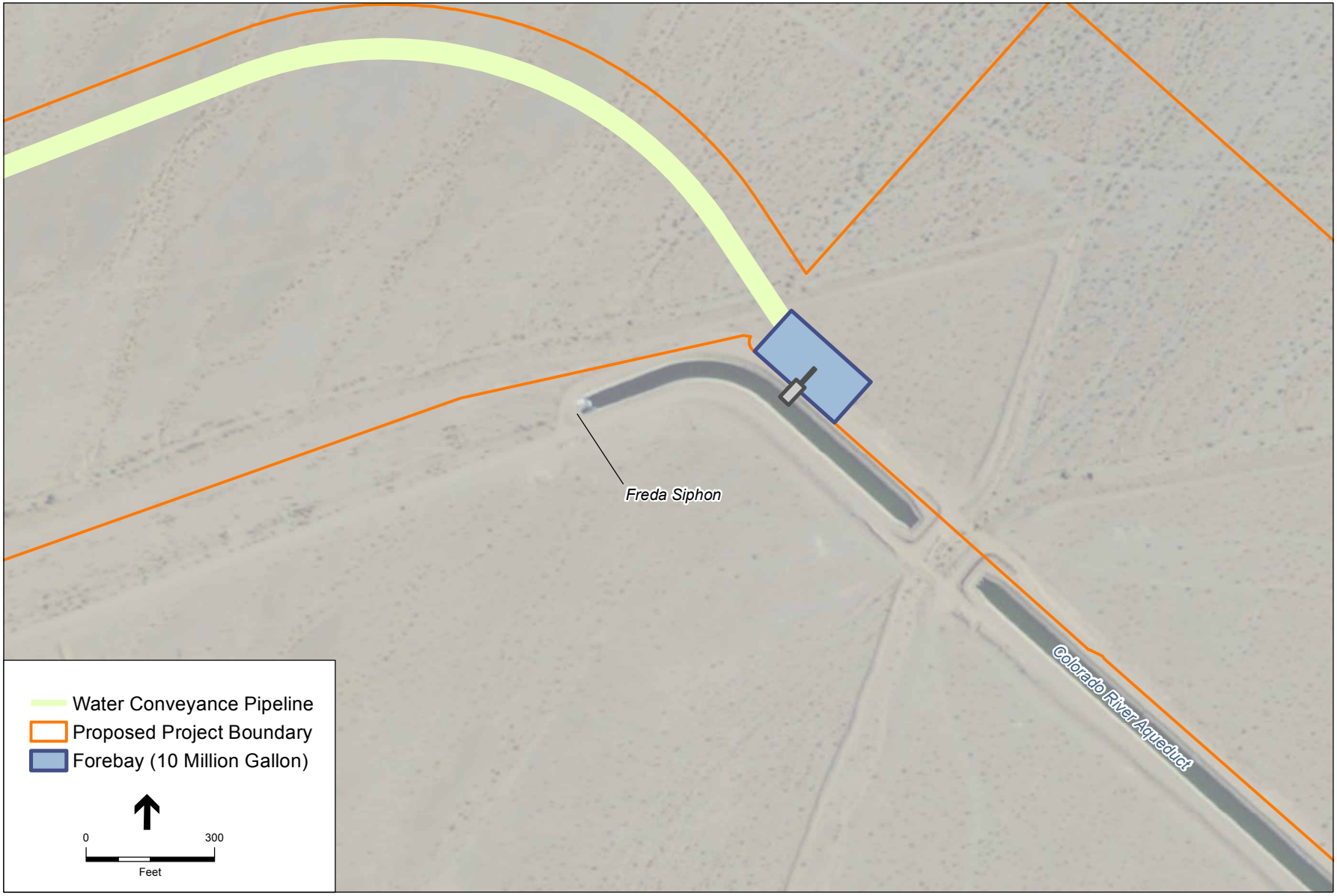
Under CRA Tie-in Option 1, a small 5,000-square-foot structure (forebay) would be constructed at the intersection of the water conveyance pipeline and the CRA to stabilize and meter flows into the CRA (see **Figure 3-11**). The forebay would be a trapezoidal reservoir, Hypalon-lined, with 3 to 1 side slopes and a flat floor with a volume of approximately 10.7 million gallons. It would be sized to hold two hours of the 250 cfs flow. The exact configuration of the forebay would be refined during final design. The forebay would have inlet and outlet facilities to connect the water conveyance pipeline to the CRA with automated gates.

The water conveyance pipeline would connect to the CRA sidewall and discharge directly into the Aqueduct. Water would be conveyed using the well head pumps; no additional pump stations or regulating storage along the pipeline route would be required. To implement this preferred tie-in option, one of the following CRA operational scenarios would be employed by Metropolitan:

A) *Option 1a - Copper Basin Inflow Reduction*. Under Option 1a, Copper Basin Inflow Reduction, Metropolitan would adjust the discharge into the CRA from Copper Mountain Reservoir in order to accommodate the Project's pump-in volume. Since there are no pump stations between Copper Mountain Reservoir and the Project tie-in, Metropolitan would not have to modify pumping operations at any of the down-stream pump stations. This is the preferred option.

B) *Option 1b - Pump Discharge Gates Throttle*. Under Option 1b, Pump Discharge Gates Throttle, the Project tie-in would require modification to accommodate the operation of each of the down-stream pump stations (Iron Mountain, Eagle Mountain, and Hinds Pump Stations). Metropolitan would throttle the pump discharge gates to allow pumps to match incoming flow from Project. This would increase energy use and would result in more frequent repair and replacement of pump equipment.

[20] CH2M Hill, *Cadiz Groundwater Conservation Project – Conceptual Engineering and Opinions of Probable Cost Technical Memorandum*, December 2010, pages 1-12.



SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-11

Proposed CRA Tie-In Option 1

C) *Option 1c - Variable Frequency (Speed) Drive Pumps at Three Metropolitan Pump Stations*. Under Option 1c, Variable Frequency, Metropolitan would install variable frequency drives at each of the downstream pumps that would allow for adjustment of the pumping rate at one of their pumps in each pump station (Iron Mountain, Eagle Mountain, and Hinds Pump Stations) in order to accommodate the flow input from the Project.

CRA Tie-In Option 2

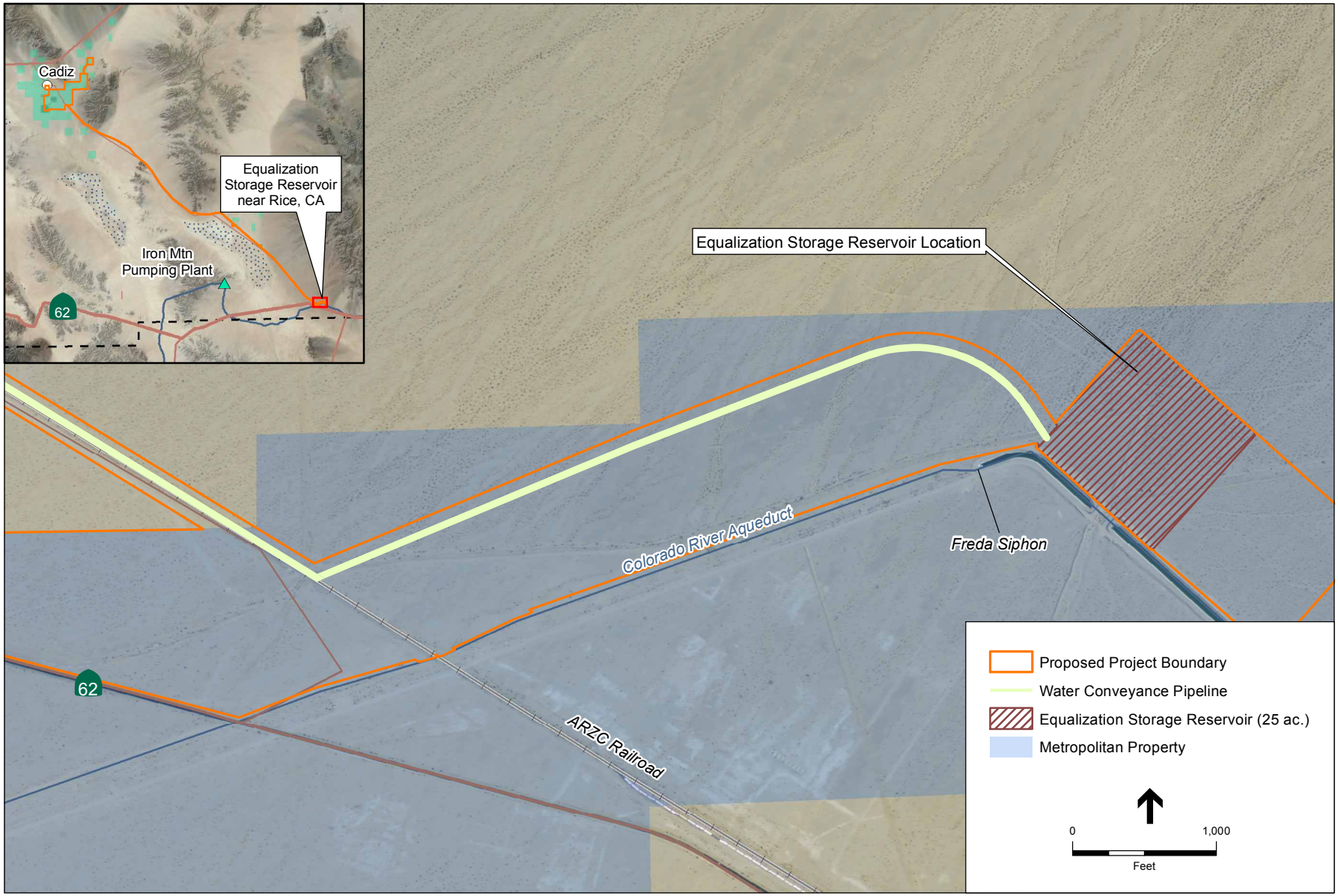
Under Option 2, an equalization storage reservoir would be constructed at one of two possible locations. Under Option 2a, the equalization storage reservoir would be constructed near Rice, California, on Metropolitan-owned land (see **Figure 3-12a**). Under Option 2b, an equalization storage reservoir and intermediate pump station would be constructed on Cadiz Property adjacent to the ARZC ROW located near Danby Dry Lake and Milligan, California (see **Figure 3-12b**).

The equalization storage reservoir would encompass approximately 25 acres with a storage capacity of 32.8 AF, sized to hold two hours of the 250 cfs flow. The exact configuration of the equalization storage reservoir would be refined during final design to optimize depth-to-surface-area ratio. The equalization storage reservoir would have inlet and outlet facilities to connect the Project to the CRA using automated gates. There are two potential locations for the equalization storage reservoir, as follows:

A) *Option 2a – Equalization Storage Reservoir near Rice, California:* Under Option 2a, an equalization storage reservoir would be constructed adjacent to the CRA on Metropolitan-owned land near Rice, California, as shown in Figure 3-12a. No intermediate pump station or forebay would be required under Option 2a; rather, Option 2a combines the forebay and equalization storage into one facility.

B) *Option 2b – Equalization Storage Reservoir and Intermediate Pump Station near Danby Dry Lake:* Option 2b would construct an equalization storage reservoir on Cadiz Property near Danby Dry Lake approximately eight miles northwest of the intersection of the ARZC ROW and the CRA (Figure 3-12b). Under Option 2b, an intermediate pump station would also be constructed at the equalization storage reservoir site to convey water from the equalization storage reservoir to the CRA. The intermediate pump station would be approximately 6,000 square feet, with a total footprint of about 1.5 acres, including ingress/egress facilities and other structures. The pump station would operate 8 hours a day, 365 days a year, at 125-220 cfs. A small, 5,000-square-foot forebay structure would also be constructed at the intersection of the water conveyance pipeline and the CRA to stabilize and meter flows into the CRA. Power for the intermediate pump station would be determined during final design; currently the options include natural gas engines, electricity from solar power, and/or delivery of power via an existing power line or solar turbine generators.

The CRA tie-in Option 1 is the simplest and preferred tie-in option. The final decision is subject to agreement with Metropolitan. Once in the CRA, the groundwater would be subject to Metropolitan's rules, regulations, and fees concerning the transportation of water to its member agencies and retail service providers.

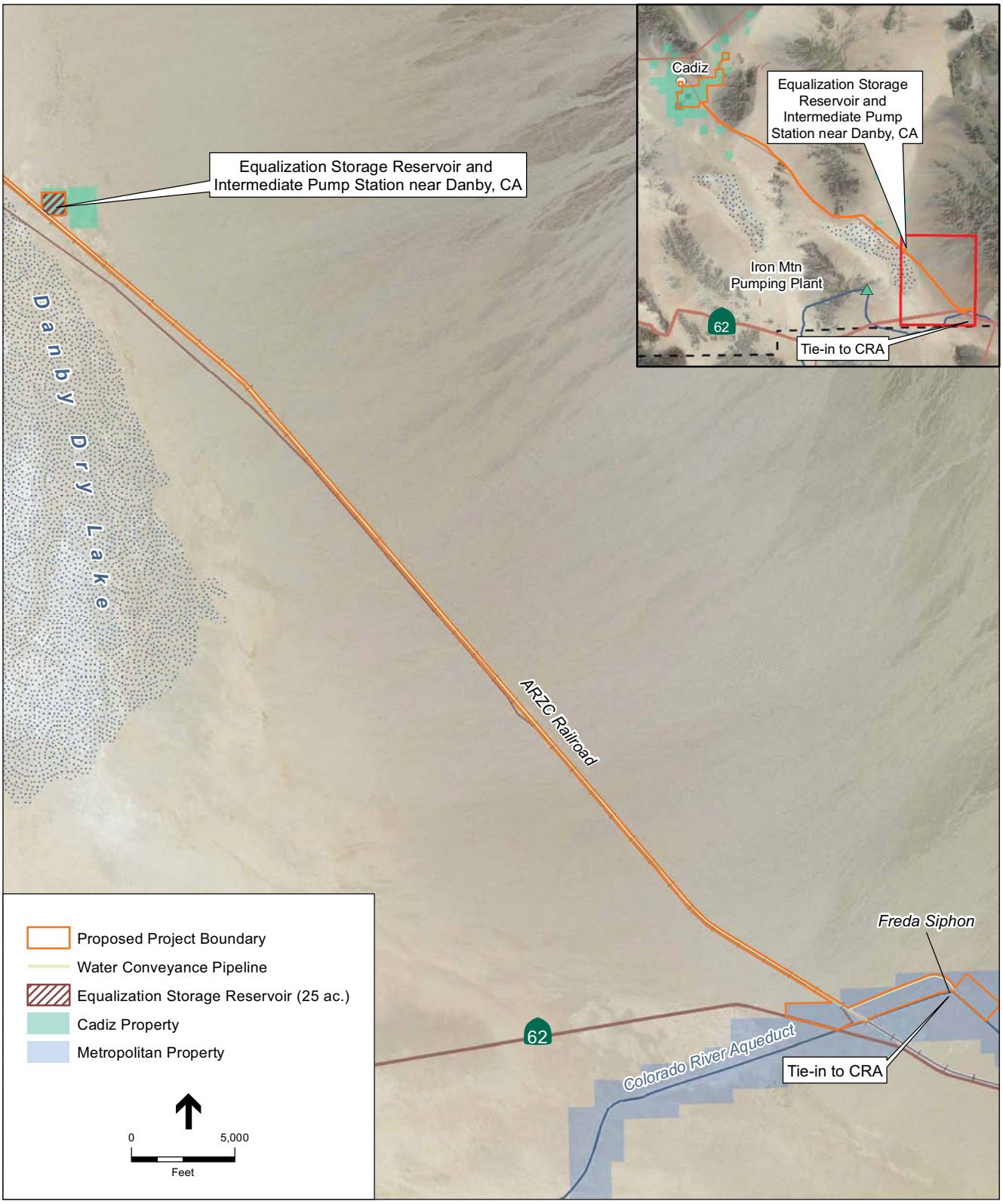


SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-12a

Proposed CRA Tie-in Option 2a,
Equalization Storage Reservoir Location



SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 3-12b

Proposed CRA Tie-in Option 2b, Equalization Storage Reservoir Location

Power Supply and Distribution

Power requirements for the Groundwater Conservation and Recovery Component are summarized in **Tables 3-2** and **3-3**. It is anticipated that approximately 50.7 million killowatt hours (kWh) per year of power would be needed to operate the Groundwater Conservation and Recovery Component at maximum capacity. The Intermediate Pump Station, required only for the CRA tie-in Option 2b, would require an additional 22 million kWh per year. This would comprise all the energy needed to operate the Project.

TABLE 3-2
CADIZ WELLFIELD POWER REQUIREMENTS
GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Wellfield Production	Average Power Requirement[a]		Annual Power Requirement[b]
Afy	hp	kW	kWh
50,000	4,250	3,160	30,800,000
75,000	7,000	5,200	50,700,000

[a] Average power requirement based on 85% pump efficiency.
[b] Annual power requirement based on 90% motor transfer efficiency, 24hrs/day, 365 days/yr.

SOURCE: RBF Consulting, *Power Requirements Analysis Technical Memorandum, Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California, Phase* 1, November 2010.

TABLE 3-3
INTERMEDIATE PUMP STATION POWER REQUIREMENTS
GROUNDWATER CONSERVATION AND RECOVERY COMPONENT
CRA TIE-IN OPTION 2B

Flow rate		TDH	Average Power Requirement[a]		Annual Power Requirement[b]
Cfs	mgd	ft	hp	kW	kWh
220	142	310	9,100	6,800	22,000,000

[a] Average power requirement based on 85% pump efficiency.
[b] Annual power requirement based on 90% motor transfer efficiency, 24hrs/day, 365 days/yr.

SOURCE: RBF Consulting, *Power Requirements Analysis Technical Memorandum, Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California, Phase* 1, November 2010.

Three power options are being examined to provide pumping capacity at the wellfield. The first option uses all natural gas and would install a centralized natural gas-fueled turbine generator that would provide electric power to engines located at each well. Gas would be accessed from an existing natural gas line which is located near the proposed wellfield and runs across Cadiz Property. The gas line has ample capacity to supply all well pumping power.

The second option is to utilize combination of a centralized natural-gas-fueled turbine generator and a solar powered generator to power electric motors located at the well pumps. The solar power would come from solar panels located at the wellfield.

The third option would be to supply electric-motor-driven well pumps. This option would require Southern California Edison (SCE) to upgrade their existing electrical lines that run in the area and to run them 30 miles to the wellfield.

Power would be distributed to the well pads either underground or on 30-foot overhead power poles.The intermediate pump station required for the CRA tie-in option 2b is anticipated to be driven by natural gas engines only since electrical power is not readily available in the area and turbine generators are not appropriate for this site.

ARZC Fire Suppression Facilities

To provide for fire suppression along the ARZC rail corridor, fire hydrants would be installed at several locations along the railroad ROW, primarily at the trestle bridge locations. The specific number and location of fire hydrants would be determined during the Project final design phase in consultation with ARZC.

As part of the Project, ARZC would be granted use of certain Project facilities including the Project access road(s), which would be developed or maintained for the Project for the purpose of providing access to and along the conveyance pipeline within the railroad alignment, as well as the power facilities located along the railroad that would be installed as part of the Project.

ARZC has reserved rights for the use of water from the Project for other designated railroad purposes, including for washing railcars, controlling vegetation, serving its offices and other improvements and future operations, such as a steam-powered excursion locomotive, new warehouses (if any), bulk transfer facilities or other railroad related facilities on the line. Each of these additional uses would be subject to additional environmental review as they are developed.

Monitoring Features

The GMMMP includes a network of monitoring features to monitor the effects of the Project. The following sections describe these facilities.

Observation Wells

Fifteen existing observation wells would be used to monitor the groundwater. The wells would be accessed from existing roads or paths and sampled periodically according to the protocols established in the GMMMP. Two new observation wells would be located outside the Watersheds —one within the neighboring Piute Wash Watershed that is tributary to the Colorado River, and one in Ward Valley to the southeast of the wellfield. Both wells would be located on Cadiz Property. Figures 3-6a and 3-6b identify the location of these wells. An access road would be constructed from the existing roads in the area. Both new observation wells would be drilled to up to 1,000 feet total depth.

Four additional observation well clusters would be constructed. The well clusters would consist of multiple observation wells near the wellfield area, at the edge of Bristol Dry Lake, and on the Bristol Dry Lake. An additional monitoring cluster would be located just north of Cadiz Dry Lake. All wells would be located on Cadiz Property except the well cluster on Bristol Dry Lake that would be located on other private property. The well clusters would consist of two wells screened at different depths in close proximity. Wells would be accessed periodically and monitored for water depth, and water quality. Electric down-hole geophysical logs would be collected at one well for each cluster.

Bench Marks and Extensometers

A network of approximately 20 benchmarks would be installed to establish a baseline land surface elevation. These benchmarks would be monitored periodically according to protocols in the GMMMP. In addition, three extensometers would be installed (1) near the railroad, (2) within Fenner Gap and, (3) at Bristol Dry Lake to continuously monitor land compaction.

3.6.2 Imported Water Storage Component

The Imported Water Storage Component would utilize the facilities described above for the Groundwater Conservation and Recovery Component but also expand these facilities as needed and add certain additional facilities necessary to support the import of surface water, groundwater recharge and recovery, and delivery back to participants. The Imported Water Storage Component would include the following new and expanded facilities:

- CRA Diversion structure and pump station.
- Extension of the water conveyance pipeline.
- Potential State Water Project intertie using existing idle pipeline(s) in Project region.
- Spreading basins.
- Expanded wellfield.
- Expanded interconnecting access roads with underground utilities.
- Expanded power distribution system.

CRA Diversion Structure and Pump Station

As part of the Imported Water Storage Component, a diversion structure would be installed within the CRA at the tie-in location to take surface water out of the aqueduct for import to the Project area. A pump station would be constructed on approximately five acres adjacent to the CRA, on Metropolitan property or within Cadiz-owned property near the edge of Danby Dry Lake. The pump station would consist of a concrete building approximately 10,000 square feet in size; it would pump water from the CRA to the Project spreading basins located northeast of the Fenner Gap. Power to the pump station would be provided by natural gas or from the nearest transmission lines.

Water Conveyance from State Water Project Using Existing Pipelines

There are existing unused pipelines (formerly used for oil and natural gas) in the Project vicinity that may provide an opportunity to connect the Storage component of the Project to the SWP

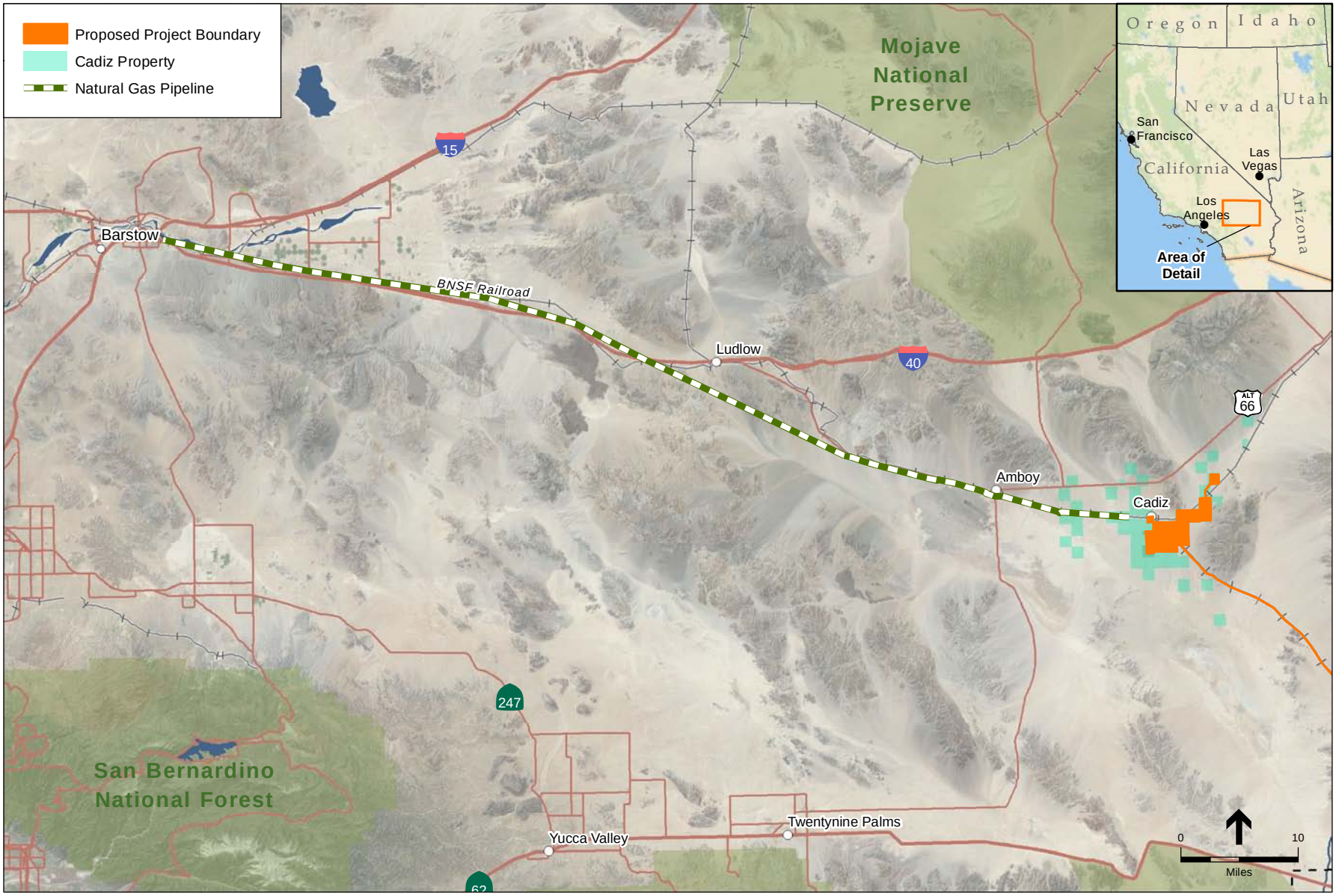
system. **Figure 3-13** shows the approximate route of a potential existing pipeline. Connecting with the SWP would expand the sources of water that could be imported for storage and also broaden the range of potential participants to include those connected not only to the Colorado River system, but also to the SWP system. One existing unused pipeline extends northwest from near the Cadiz Property to Kern County and could be converted for water conveyance to intertie with the SWP. Other existing unused pipelines in the region may offer similar intertie opportunities. Use of an existing unused pipeline for water conveyance is analyzed in this Draft EIR as a potential additional water conveyance option that could be incorporated into the Storage component.

Use of one or more of the existing idle pipelines would involve installation of pump stations and air valves. Development of each pump station would require up to two acres of area. Air valves/blow-off valves also would be installed along the pipeline. Blow-off valves and air valves are permanent release valves for water and air, respectively, used during pipeline filling and draining and during routine operations.

Blow-off valves and air valves are installed at low points and high points, respectively. The actual locations of these valves would depend on the pipeline alignment; however, for purposes of this analysis, it is assumed that either a blow off or air valve would be installed approximately every \one-half mile. The valve structures have a small concrete base pad (approximately 12 square feet) with a medium diameter pipe extending about 2 feet above the base for a total height of about 2 to 4 feet above the ground. Prior to use for water conveyance, the existing pipeline(s) would be inspected to assess their condition and lining may be proposed in some sections to address or protect against corrosion. In the alternative, sequestering chemicals may be used. Lining an existing pipeline would involve limited excavation at regular intervals along the pipeline alignment to allow the insertion of lining equipment and materials. Once the lining is installed, the pipeline trench would be filled and the pipeline fully re-buried.

Water Conveyance Pipeline Extension to Spreading Basins

Under the Imported Water Storage Component, the water would be conveyed from the CRA to the spreading basins via the pipeline constructed under the Groundwater Conservation and Recovery Component. A new segment of this pipeline would be constructed from the wellfield to the spreading basins as shown in **Figure 3-14**. The water conveyance facility would terminate at the Project spreading basins and discharge Colorado River water for percolation into the ground, where it would be stored for future use. The underground conveyance extension would be installed entirely on Cadiz Property. The pipeline would cross the ARZC rail line using jack and bore construction methods. The Intermediate Pump Station located near the CRA would provide the energy to convey water from the CRA to the spreading basins. Access to the spreading basin would be provided using existing under-crossings. No new grade crossings would be required.

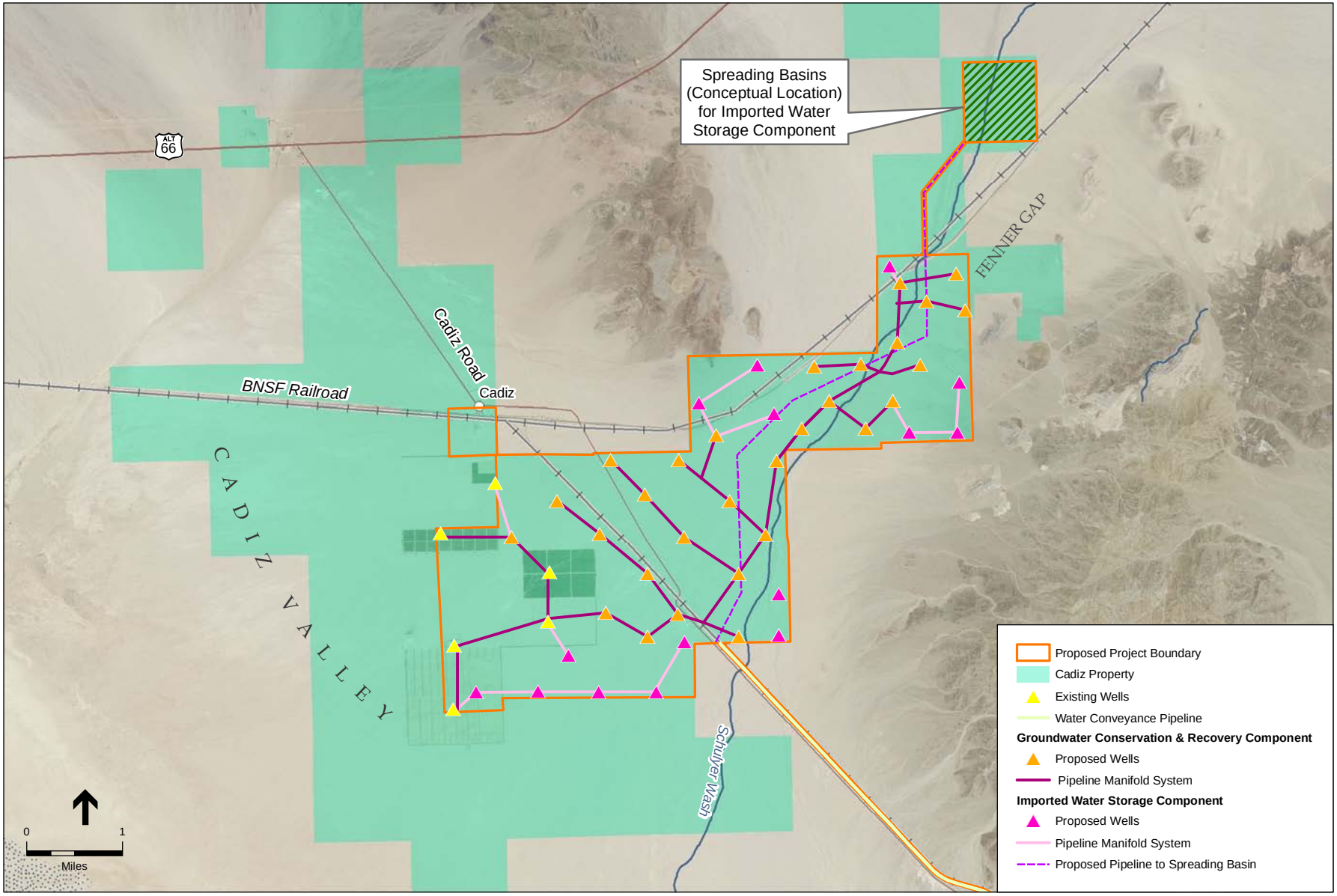


SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-13

Existing Natural Gas Pipeline



SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 3-14

Expanded Wellfield
Imported Water Storage Component

Spreading Basins

As part of the Imported Water Storage Component, spreading basins would be constructed on Cadiz Property northeast of the Fenner Gap. Figure 3-14 shows a conceptual location for the proposed spreading basins, which would encompass up to 400 acres. Each individual basin would range from 10 to 15 acres in size, surrounded by fencing. Individual basins would be about 400 feet wide and would range from 1,700 to 2,100 feet long. Water would flow by gravity through the basins in succession. An access road would be constructed from the wellfield to the basins.

The basins would be constructed with earthen berms using from 3:1 to 6:1 (horizontal:vertical) side slopes. Structures associated with the basins would include control structures, inlet structures, flow control structures, and overflow structures. Control structures would control and divert water from the transmission pipeline to the inlet structure.

Flow control structures would be used to cascade flow from upstream basin cells to downstream basin cells. The flow control structures would consist of reinforced concrete structures with wingwalls, weir guides and supports, weir boards, piping handrails, and riprap at the inlet and outlet. Spreading basin operations would occur when water is available for diversion from the CRA under executed contracts.

It is anticipated that spreading basins would be full for up to several weeks at a time and otherwise dry much of the year. The spreading basins would be cleaned periodically depending on the sediment load of the imported water. Cleaning would require scraping the floor of the basins and disposing of the silts at an on-site location. The basin floors would be scarified to improve percolation.

Wellfield Expansion

Under the Imported Water Storage Component, additional wells would be constructed, as needed, to increase capacity. A conceptual wellfield expansion area for the Imported Water Storage Component is depicted in Figure 3-14. An additional 10 to 15 wells may be needed to accommodate the Imported Water Storage Component. Wells would be similar to those constructed for the Groundwater Conservation and Recovery Component.

The power distribution system installed for the Groundwater Conservation and Recovery Component would be expanded to accommodate the expanded wellfield. Energy consumption would be increased by 75 million kWh per year as summarized in **Table 3-4**.

TABLE 3-4
CADIZ WELLFIELD POWER REQUIREMENTS
IMPORTED WATER STORAGE COMPONENT

Wellfield Production	TDH	Average Power Requirement[a]		Annual Power Requirement[b]
Afy	ft	hp	Kw	kWh
100,000	565	10,400	7,800	75,600,000

a Average power requirement based on 85% pump efficiency.
b Annual power requirement based on 90% motor transfer efficiency, 24hrs/day, 365 days/yr.

SOURCE: RBF Consulting, *Power Requirements Analysis Technical Memorandum, Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California, Phase* 1, November 2010.

3.7 Project Construction

3.7.1 Groundwater Conservation and Recovery Component

Project Wellfield

The first construction activity would be to stake the location of the access roads to the wells and the well pads for the drillers. The staked locations would be cleared and a bladed access provided to the drilling sites. Drilling pads would be graded, including a "mud" pit for drilling fluids. The drill rig would be mobilized to the site and drilling operations would commence. Upon completion, the well would be developed, the well pad completed, pump and motor set, and power and control panels constructed. The drill rig would then mobilize to another site. Piping and other utilities, such as power, would be installed to the main wellfield collector, and the access road to the well site would be completed. As wells and well piping are completed, the wellfield main collector would be constructed within previously cleared areas and connected to individual well pipes. Construction related activities would take place entirely on Cadiz Property. Approximately 0.25 to 0.5 acre of land would be kept clear around each well location for construction, staging, and ongoing maintenance.

Well drilling would be accomplished with drill rigs using the reverse rotary drill method. Each well would be approximately 1,000 feet Total Depth. A crane would lower the well casing and screens into the borehole. The annular space between the well casing and borehole would be filled with a mixture of soil and rock filter pack to ensure that fine-grained material from the formation surrounding the well is not pumped through the well during operation. Well screens would be installed within the water bearing formations at depths between 400 to 900 feet. A concrete seal would be placed at the top 50 feet of the annular space to provide a sanitary seal for the well. Figure 3-7 illustrates a typical well cross section. As wells are developed, pumped water would be conveyed to detention basins to percolate into the ground until the Project is ready to begin operations. Water quality data would be collected as part of the well development process. Each well would be equipped with internal pumps and sensors. Pressure gages and valves would be installed at the surface to control pressure. The well pumps would provide enough power to lift water in the well and convey it all the way to the CRA through the conveyance pipeline.

A backhoe would excavate pipe trenches for the Project wellfield distribution system that would carry water to the conveyance pipeline leading to the CRA. A crane would be used to lower pipe segments into the trench. The pipe trench would be backfilled by a loader and the backfill compacted to ensure pipe integrity. A separate trench would be excavated to install the Project wellfield electrical power and SCADA control systems. A maintenance road along the entire well network would be constructed to provide access to each Project well site and the collector pipeline. Construction of the Project power supply and distribution facilities would occur concurrently with the construction of the Project wellfield.

Water Conveyance Facility

For the conveyance pipeline, the first construction activity would be to stake the construction limits. Following staking, best management practices to control sediment discharges would be installed, such as silt fencing, erosion control blankets, etc. This activity would be in coordination with the clearing of the construction limits, including stockpiling topsoil to use in surface restoration. Construction equipment would be mobilized at the site to start trench excavation, pipe installation, and backfilling, including installation of cathodic protection test stations. Following pipe installation, additional crews would follow behind to install appurtenances, such as air valves and blow offs. A surface restoration crew would follow the appurtenance crew to perform fine grading, place stockpiled topsoil, and perform revegetation and erosion control. Washes and training dikes that are impacted by construction would be returned to their pre-construction condition in coordination with ARZC operators.

Upon completion of the pipe laying operation, the pipe would be filled with water and hydrostatically tested. Hydrostatic testing may be performed in sections. Upon acceptance, the pipeline would be placed in service. Grading operations associated with regulating storage or forebays would be performed following site clearing and staking. Storage facilities would be excavated and surfaces restored. If an intermediate pump station is required in the final Project configuration it would be constructed as follows: Site clearing and staking; excavation of foundation; construction of foundation; construction of walls and roof (if a structure is required); installation of equipment; performance of functional testing; and startup and performance testing.

Figure 3-8 depicts a typical pipe trench. The conveyance pipeline would be installed underground using open-trench construction methods at a depth of 15 feet bgs. The pipeline would be installed more than 50 feet from the centerline of the existing track. The pipeline may cross under the railroad tracks in a few places to avoid sensitive areas or geologic constraints, to be determined during final design. Such crossings would be subject to written approval by ARZC and installed, maintained, renewed, and repaired at a depth of not less than five feet below the base of the rail. Railroad undercrossings would use bore and jack methods or directional drilling. Blasting may be required in some areas. There are approximately 70 road and wash crossings. These wash crossings, from the wellfield to the spreading basins, would be constructed with at least five feet of cover and may require reinforcing with concrete casing or pads at least five feet below the surface.

It is assumed that no import or export of soil would be required for construction of the pipeline. Pipe segments would be delivered to the Cadiz Inc. agricultural operation (Cadiz Ranch) via the

BNSF railroad where it intersects with the ARZC on Cadiz Property. Pipe would then be delivered to the construction sites using either the existing ARZC rail system or by truck. The pipe-laying work area would be within the railroad ROW. The ARZC rail line would remain operational for the duration of the construction. The pipeline may be installed within multiple locations simultaneously, requiring a second or third crew and equipment.

Monitoring Features

Observation wells, benchmarks, and extensometers would be installed as required in the GMMMP prior to Project operation. The observation wells would be drilled in a similar fashion to the production wells, but the well diameters would be much smaller, between 2 and 3 inches. Well pad disturbance areas would be smaller than those used for the production wells due to the smaller size of the wells and the lack of surface appurtenances needed. Access roads would be graded to each new well. Bench marks and extensometers would be placed near roads or existing structures, resulting in minimal disturbance.

Construction Equipment

Construction equipment that would be required during construction of the Groundwater Conservation and Recovery Component is shown below in **Table 3-5**.

Workers

Approximately 240 workers would be employed at any given time at the Project site.[21] On-site workers would reside within the existing housing areas on Cadiz Property. These existing worker housing areas support the agricultural activities and are sized to house over 300 workers at peak harvest season. These areas are expandable if necessary, within the footprint of the existing disturbed areas. Worker commutes would include individuals arriving at and leaving the worker housing areas once a week (typically arriving on Monday mornings and leaving on Friday nights). During the week, commutes would consist of van pools from the worker housing areas to the work zones.

Staging Areas

Staging areas would be required for the temporary storage of equipment and materials during construction of the Project. Preparation of these staging areas would consist of flattening vegetation in place or blading the site in a manner that would allow native vegetation to recover from rootstock.

[21] Economics & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Conservation, Recovery and Imported Water Storage Project,* April 2011, pages 5-7, 11-13 and Executive Summary. (Project would create more than 1,200 direct and indirect jobs over the two phases of the Project. Jobs include the following: construction material production or planning; engineering; and firms assisting those operations; fabricated pipe and pipe fitting manufacturing; management, scientific and technical consulting.)

TABLE 3-5
CONSTRUCTION EQUIPMENT REQUIRED FOR THE GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Description	Wellfield Installation[a]	Conveyance Pipeline	Storage Reservoir/Pump Stations	CRA Tie-in Facility
Grader	1	1	3	1
Dozer	1	1	2	2
¾ ton Pickup Truck	6	6	10	-
End Dump Truck, 12 cy	2	2	4	1
Crane	2	1	1	1
Air Compressor	2	1	1	2
Tractor / Lowboy Hauling Rig	2	2	-	2
3 cy Rubber Tire Loader	1	3	3	2
Backhoe	-	3	3	1
Highway Water Truck	1	2	2	1
Truck Crane	1	2	1	1
Concrete Truck[b]	2	1	2	1
Well Drill Rig	4	-	-	-
Directional Drill Rig	-	1	-	-
Workers	60	100	40	40
Mobilization Maximum Daily Miles Travelled[c]	100	2,500	1,000	1,000
Commute to Cadiz once per week Maximum Daily Miles Travelled (200 miles per worker per one way trip).	12,000	20,000	8,000	8,000

[a] per header. Assumes Project would be constructed with two headers simultaneously
[b] daily average
[c] assumes workers stay at Cadiz Property five days per week. Miles traveled shown here are mobilization miles from Cadiz worker housing area to work site. Assumes four workers per car.

NOTE: The types and quantities of equipment are approximate and intended only for estimating construction related impacts. Actual equipment types and quantity may vary.

SOURCE: ESA, 2011.

As described above, Cadiz Inc. owns and operates housing facilities in the northern portion of the Project area that would be utilized to house employees throughout the construction period (see Figure 3-10a). Residential facilities include a trailer park with 50 available mobile home/RV hook-ups, a dormitory which sleeps 150 people, and a worker housing facility with beds for an additional 150 people. The worker housing area includes a kitchen facility large enough to provide meals to the entire workforce.

Depending on the construction contractor, a second worker housing facility may be established within the staging area footprints at the south end of the proposed pipeline alignment. If established, these housing facilities would be rustic in nature, relying on portable sanitation, portable generators, and tents. No new permanent structures would be constructed in these areas.

Site Access

It is assumed that access to the construction site would be either from the north at SR 66 or south from SR 62. Workers and equipment could access SR 66 from Amboy Road, which connects with SR 62 at Twentynine Palms. From SR 66, construction traffic would turn south at Cadiz Road and utilize the existing at-grade rail crossing to enter Cadiz Property. Staging areas and worker housing facilities would be established near the Cadiz Ranch. Access from the south would be from SR 62 at Rice. Construction traffic would cross the CRA within the ARZC easement over the Frieda Siphon.

Workers would access work zones from worker housing facilities along the Project access roads either by van or truck. It may be possible to utilize high-rail trucks as well with pre-approval from ARZC. Material deliveries could come from trucks or rail.

Construction Schedule

It is assumed that construction of the Groundwater Conservation and Recovery Component would begin immediately following certification of the EIR and acquisition of necessary permits, completion of final designs, and Project bidding process. For planning purposes, this permitting process is expected to take from six months to a year. Installation of the wellfield would require approximately 10 to 11 months thereafter; it is expected to take approximately 1 to 2 months to drill each well, with multiple wells being drilled simultaneously. The drilling operation would be continuous, 24 hours per day.

The pipeline, including the CRA connection, would be installed within a 12-month period, assuming construction would occur 12 hours a day, five days a week, with approximately 7,000 feet of pipeline constructed each week. Actual work schedules may include work on the weekends as well. It is anticipated that two pipeline crews would work to lay pipe simultaneously, with restoration crews following to re-vegetate in the wake of the backfill. During the hot, dry summers, it is likely that construction would occur predominantly during the pre-dawn and early mornings or in the evening and nighttime hours when it is cooler. Wells and possibly portions of the pipeline would be constructed 24-hours per day. Construction for the entire Project is expected to last approximately 18 months, potentially beginning in 2012 and concluding in 2014.

3.7.2 Imported Water Storage Component

The Imported Water Storage Component is being evaluated at a programmatic level. Because of potential synergies and economies of scale, the Imported Water Storage Component would be ripe for further analysis upon approval of the Groundwater Conservation and Recovery Project. Although the storage and recovery of imported water was examined extensively in the 2002 EIR/EIS a substantial quantity of new data has been obtained and new modeling undertaken since 2002. The earlier analysis must be updated to account for this as well as the new hydrologic conditions that exist on the Colorado River and the SWP among other things. Consequently, the Imported Water Storage Component would be constructed only after additional appropriate CEQA analysis is conducted, as appropriate, in accordance with *CEQA Guidelines* §15168.

Wellfield Expansion

Construction of the expanded Project wellfield would be similar to the Project wellfield. Approximately 10 to 15 additional wells would be constructed. Well-pads, connector pipeline routes, and access roads would be cleared. Approximately 0.25 to 0.5 acre of land would be kept clear around each well location for construction, staging, and ongoing maintenance.

CRA Diversion Structure and Pump Station

A diversion structure would be installed within the CRA. A pump station would be constructed to pump water from the CRA to the Project spreading basins. Site grading and excavation would be conducted to establish a foundation for the structure. Approximately 10,000 cubic yards of soil would be excavated and spread near the site. No soil would be hauled off site. A concrete building approximately 25 feet tall, encompassing approximately 10,000 square feet would be constructed. Pumps would be installed within the pump station.

Water Conveyance Extension

Construction methods for the conveyance pipeline extension would be similar to those used for installing the pipeline to the CRA. The entire pipeline extension would be installed underground using open-trench construction methods at a depth of 15 feet bgs. Utility and railroad crossings would require jack and bore installation techniques.

Project Spreading Basins

Construction activities for the spreading basins would include excavation, embankment or berm construction, gate and valve installation, and appurtenant construction. All construction-related activities would take place on Cadiz Property. Construction equipment that would be required for the Imported Water Storage Component is shown below in **Table 3-6**.

Staging Areas

Staging areas would be required for the temporary storage of equipment and materials needed during construction of the Imported Water Storage Component. Preparation of these staging areas would consist of flattening vegetation in place or blading the site in manner that would allow native vegetation to recover from rootstock.

Construction Schedule

Construction of the spreading basins, pipeline extension, and expanded wellfield for the Imported Water Storage Component would only begin following appropriate CEQA compliance review and compliance with any additional permitting requirements. Once approved for construction, the Imported Water Storage Project would be completed in approximately 12 months.

TABLE 3-6
CONSTRUCTION EQUIPMENT REQUIRED FOR THE IMPORTED WATER STORAGE COMPONENT

Description	Diversion Structure/ Pump Station	Wellfield Expansion	Spreading Basins
Grader	3	1	4
Dozer	2	1	4
Scraper	-	-	2
¾ ton Pickup Truck	10	6	6
End Dump Truck, 12 cy	4	2	2
Crane	1	2	-
Air Compressor	1	2	1
Tractor / Lowboy Hauling Rig	-	2	2
3 CY Rubber Tire Loader	3	1	3
Backhoe	3	-	2
Highway Water Truck	2	1	2
Truck Crane	1	1	1
Concrete Truck[a]	2	2	1
Well Drill Rig	-	4	-
Workers	60	60	60
Mobilization Maximum Daily Miles Travelled[b]	1,500	100	100
Commute to Cadiz once per week Maximum Daily Miles Travelled (200 miles per worker per one way trip).	12,000	12,000	12,000

[a] daily average

[b] assumes workers stay at Cadiz Property five days per week. Miles traveled shown here are mobilization miles from Cadiz to work site. Assumes four workers per car.

NOTE: The types and quantities of equipment are approximate and intended only for estimating construction related impacts. Actual equipment types and quantity may vary.

SOURCE: ESA, 2011.

3.8 Agreements, Permits, and Approvals

Implementation of the proposed Project may require the following agreements, permits, and approvals:

Santa Margarita Water District	Project Approval/CEQA	A Project Participant and CEQA Responsible Agency pursuant to California Public Resources Code section 21069, SMWD would evaluate potential environmental impacts within its boundaries and has discretion to approve or reject its participation in the proposed Project
Three Valleys Municipal Water District	Project Participation Approval/CEQA	A Project Participant and CEQA Responsible Agency pursuant to California Public Resources Code section 21069, Three Valleys would evaluate potential environmental impacts within its boundaries and has discretion to approve or reject its participation in the proposed Project
Jurupa Community Services District	Project Participation Approval/CEQA	A Project Participant and CEQA Responsible Agency pursuant to California Public Resources Code section 21069, JCSD would evaluate potential environmental impacts within its boundaries and has discretion to approve or reject its participation in the proposed Project
Arizona California Railroad	Agreement of right of way easement	Needed to utilize railroad right of way
	Project Participation Approval	A Project Participant. Has discretion to approve or reject its participation in the proposed Project
California Public Utilities Commission	CPUC Approval	Regulatory authority over Golden State and Suburban, the CPUC has approval authority over Golden State's and Suburban Water's agreements if rates are affected
US Fish and Wildlife Service	Endangered Species Act Section 7	Needed due to presence of desert tortoise

US Army Corps of Engineers	Clean Water Act Section 404	Needed for Piute Wash observation well
	Commitment to remove unexploded ordnance	Needed if unexploded ordnance removal is necessary
California Department of Fish and Game	California Fish and Game Code Section 2081	Needed due to presence of desert tortoise
	California Fish and Game Code Section 1602	Needed for effects to streambeds
California Department of Transportation	Encroachment Permit	Needed for lane closures if necessary on SR62 and SR66
Regional Water Quality Control Board	Clean Water Act Section 401	Needed for effects to waters of the US
	WDRs for waters of the state	Needed to cross washes as waters of the state;
	Storm Water Pollution Prevention Plan	Needed for construction activities
	Waste Discharge Requirements	Needed for land discharges including spreading basins, well completion discharges, and blow-off discharges
	Anti-Degradation Analysis for storage recharge	Needed per Basin Plan to protect groundwater
Metropolitan Water District of Southern California	Approval to modify CRA for the proposed intertie and diversion structures	Needed for use of CRA
	Agreement to convey water through the CRA	
Mojave Desert Air Quality Management District	Natural gas engine emissions permits	Needed for well pumps and Intermediate Pump Station
San Bernardino County	Groundwater Management, Monitoring and Mitigation Plan pursuant to County MOU	Needed to comply with County MOU

CHAPTER 4
Environmental Setting, Impacts, and Mitigation Measures

This Draft EIR is prepared in accordance with CEQA (California Public Resources Code, Section 21000 et seq.), the *CEQA Guidelines* (California Code of Regulations, Title 14, Section 15000 et seq.), and applicable rules and regulations of regional and local entities. This Draft EIR evaluates the potential environmental impacts associated with the construction and operation of the Cadiz Valley Water Conservation, Recovery, and Storage Project. This Draft EIR is intended to serve as an informational document for the public agency decision-makers and the public regarding the proposed Project.

Introduction to the Environmental Analysis

In accordance with Section 15126 of the *CEQA Guidelines*, Chapter 4 provides an analysis of the direct and indirect environmental effects of the proposed Project with respect to existing conditions at the time the Notice of Preparation (NOP) was published (Appendix A). The physical conditions by which a lead agency determines whether an impact is significant are established at the time the NOP is published (*CEQA Guidelines*, Section 15125(a)). The following environmental resources are assessed in this chapter in accordance with Appendix G of the *CEQA Guidelines:*

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use and Planning
- Mineral Resources
- Noise
- Public Services and Utilities
- Recreation
- Transportation and Traffic

The proposed Project would have no impact on Population and Housing, and therefore an assessment of Project impacts on Population and Housing is not included in Chapter 4. The proposed Project does not propose new homes or businesses that would directly induce population growth to the area. The proposed Project would not displace substantial numbers of existing houses or people and would not necessitate construction of replacement housing. The

potential for the proposed Project to induce population growth indirectly is discussed in Chapter 6, Growth Inducement.

Environmental Setting

According to Section 15125(a) of the *CEQA Guidelines*, an EIR must include a description of the existing physical environmental conditions in the vicinity of the proposed Project to provide the "baseline condition" against which Project-related impacts are compared. Normally, the baseline condition is the physical condition that exists when the NOP is published. The NOP for the proposed Project was published in February 2011, which is considered the baseline for the analysis contained in this EIR (Appendix A).

Regulatory Framework

The Regulatory Framework provides a summary of regulations, plans, policies, and laws that are relevant to each issue area at the federal, state, and local levels.

Impact and Mitigation Analysis

The Impact and Mitigation Analysis subsection describes the potential environmental impacts of the proposed Project and, based upon the thresholds of significance, concludes whether the environmental impacts would be considered significant, potentially significant, or less than significant. Each resource that is analyzed is divided into issues, based on potential impacts. Each issue is addressed in its own subsection and mitigation measures are also included and discussed when applicable.

Significance Criteria

Significance criteria have been developed for each environmental resource in accordance with Appendix G of the *CEQA Guidelines* and are defined at the beginning of each impact analysis section. Impacts are categorized as follows:

- **Significant and Unavoidable:** mitigation might be recommended but impacts are still significant;
- **Less than Significant with Mitigation:** potentially significant impact but mitigated to a less than significant level;
- **Less than Significant:** mitigation is not required under CEQA but may be recommended; or
- **No Impact:** Mitigation not required or recommended.

4.1 Aesthetics

The purpose of this Section is to identify existing aesthetic resources within the Project area, analyze potential impacts to aesthetic resources associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. The aesthetics analysis identifies and evaluates key visual resources in the Project area and determines the degree of visual impacts that could occur from the proposed Project. The assessment is based on field observations of the proposed Project site, in addition to a review of topographic maps, Project drawings, and aerial and ground-level photographs of the Project area from representative viewing locations. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.1.1 Environmental Setting

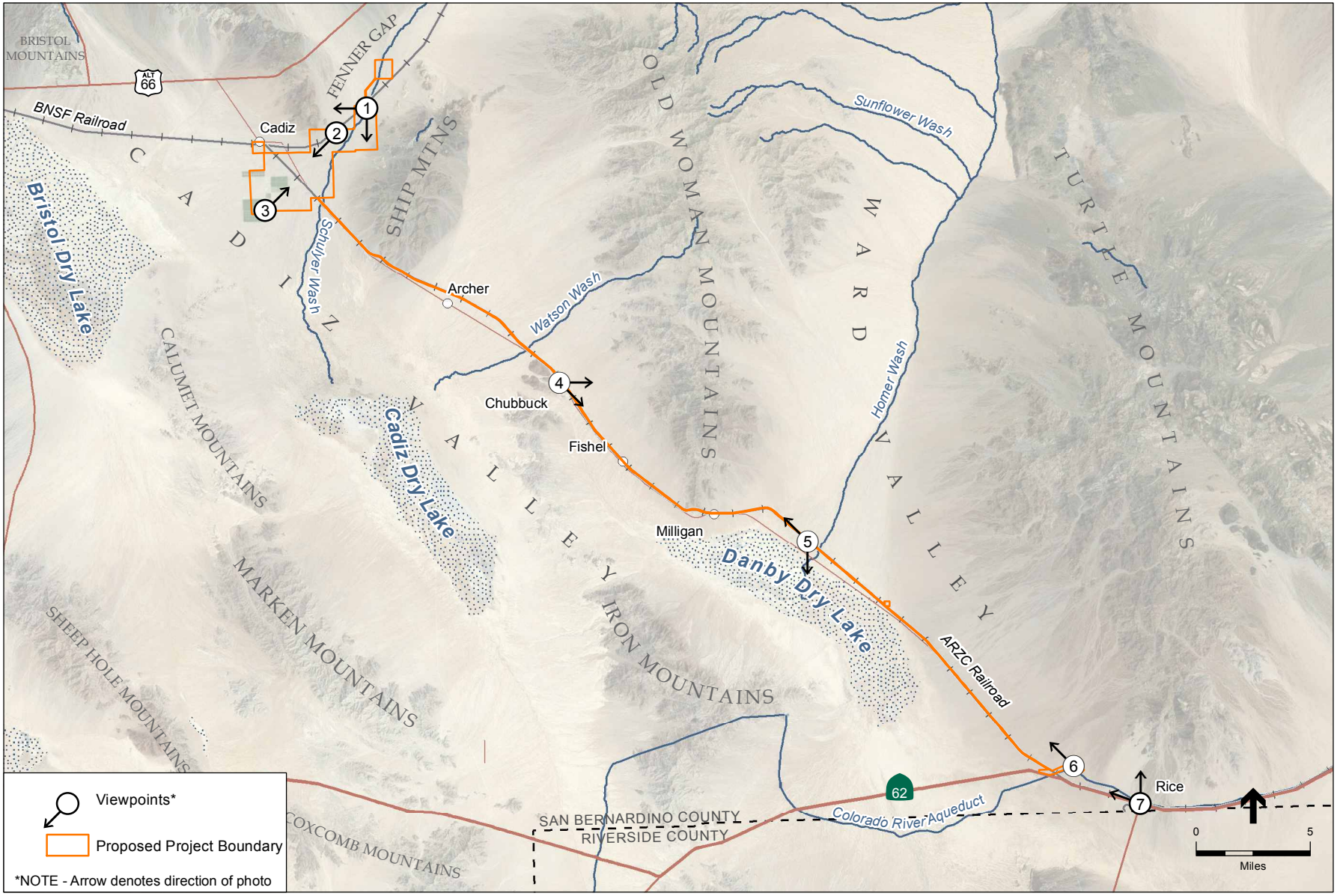
Regional Setting

The Project is located in a generally undeveloped region of the Mojave Desert within San Bernardino County, California (**Figure 4.1-1**). The Project area is approximately 10 miles south of the Mojave National Preserve and surrounded by federal lands managed by the U.S. Bureau of Land Management (BLM) for open space values. The visual character of the region is shaped by an arid landscape consisting of sparsely vegetated mountain ranges and broad valleys with expansive bajadas[1] and scattered dry lakes.[2] Land in the Project vicinity consists of open space and undeveloped natural areas, with scattered, isolated development including existing salt mining operations on the Bristol and Cadiz Dry Lakes, agricultural operations on Cadiz Property, scattered structures near Amboy and Cadiz, railroad lines, major roadways, dirt roads, and utility corridors crossing large expanses of the desert.

Local Setting

The Cadiz Property is located in a broad desert valley surrounded on all sides by mountain ranges, salt pans, and geologic outcroppings. Views from the Cadiz Property are dominated by long-range vistas of expansive alluvial valleys supporting sparse desert scrub vegetation and surrounded by rugged mountain ranges. The Cadiz Property consists of several square miles of active agriculture including citrus orchards and vineyards, a small airstrip, an office (trailer) and other structures related to the agricultural operations. The green rows of citrus trees and grapevines at the Project area contrast sharply with the tan and muted tones of the native desert landscape. Two active railroads cross the Project area in east-west and north-south directions.

1 A bajada is a broad, sloping depositional deposit caused by coalescing alluvial fans.
2 County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report*, February 2007, page IV-7.



SOURCE: Bing Maps, 2010; ESRI, 2010; DeLorme, 2010; Cadiz Inc., 2010; and ESA, 2010

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 4.1-1

Photo Viewpoints

Because this area is largely undeveloped, there are very few sources of night light and glare. Some reflection is generated from the windows of vehicles using the east-west highways and other unpaved roads in the Project vicinity. Infrequent vehicles using area roadways after dark are a temporary source of night light. However, traffic through the area is minimal. The Cadiz Inc. agricultural operation has few lights and is not the dominant source of nighttime light in the valley. Lights from several salt mining operations on the Bristol and Cadiz Dry Lakes are visible in the evening hours.

Aesthetic features surrounding the Project area are summarized below:

NORTH: A BNSF rail line travels east-west in the vicinity of the Project area and crosses the Cadiz Property north of the Project area at the Ship Mountains. The ARZC rail line originates in Cadiz just north of the Project site, where it branches off the BNSF rail line and proceeds southeastward toward Parker, Arizona (see Figure 4.1-1). SR66 also traverses the valley roughly parallel with the BNSF connecting Cadiz with points east and west.

SOUTH: Metropolitan's Iron Mountain Pumping Plant facilities are located near the southern end of the Project area. The CRA, also owned by Metropolitan, crosses the southern terminus of the Project site from east to west. SR62 also traverses east-west at the southern end of the Project near the CRA tie-in.

EAST/WEST: The majority of the remaining lands to the east and west of the Project area are managed by BLM. The Marine Corps Air Ground Combat Center at Twenty-nine Palms occupies an extensive area west of the Cadiz Valley and Bristol Dry Lake.

Bureau of Land Management Wilderness Areas

Wilderness Areas in the Project vicinity are defined in the CDCA, as amended by the Northern and Eastern Colorado Desert (NECO) Plan (see Figure 4.1-1). There are five Wilderness areas within an approximately 5 mile radius of the Project. The Trilobite Wilderness Area is located 3.5 miles north of the Project site. Views of and from the Trilobite Wilderness Area are shielded from the Project area by the Marble Mountains. The Old Woman Mountains Wilderness Area is located east of the ARZC ROW and is closest to the ROW at the segment between Chubbuck and Milligan.

The Cadiz Dunes Wilderness Area is located west of and adjacent to the proposed water conveyance pipeline along an approximately 5-mile-long portion of the ARZC ROW, between Archer and Chubbuck. At its closest point, the Cadiz Dunes Wilderness is 100 feet west of the ARZC ROW. The Sheephole Valley Wilderness Area is located approximately 5 miles west of the Project site, and the Turtle Mountains Wilderness Area is located approximately 4.2 miles to the east.

Viewpoint Photos

Photographs illustrating the existing environment were taken at various locations within and adjacent to the Project site in October 2010. Figure 4.1-1 depicts the viewpoint locations and the direction of representative views. **Figures 4.1-2** through **4.1-7**, beginning on page 4.1-7, include photographs taken of and from the Project site. Viewpoints and representative views depicted in Figures 4.1-2 through 4.1-7 are described in more detail below.

In general, public views of the proposed Project would be limited as access to the Cadiz Inc. Property to the north and Metropolitan lands and the CRA to the south are private property and are not accessible to the general public. Cadiz-Rice Road, which runs parallel to the ARZC ROW between SR 62 and SR 66 in Cadiz, California, is open to the public. However, the dirt road is not well maintained, and therefore traffic along the road is infrequent and generally limited to employees of the mining, railroad, and agricultural operations.

Photo 1 – Viewpoint 1, T5N, R15E, Section 8, looking south towards Ship Mountains.

Photo 1 depicts representative views from Fenner Gap and the northeastern extent of the proposed wellfield area in the vicinity of (south of) the proposed spreading basins (see Figure 4.1-2). Views to the south are dominated by the Ship Mountains in the background, with scattered, sparse, scrubby vegetation in the expansive and flat desert foreground. This location is not readily accessible to the public because it does not have any paved roads leading to the photo location and would require traveling along unmaintained dirt roads.

Photo 2 – Viewpoint 1, T5N, R15E, Section 8, looking west towards Bristol Mountains.

Photo 2 depicts representative views from Fenner Gap and the northeastern extent of the proposed wellfield area in the vicinity of (south of) the proposed spreading basins (see Figure 4.1-2). Views to the west are dominated by the foreground, which consists of open desert land crossed by several dirt access roads and overhead telephone power lines. The Bristol Mountains can be seen in the distant background. This location is not readily accessible to the public because it does not have any paved roads leading to the photo location and would require traveling along unmaintained dirt roads.

Photo 3 – Viewpoint 2, T5N, R15E, Section 18, looking southwest towards the proposed wellfield area.

Photo 3 depicts existing views of the proposed wellfield area (see Figure 4.1-3). Views are dominated by the foreground, which is generally flat, with sparse vegetation. A drill rig can be seen on the right side of the image, approximately 1 mile away. The Calumet Mountains can be seen in the distant background. This location is not readily accessible to the public because it does not have any paved roads leading to the photo location and would require traveling along unmaintained dirt roads.

Photo 4 – Viewpoint 3, T5N, R14E, Section 33, looking northeast towards the proposed wellfield area.

Photo 4 depicts representative views from the southeastern portion of the proposed wellfield area, looking northeast towards Cadiz agricultural operations (see Figure 4.1-3). Views are dominated by the foreground, which consists of desert land that has been used previously for farming. Fenner Gap can be seen in the distance, as well as the Ship Mountains to the right and Trilobite Mountains to the left. This location is not readily accessible to the public because it does not have any paved roads leading to the photo location and would require traveling along unmaintained dirt roads.

Photo 5 – Viewpoint 4, Chubbuck, looking east towards Old Woman Mountains.

Photo 5 depicts representative views from the Chubbuck railroad siding, looking east (see Figure 4.1-4). Views are dominated by the ARZC railroad tracks and the expanse of vacant, sparsely vegetated desert in the foreground. Old Woman Mountain Wilderness Area is in the background, approximately 3 miles away. This photo location is accessible from Cadiz-Rice Road, which runs parallel to the ARZC railroad tracks.

Photo 6 – Viewpoint 4, Chubbuck, looking southeast towards Iron Mountains.

Photo 6 depicts views from the Chubbuck railroad siding, looking southeast (see Figure 4.1-4). Views are dominated by Cadiz-Rice Road, which runs parallel to the ARZC railroad tracks. In the background, the southern tip of Old Woman Mountains Wilderness Area is to the left and the Iron Mountains are to the right. This photo location is accessible from Cadiz-Rice Road.

Photo 7 – Viewpoint 5, Cadiz Property parcel in Section 16 T2N R18E, looking south towards Danby Dry Lake.

Photo 7 depicts views from the ARZC ROW near Cadiz properties that intersect the ROW in Section 16, T2N, R18E (see Figure 4.1-5). These parcels may be used for staging during construction or for a substation that would links to aboveground or underground power transmission lines along the ARZC ROW. Views to the south are dominated by flat desert scrub in the foreground. Danby Dry Lake can be seen in the distant midground and the Iron Mountains in the background. This photo location is accessible from Cadiz-Rice Road.

Photo 8 – Viewpoint 5, Cadiz Property parcel in Section 16 T2N R18E, looking northwest towards Old Woman Mountains Wilderness Area.

Photo 8 depicts views from the ARZC ROW near Cadiz properties that intersect the ROW in Section 16, T2N, R18E (see Figure 4.1-5). These parcels may be used for staging during construction or for a substation that would link to aboveground or underground power transmission lines along the ARZC ROW. Views to the northwest are dominated by desert scrub habitat and Danby Dry Lake. The Old Woman Mountains Wilderness Area is in the distant background. This photo location is accessible from Cadiz-Rice Road.

Photo 9 – Viewpoint 6, Looking northwest at the CRA transition from canal to underground.

Photo 9 depicts views in the vicinity of the CRA at the point where the canal transitions underground, looking northwest (see Figure 4.1-6). Land in the vicinity of the CRA is flat, but the walls of the CRA are raised so that views of the canal are limited from public viewpoints. Access to the CRA is controlled, and Metropolitan posts signs at the entrance to their access roads prohibiting trespassing.

Photo 10 – Viewpoint 6, close up of CRA transition point and underground route looking northwest.

Photo 10 was taken from Metropolitan's private access road, looking north across Metropolitan-owned lands traversed by the CRA (see Figure 4.1-6). Views in this area are dominated by the flat, nearly barren desert. The point at which the CRA transitions underground from an aboveground canal can be seen to the right; a Metropolitan security gate surrounds the transition point. The Turtle Mountains Wilderness Area can be seen in the distance, to the right. Access to the CRA is controlled, and Metropolitan posts signs at the entrance to their access roads prohibiting trespassing.

Photo 11 - Viewpoint 7, views from the ARZC railroad tracks adjacent to SR 62 near Rice, looking northwest.

Photo 11 depicts public views of the CRA from the ARZC ROW that runs parallel to and north of SR 62, near Rice, California (see Figure 4.1-7). Views are dominated by the railroad and flat desert, and the raised walls of the CRA can be seen in the midground and fading into the background where the Turtle Mountains Wilderness Area can be seen in the distance. Access to the CRA is controlled, and Metropolitan posts signs at the entrance to their access roads prohibiting trespassing.

Photo 12 - Viewpoint 7, views from SR 62 near Rice, looking north towards the ARZC railroad tracks and CRA.

Photo 12 depicts typical views of the CRA from cars driving west along SR 62, looking north. Views are balanced by the nearly-barren desert in the foreground and the Turtle Mountains in the background. Less visible are the ARZC ROW and CRA in the midground. Access to the CRA is controlled, and Metropolitan posts signs at the entrance to their access roads prohibiting trespassing.

Photo 1, Viewpoint 1: T5N, R15E, Section 8, looking south towards Ship Mountains.

Photo 2, Viewpoint 1: T5N, R15E, Section 8, looking west towards Bristol Mountains.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-2
Viewpoint 1

Photo 3, Viewpoint 2: T5N, R15E, Section 18, facing southwest towards the proposed wellfield area.

Photo 4, Viewpoint 3: T5N, R14 E, Section 33, looking northeast towards the proposed wellfield area.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-3

Viewpoints 2 and 3

Photo 5, Viewpoint 4: Chubbuck, looking east towards Old Woman Mountains.

Photo 6, Viewpoint 4: Chubbuck, looking southeast towards Iron Mountains.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-4
Viewpoint 4

Photo 7, Viewpoint 5: Cadiz Property parcel in Section 16 T2N R18E, looking south towards Danby Dry Lakes.

Photo 8, Viewpoint 5: Cadiz Property parcel in Section 16 T2N R18E, looking northwest towards Old Woman Mountains Wilderness Area.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-5
Viewpoint 5

Photo 9, Viewpoint 6: Looking northwest at the CRA transition from canal to underground.

Photo 10, Viewpoint 6: Closeup of CRA transition point and underground route looking northwest.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-6
Viewpoint 6

Photo 11, Viewpoint 7: Views from the ARZC railroad adjacent to SR-62 near Rice, looking northwest.

Photo 12, Viewpoint 7: Views from SR-62 near Rice, looking north towards the ARZC and CRA.

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.1-7
Viewpoint 7

4.1.2 Regulatory Framework

Federal

BLM Visual Resource Management (VRM) Policy

BLM has developed visual resource management policies and procedures for determining visual resource values. The assessment method is used to develop land management actions on BLM land. The method does not limit management of neighboring non-BLM lands.

The primary means to establish visual resource values are to conduct a Visual Resource Inventory (VRI), as described in BLM handbook H-8410. Visual resource values are determined through a systematic process that documents the landscape's scenic quality, public sensitivity and visibility. Rating units for each of the three factors are mapped individually, evaluated, and then combined through an over-layering analysis. The three considerations are briefly described below.

Scenic Quality: Scenic Quality Rating Units (SQRUs) are delineated based on common characteristics of the landscape. There are seven criteria used for inventorying the landscape's scenic quality within each SQRU: landform, vegetation, water, color, influence of adjacent scenery, scarcity, and degree of cultural modification. Each factor is scored for its respective contribution to the scenic quality, the scores are summed, and the unit is given a rating of A (highest), B, or C (lowest) based on the final score.

Sensitivity Level: Sensitivity Level Rating Units (SLRU) are delineated and evaluated for public sensitivity to landscape change. Criteria used for determining level of sensitivity within each unit includes types of use, amount of use, public interest, adjacent land uses, special areas, and other factors. Each criterion is rank high, medium, or low and an overall sensitivity level rating then is assigned to the unit.

Distance Zones (visibility): The third factor is visibility of the landscape evaluated from where people commonly view the landscape. The distance zones are divided into foreground/middleground (three to five miles); background (five to 15 miles); and seldom seen (beyond 15 miles or topographically concealed areas within the closer range distance zones).

State

State Scenic Highway Program

The State Scenic Highway Program, created by the California Legislature in 1963, was established to preserve and protect scenic highway corridors from change that would diminish the aesthetic value of lands adjacent to highways. A highway is designated under this program when a local jurisdiction adopts a scenic corridor protection program, applies to the California Department of Transportation (Caltrans) for scenic highway approval, and receives notification from Caltrans that the highway has been designated as a Scenic Highway. There is only one designated State Scenic Highway in San Bernardino County; a portion of SR 38 near Big Bear City, which is not in the Project vicinity.

According to Caltrans, “a highway may be designated scenic depending upon how much of the natural landscape can be seen by travelers, the scenic quality of the landscape, and the extent to which development intrudes upon the traveler’s enjoyment of the view.” Caltrans defines a State Scenic Highway as any freeway, highway, road, or other public ROW that traverses an area of exceptional scenic quality, containing striking views, flora, geology, or other unique natural attributes. There are two "eligible" State Scenic Highways: Interstate 40 (I-40), which is located approximately 20 miles to the north of the proposed spreading basins, and SR 62, which is located approximately 1 mile south of the intersection of the ARZC ROW and the CRA. The entire portions of I-40 and SR 62 that are within San Bernardino County are designated as eligible State Scenic Highways.

To be designated as “eligible” for State Scenic Highway status, the highway needs to meet the following criteria:

a) Consists of a scenic corridor that is comprised of a memorable landscape that showcases the natural scenic beauty or agriculture of California;

b) Existing visual intrusions do not significantly impact the scenic corridor;

c) Demonstration of strong local support for the proposed scenic highway designation; and

d) The length of the proposed scenic highway is not less than a mile and is not segmented.

Local

San Bernardino County General Plan

The Open Space Element and Conservation Element of the San Bernardino County General Plan (2007) govern the natural resources and scenic vistas located within the County. Accordingly, the San Bernardino County General Plan identifies goals and policies related to protect aesthetic values of natural landscapes. The policies aim to retain the natural beauty of the desert areas through minimizing intrusive development, restoring construction areas, and employing building methods that minimize impacts to views. For discussion of the applicability of the County General Plan and Development Code policies to the Project, please see Section 4.10.3 (*Consistency with Land Use Plans)* of the Land Use and Planning Chapter.

4.1.3 Impact and Mitigation Analysis

Significance Criteria

Based on *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to aesthetics if it would:

- Have a substantial adverse effect on a scenic vista;
- Substantially damage scenic resources, including but not limited to trees, rock outcroppings, and historic buildings within a State Scenic Highway;

- Substantially degrade the existing visual character or quality of the site and its surroundings; or
- Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area.

The significance determination is based on several evaluation considerations, including the extent of project visibility from sensitive viewing areas such as designated scenic routes or public open space; the degree to which the various project elements would contrast with or be integrated into the existing landscape; the extent of change in the landscape's composition and character; and the number and sensitivity of viewers. For the purposes of this analysis, a scenic vista is defined as any long range view of substantially undisturbed natural landscape that includes flora, geology, or other unique natural or man-made attributes that contribute to an exceptional aesthetic quality or character of the area. For the proposed Project, this would include views in every direction including natural vegetation, day and nighttime sky-views, and BLM Wilderness Areas as the backdrop.

Methodology

Aesthetic resources are generally defined as both natural and built features of the landscape that contribute to the public's experience and appreciation of the environment. Aesthetic impacts are determined through a comparison to existing characteristics of an area. This Section addresses the visual condition of the Project site and its vicinity and the potential for the Project to adversely affect those conditions. The analysis focuses on the visual character of the Project site and selected views from the surrounding areas. The following analysis is based upon a field assessment by ESA staff on October 27, 2010, proximity of designated scenic highways, and site photo documentation.

The scenic quality of the wellfield area is relatively high due to the preponderance of natural vegetation and the limited development. The existing agricultural fields do not diminish the area's scenic quality greatly since they appear rural in nature. The visual sensitivity of the wellfield area is relatively low since it is not readily visible from a State Scenic Highway. The long range views that include the wellfield are dominated by undeveloped valleys bounded by rocky mountains with minimal vegetation. They are generally of high quality due to the limited development and surrounding Wilderness Areas. The pipeline alignment is generally within a high quality scenic area with low sensitivity since it abuts the existing railroad and is generally hidden from any readily attainable view points.

Groundwater Conservation and Recovery Component

Scenic Vistas

Significance Threshold

Would the proposed Project have a substantial adverse effect on a scenic vista?

Impact Analysis

Construction of Wellfield Facilities

There are no designated State Scenic Highways or county-designated scenic routes in the Project vicinity. The closest State Scenic Highway is I-10 in Riverside County and the closest county-designated scenic route is Amboy Road which is approximately 13 miles to the west of the proposed Project wellfield area. The Project may be visible from Amboy Road in isolated spots on the road as the topography allows. However, the construction activities associated with the wellfield facilities and pipeline would appear similar to other small disturbances in the overall expansive landscape and would not significantly affect the overall views from the roadway.

Construction of Conveyance Facilities

SR 62 and I-40 are considered eligible State Scenic Highways by Caltrans.[3] The Project would not be visible from I-40, which is located approximately 16 miles north of the Project site. SR 62 is located less than 1 mile south of the ARZC ROW and CRA intersection and runs parallel to the segments of ARZC ROW and CRA located near Rice, California. Construction activities associated with southern portions of the water conveyance facilities, access road, power supply and distribution facilities, and construction of the CRA tie-in would be potentially visible from portions of SR 62. Other Project facilities including staging areas on the Danby Property, air relief valves, and pipeline installation footprint would not be visible from any Scenic Highway due to the distances and topography.

Photo 11 depicts typical public views of the CRA from cars driving along SR 62, looking north (see Figure 4.1-7). Views from SR 62 are dominated by the expanse of nearly-barren desert in the foreground and the Turtle Mountains in the background. The ARZC ROW and CRA facilities are visible in the midground, but do not obstruct the long-range views. Construction activities visible from SR 62 would not obscure or substantially alter long-range views.

Operation and Maintenance

Once constructed, the wellfield would consist of a series of cleared and fenced well pads connected by access roads with underground or overhead power and water pipelines. The individual wells would be equipped with emergency lighting, but would not require nighttime lighting for general operations. Project facilities on the valley floor would not be visible from Amboy Road. However, they would be visible from higher elevations in the surrounding mountain ranges. These mountain ranges are largely publicly owned lands managed by BLM, and are visited less frequently than the National Parks located to the north and southwest due to their remote and rugged location and the lack of services. The wellfield would appear as connected pads within a large undeveloped valley. If overhead powerlines are used instead of underground lines, impacts to the scenic quality of the area would be adversely affected. However, the 30-foot tall poles would blend into the long range views from local roads and surrounding areas and would not significantly affect the scenic vistas since the overhead lines would constitute a low

[3] California Department of Transportation, *California State Scenic Highways, San Bernardino County,* http://www.dot.ca.gov/hq/LandArch/scenic_highways/index.htm, accessed October 2010.

intensity development in the desert area which is compatible with the long-range, generally uninterrupted views.

Cadiz owns over 25,000 acres of mostly undeveloped land in the wellfield area and the proposed Project would utilize approximately 150 acres, or less than one percent. The wellfield would be near the agricultural lands, mining operations, and transportation alignments, but would not significantly alter or obscure the long range views from these higher elevations.

The conveyance pipeline would be constructed underground and would not alter the local aesthetics once installed. Periodic air relief valves and blow off valves would be visible at close range near the railroad. These 6-foot tall structures would not substantially alter or reduce the quality of the scenic resources near the railroad.

To provide for fire suppression along the ARZC rail corridor, fire hydrants would be installed at several locations along the ARZC ROW, primarily at the trestle bridge locations. These fire hydrants would not substantially alter or reduce the quality of the scenic resources near the railroad.

Three alternative scenarios are being considered for the CRA tie-in. Each scenario would be constructed within a fenced area. The first scenario would construct a 10-foot-high pump-in facility adjacent to the CRA that would tie-in directly to the canal (see Figure 3-11). While the direct tie-in would be slightly taller than the existing berm around the CRA, views from SR 62 would not be substantially impacted because of the short-term nature of views from moving cars and because mid-ground features in the vicinity of the CRA do not dominate views from SR 62. Under this scenario, impacts would be less than significant.

The second scenario would construct a new forebay on approximately 25 acres of Metropolitan property, adjacent to and northeast of the intersection of the ARZC ROW and CRA. An approximately 6-foot berm would be constructed around the forebay as a visual screen, which would assist in blending the facility into the surrounding area to soften long range views and would be consistent with the existing berm that screens the CRA facilities (see Figure 4.1-7). Views from SR 62 would not be substantially impacted because of the short-term nature of views from moving cars and because views of the new forebay would be screened by a new berm. Impacts on views from SR 62 would therefore be less than significant.

The third scenario would construct a new forebay on approximately 25 acres of Cadiz Property located approximately 10 miles northwest of SR 62, adjacent to the ARZC ROW. The third scenario would not be visible from SR 62, and would therefore be less than significant.

In all three scenarios, impacts to scenic vistas associated with the operation of the Groundwater Conservation and Recovery Component are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Scenic Resources

Significance Threshold

Would the proposed Project substantially damage scenic resources, including but not limited to trees, rock outcroppings, and historic buildings within a State Scenic Highway?

Impact Analysis

As discussed above, there are no designated State Scenic Highways in the Project vicinity. Impacts on scenic resources from eligible State Scenic Highways are discussed above under Scenic Vistas. The Project would have no impact on scenic resources within designated State Scenic Highways. Further discussions of historic resources can be found within Section 4.5, Cultural Resources.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Visual Character

Significance Threshold

Would the proposed Project substantially degrade the existing visual character or quality of the site and its surroundings?

Impact Analysis

The San Bernardino County General Plan encourages the preservation of unique environmental features and natural resources of the Desert Region, including native wildlife, water bodies, scenic vistas, and native vegetation, particularly Joshua trees, Mojave yuccas, and creosote rings. The visual character of the Project area is shaped by an arid landscape consisting of sparsely vegetated mountain ranges and broad valleys with expansive bajadas and scattered dry lakes. Views in the Project area tend to be dominated by the extensive foreground (lands located within 0.5 mile of the viewer) and, to a lesser extent, distant mountain ranges.

Several BLM Wilderness Areas are located in close proximity to the Project site, including the Cadiz Dunes, Old Woman Mountains, and Turtle Mountains Wilderness Areas. Because the Cadiz Dunes are low-lying features on the landscape, recreationists visiting the Cadiz Dunes area

would not have views of the Project. Views from vantage points in the Turtle Mountains and Old Woman Mountains consist of vast expanses of open desert land interspersed by scattered linear features that cross the landscape, including utility poles and lines, unpaved access roads, and railroad lines. Project facilities that could potentially be visible from the Old Woman Mountains and Turtle Mountains are discussed below.

Construction of Wellfield Facilities

Construction of the wellfield would be completed over an approximately 18-month period. Construction activities may be visible from Route 66 in the distance, but, as part of the expansive landscape of the Fenner Valley, they would not significantly affect the overall views from the roadway. The small disturbances seen from long range would not change the overall visual character of the open desert.

Construction of Conveyance Facilities

Most of the construction of the conveyance facilities would occur beyond the long range views from SR62 or SR 66. Local views of the construction activities would be temporary and would mix with those of the railroad. The visual character of the pipeline alignment is dominated by the proximity of the railroad. The construction would not adversely affect the visual character of the rail corridor. The construction zone would be returned to its pre-construction condition when complete.

Operation and Maintenance of Wellfield Facilities

The Project wellfield would introduce new facilities to the existing landscape. The proposed wellfield would be located in the north portion of the Project site in the vicinity of Fenner Gap (see Figure 4.1-3, Photo 3). A site plan for the wellfield is provided in Figure 3-6a and 3-6b. Each well site would typically be 80 feet by 130 feet enclosed by a 6-foot high chain-link-fence. Inside the fence, crushed gravel would surround the 35-foot by 75-foot concrete slab that supports the well equipment. Equipment would include pipe, various types of valves, gauges and meters, pump motor and starter equipment, a lighting panel, and a SCADA panel. The tallest equipment would be up to 12 feet high. The well sites would typically be at least 0.5 mile apart. Nighttime lighting at the well pads would be available but would only be used during nighttime maintenance visits.

Power to operate Project facilities would be provided by underground natural gas pipelines or overhead electric distribution lines. Project wellfield substations would be located in the Project wellfield. A typical substation would be 50 feet by 95 feet and enclosed with a 6-foot-high chain link fence. Equipment would include various batteries, a switcher separated from a transformer by a 10-foot-high concrete wall and connected by an overhead duct, two disconnect switches and an oil circuit breaker. A cable would connect the disconnect switch with underground power lines. The tallest elements on site would be the duct, at approximately 12 feet, and potentially the overhead power lines at approximately30 feet.

There are existing extraction wells on the Project site, as well as large active mining operations on the nearby Dry Lakes that, when viewed from afar, are not dominant visual elements in the

landscape. Because the wellfield facilities would have a low profile (less than 12 feet high), and because views would be limited to distant mountain vistas, contrasting elements introduced into the landscape would be minimal. Cadiz Inc. owns over 25,000 acres of mostly undeveloped land in the wellfield area and the proposed Project would utilize approximately 150 acres, or less than one percent. The wellfield and substation facilities would have a less than significant impact on the existing visual character.

Operation and Maintenance of Conveyance Facilities

Most or all of the Project water conveyance and power distribution facilities would be installed underground, so aesthetic impacts along the ARZC ROW would be temporary in nature and limited to the construction period. The ARZC rail line is one of several linear features that are currently visible from distant mountain vistas; the 200-foot-wide ROW is kept clear for safety reasons, and Cadiz-Rice Road and multiple perpendicular railroad access roads cross the landscape. Project construction within the ARZC ROW would therefore not introduce a new linear feature to the visual environment. The water conveyance pipeline would require minor aboveground appurtenances such as air/vacuum relief valves (see Figure 3-9 for a rendering of a typical air relief valve structure), blow-off facilities, and access manholes, which would not be visible to casual observers viewing the facilities from a distance.

As mentioned above, three scenarios are being considered for the CRA tie-in facility. Each of these scenarios is discussed in detail above, under Scenic Vistas. In addition to views from SR 62, the CRA tie-in could be visible to drivers using Cadiz-Rice Road and recreationists using nearby BLM wilderness areas. However, based on photographs taken from nearby vantage points, from which foreground views are dominant, none of the proposed facilities would substantially degrade the existing visual character of the Project site. Impacts associated with construction of conveyance facilities for the Groundwater Conservation and Recovery Component are therefore considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Light and Glare

Significance Threshold

Would the proposed Project create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?

Impact Analysis

Construction of Wellfield Facilities

Night lighting would be required during construction of the proposed wellfield, which would, in some cases, occur 24 hours a day. The area surrounding the Project site consists of uninhabited open space and there are no designated campgrounds or residences located near the Project site. However, if a series of lights in the wellfield or pipeline were permanently on and visible from surrounding areas, the nighttime character of the valley would be affected, but implementation of Mitigation Measure **AES-1** would reduce the potential impact to a less than significant level.

Construction of Conveyance Facilities

Night lighting would be noticeable in the Project area because there are few light sources in this area. Night lighting would be required during construction of the proposed conveyance, which would, in some cases, occur 24 hours a day. Worker housing areas and nighttime security lighting within staging areas would increase light in the area during the construction period. The area surrounding the Project site consists of uninhabited open space and railroad tracks. There are no designated campgrounds or residences located near the Project site. Mitigation Measure **AES-1** would reduce potential nighttime construction light impacts to a less than significant level.

Sources of glare would be minimal because of the relatively small scale of the proposed facilities and because the proposed forebay would be surrounded by a 6-foot-high berm. Glare would not be noticeable from the valley floor and would not dominate vistas from elevated viewpoints in the Project vicinity. Glare-related impacts associated with the proposed Project are therefore considered less than significant.

Operations

Wellpads within the wellfield may be equipped with permanent lighting, but these would only be used during infrequent nighttime maintenance activities. Implementation of Mitigation Measure **AES-2** would reduce potential nighttime lighting impacts to a less than significant level.

Mitigation Measures

AES-1: Construction lighting shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way, and towards the construction site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the construction site to the maximum extent feasible.

AES-2: Outdoor lighting shall be minimized and installed for safety and security purposes only. Outdoor lighting of Project facilities and access roads shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way and towards the Project site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the Project site to the maximum extent feasible.

Significance Conclusion

Less than significant with mitigation.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Scenic Vistas

Significance Threshold

Would the proposed Project have a substantial adverse effect on a scenic vista?

Impact Analysis

As described above, there are no designated State Scenic Highways or county-designated scenic routes in the Project vicinity. SR 62 and I-40 are considered eligible State Scenic Highways by Caltrans.[4] The Project would not be visible from I-40, which is located approximately 16 miles north of the Project site. SR 62 is located less than 1 mile south of the ARZC ROW and CRA intersection and runs parallel to the segments of ARZC ROW and CRA located near Rice, California.

The expanded wellfield would slightly increase the development in the desert beyond the Groundwater Conservation and Recovery Component. The spreading basins would be fenced with chain-link fence and shielded from surrounding views by a 4-foot earthen berm that would soften impacts to views from all sides. The Imported Water Storage Component would expand the footprint of the Groundwater Conservation and Recovery Component and would add spreading basins, but would not significantly alter scenic vistas. Impacts to scenic vistas would be less than significant.

The existing natural gas pipeline element would result in limited short-term impacts resulting from construction activities along the existing pipeline alignment. As the pipeline area is currently equipped with existing facilities, the upgrading and construction of new pump stations and air valves would not significantly alter scenic vistas. The construction of the pump stations would be designed to blend with the surrounding so as to less en visual impacts. Furthermore, construction of the element would not be visible from I-40 or SR 62. Thus, impacts to scenic vistas would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

[4] California Department of Transportation, *California State Scenic Highways*, http://www.dot.ca.gov/hq/LandArch/scenic_highways/index.htm, accessed October 2010.

Scenic Resources

Significance Threshold

Would the proposed Project substantially damage scenic resources, including but not limited to trees, rock outcroppings, and historic buildings within a State Scenic Highway?

Impact Analysis

As discussed above, there are no designated State Scenic Highways in the Project vicinity. Impacts on scenic views from eligible State Scenic Highways are discussed above under Scenic Views. However, the Project would have no impact on scenic resources within designated State Scenic Highways.

In addition, as previously discussed, the existing natural gas pipeline construction area is already disturbed with existing facilities and is not located within designated State Scenic Highways. Thus, no impacts to scenic resources within designated State Scenic Highways would occur.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Visual Character

Significance Threshold

Would the proposed Project substantially degrade the existing visual character or quality of the site and its surroundings?

Impact Analysis

As discussed above under the Groundwater Conservation and Recovery Component, views in the Project area are dominated by the immediate foreground (lands located within 0.5 mile of the viewer) and enhanced by views of distant mountain ranges. Several BLM Wilderness Areas are located within the vicinity of the Project site including the Cadiz Dunes, Old Woman Mountains, and Turtle Mountains Wilderness Areas. The Cadiz Dunes are low-lying features on the landscape and viewers recreating in the Dunes area would not have views of the Project since foreground views would dominate. Currently, visitors to the Turtle Mountains and Old Woman Mountains Wilderness Areas experience views of vast expanses of open desert land interspersed by linear features including utility poles and lines, unpaved roads, and railroad tracks. In addition to the impacts described for Groundwater Conservation and Recovery Component facilities, under the Imported Water Storage Component the proposed spreading basins could be visible from the Old Woman Mountains and Turtle Mountains Wilderness Areas.

The Project spreading basins would be located on Cadiz Property northeast of the Fenner Gap. The spreading basins would encompass up to 390 acres, with about 330 acres of usable recharge area. Figure 4.1-1 shows the approximate location of the proposed spreading basins. When empty, the spreading basins would blend in with the surrounding landscape. The berms forming the sides of the basins have a maximum height of 4 to 5 feet and would be composed of native soils of similar texture and color to those of the adjacent landscape. The basins would be surrounded by chain-link fence. Removal of vegetation from up to 390 acres would be noticeable from nearby mountain vistas. However, views in the Project vicinity tend to be dominated by foreground components, and therefore the overall visual effect of the spreading basins, considered in a regional context, would be minimal. When filled with water, the spreading basins would contrast with the existing landscape when viewed from mountain vistas, but would not significantly alter the character of the valley or long range views that include sporadic developments and linear corridors. Impacts to visual character are therefore considered less than significant.

The existing natural gas pipeline is currently equipped with metering facilities, mainline valves, and pressure control valves located along intervals of the pipeline. The construction of the new air relief valves and pump stations would not introduce significant new obstructions to the visual resources of the area.The pump station facilities would be designed and built to match the existing landscape and area. As the pipeline area is already disturbed and currently equipped with existing facilities, the upgrading of the pipeline and construction of new pump stations and air valves would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Light and Glare

Significance Threshold

Would the proposed Project create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?

Impact Analysis

As discussed above under the Groundwater Conservation and Recovery Component, night lighting would be required for expansion of the Project wellfield under the Imported Water Storage Component of the proposed Project. The area surrounding the Project site consists of uninhabited open space and there are no designated campgrounds or residences located near the Project site. However, permanent night lighting could affect the character of the valley.

Implementation of Mitigation Measures **AES-1** and **AES-2** would reduce the potential impacts to a less than significant level.

Under the Imported Water Storage Component, some glare would be generated by water reflecting off of the proposed spreading basins, which would be constructed on up to 390 acres of land in the northern portion of the Project site (with about 330 acres of usable recharge area). However, the Project spreading basins would be filled on an intermittent basis. In some years, they may contain water for several weeks or months; at other times, the spreading basins may be dry for a year or more. The proposed spreading basins would not be noticeable from the valley floor and would not dominate vistas from elevated viewpoints in the Old Woman Mountains or Turtle Mountains. Nighttime security lighting would be kept off unless needed for maintenance. Glare-related impacts associated with the Imported Water Storage Component are therefore considered less than significant.

Construction activities at the existing natural gas pipeline would not create light and glare impacts since construction activities would likely not occur at night. During operation of the pipeline and pump stations, permanent lighting at the pump stations would be directed downwards to limit light spillover. Implementation of Mitigation Measures **AES-1** and **AES-2** would ensure that light and glare impacts remain at less than significant levels.

Mitigation Measures

Implement Mitigation Measures **AES-1** and **AES-2**.

Significance Conclusion

Less than significant with mitigation.

Mitigation Measure Summary Table

Table 4.1-1 on the following page presents the impacts and mitigation summary for Aesthetics.

TABLE 4.1-1
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Scenic Vistas	None required	Less than significant
Scenic Resources	None required	No impact
Visual Character	None required	Less than significant
Light and Glare	**AES-1** and **AES-2**	Less than significant with mitigation
Imported Water Storage Component		
Scenic Vistas	None required	Less than significant
Scenic Resources	None required	No impact
Visual Character	None required	Less than significant
Light and Glare	**AES-1** and **AES-2**	Less than significant with mitigation

4.2 Agriculture and Forestry Resources

The purpose of this Section is to identify existing agriculture and forest resources within the Project area, analyze potential agriculture and forest resources associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. This Section also addresses potential conflicts between the proposed Project and ongoing agricultural activities on and around the Project site.

Information presented in this Section is based on site photographs and field visits, local planning documentation, and operational data from ongoing agricultural operations. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*. In 2010, the *CEQA Guidelines* were amended to change the title of the "Agricultural Resources" Section to "Agriculture and Forestry Resources," and the thresholds were expanded to include potential impacts on forest land and timberland. While these thresholds are listed in Section 4.2.3 (Significance Threshold Criteria), the Project site does not contain forest or timberland-related resources.

4.2.1 Environmental Setting

State

More than one-quarter of California's landmass is used for agriculture. Just over half of the 27.6 million acres of agricultural land is pasture and rangeland and about 40 percent is cropland.[1] Agriculture in California generated nearly 36.6 billion in cash receipts in 2007. California has been the nation's top agricultural state in terms of cash receipts every year since 1948 and has gradually increased its share of U.S. farm cash receipts from 9.5 percent in 1960 to 12.8 percent in 2007. Including multiplier effects, California farms and closely related processing industries generate 7.3 percent of the State's private sector labor force and account for 5.6 percent of the State labor income (2002). For every $1 billion in farm sales, there are 18,000 jobs created in the State, about 11,000 in the farm sector itself plus about 7,000 in other industries. Agricultural employment has been reduced in recent years as result of the current recession as well as by fluctuations in the availability of water for irrigation and the conversion of agricultural land to other developed uses. In 2009 the State's Employment Development Department (EDD) estimated that agriculture employed a seasonally adjusted average of 375,800 people, compared to 390,900 in 2008.[2]

1 Agricultural Issues Center, University of California Davis, *The Measure of California Agriculture*, August 2009, page 1.

2 California Employment Development Department, Labor Market Information Division, *Detailed Agricultural Employment and Earnings Data* 2009, www.edd.ca.gov, accessed June 2010; California Employment Development Department, Labor Market Information Division, *California's Agricultural Employment Report 2008*, www.edd.ca.gov, accessed June 2010.

Regional

The Project is located in the southeastern portion of California, in the County of San Bernardino County. The County estimates that approximately 90 percent of the County's land area is desert.[3] Agriculture accounts for approximately 41,793 acres, or 2.32 percent, of County land area and has decreased over time. Despite the small land area devoted to agriculture, in 2009, the value of agricultural production in San Bernardino County was approximately $355,379,500, and its top five crops (milk, eggs, cattle and calves, alfalfa, and replacement heifers) generated approximately $94,785,670.[4] The San Bernardino National Forest, located more than 70 miles southwest of the Project site, covers approximately 823,000 acres in the southwestern region of the County. The San Bernardino National Forest contains wilderness areas, visitor centers, recreation residences, campgrounds, resorts, and target shooting ranges and is home to 71 threatened, endangered, or sensitive animal species and 85 plant species.[5]

Local

The San Bernardino County General Plan agricultural land use designations for the Project area and the surrounding areas are shown in **Figure 4.2-1**. All of the lands within the Project site and vicinity are designated in the San Bernardino County General Plan as Resource Conservation (RC) areas with the exception of 9,600 acres in the northern portion of the Cadiz Property near Cadiz, California which are designated as Agriculture (AG). For a discussion of the applicability of the County General Plan and Development Code policies to the Project, please see Section 4.10.3 (*Consistency with Land Use Plans)* of the Land Use and Planning Section. The AG designation provides for commercial agricultural operations, agricultural support services, rural residential uses, open space and recreation uses, and similar and compatible uses. The AG designation in Cadiz, California was made in 1993 upon approval by the County of San Bernardino Board of Supervisors of the 9,600-acre Cadiz Valley Agricultural Development Project.[6] Active agricultural cultivation at the Cadiz AG-designated lands currently covers 1,600 acres (Sections 21, 27, and 33) (see **Table 4.2-1**).

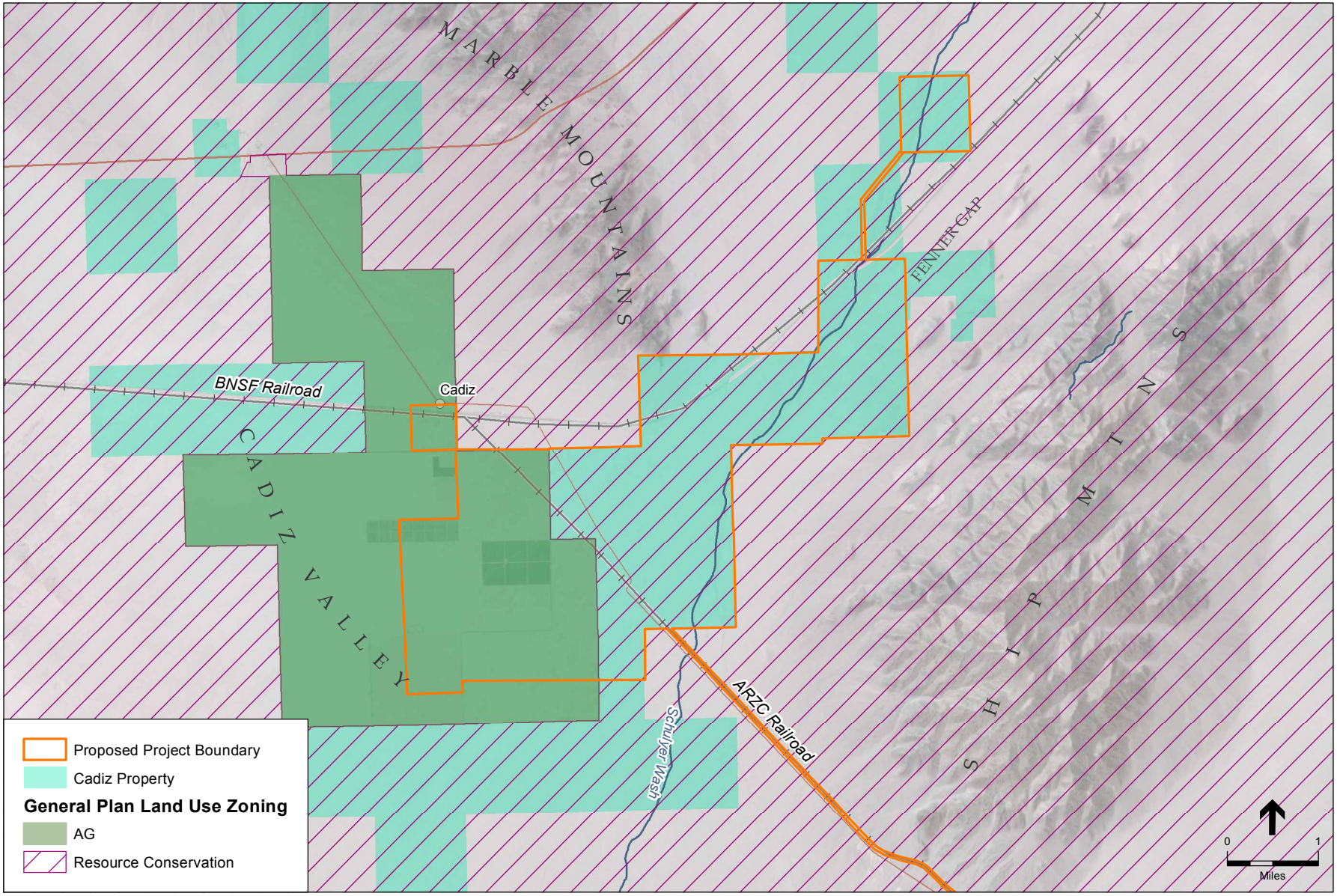
Approximately 2,295 acres of the 9,600 acres of AG-designated lands are located within the proposed wellfield. Only 240 acres located within the proposed wellfield development area are engaged in active agricultural cultivation as of November 2011.

3 County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report*, February 2007, page VI-1.

4 California Farm Bureau Federation, *San Bernardino County Farm Bureau*, http://www.cfbf.com/counties/?id=36, accessed October 2010.

5 U.S. Department of Agriculture, Forest Service, San Bernardino National Forest, *About the Forest*,www.fs.fed.us/r5/sanbernardino/, accessed October 2010.

6 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I,* September 2001, page 5-1.



SOURCE: Bing Maps, 2010; ESRI, 2010; Cadiz Inc., 2010; San Bernardino Co., 2010; and ESA, 2010

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.2-1

Agricultural Zoning in the Project Area

Cadiz agricultural operations receive water from seven existing wells within the AG lands. An extensive irrigation system consisting of pipes and hoses delivers water directly to each individual plant or tree. The grapes/raisins and row crops are irrigated with water-saving drip systems, and the citrus trees are irrigated with microspray emitters. Generally, agricultural production responds to market conditions such as changes in the demand for specific agricultural products at specific times of the year.

TABLE 4.2-1
CURRENT AGRICULTURAL CULTIVATION IN THE PROJECT AREA

Crop	Acres
Black Seedless Grapes	35
Red Flame Seedless Grapes	125
Lisbon and Eureka Lemons	370
Row Crops/ Fallow	1,070
TOTAL	**1,600**

SOURCE: Cadiz Inc., 2011.

4.2.2 Regulatory Framework

Federal

U.S. Forest Service–Department of Agriculture

Under authority of the Department of Agriculture, the U.S. Forest Service manages the majority of federal lands within the mountain regions of San Bernardino County. These are mostly located within the Angeles and San Bernardino National Forests along the southwestern boundary of San Bernardino County. No U.S. Forest Service lands are located in the Project vicinity.

Farmland Protection Policy Act

The Farmland Protection Policy Act (FPPA) of 1981 is intended to minimize the unnecessary conversion of farmland into nonagricultural uses. The FPPA established the Farmland Protection Program (FPP) and a Land Evaluation and Site Assessment (LESA) system. The Natural Resources Conservation Service administers the FPP, which is a voluntary program that provides funds to help purchase development rights to keep productive farmland in agricultural use. The program provides matching funds to state, local, and tribal government entities and nongovernmental organizations with existing farmland protection programs to purchase conservation easements. Participating landowners agree not to convert the land to nonagricultural uses and to retain all property rights for future agriculture. A minimum 30-year term is required for conservation easements and priority is given to applications with perpetual easements. The

Natural Resources Conservation Service provides up to 50 percent of the fair market value of the easements.[7]

State

California Important Farmland Inventory System and Farmland Mapping and Monitoring Program

The California Department of Conservation, Farmland Mapping and Monitoring Program (FMMP) identifies lands that have agricultural value and maintains a statewide map of agricultural lands in its Important Farmlands Inventory (IFI). IFI classifies land based upon its productive capabilities, which is based on many characteristics, including fertility, slope, texture, drainage, depth, salt content, and availability of water for irrigation. The State employs a variety of classification systems to determine the suitability of soils for agricultural use. The two most widely used systems are the Capability Classification System and the Storie Index. The Capability Classification System classifies soils from Class I to Class VIII based on their ability to support agriculture with Class I being the highest quality soil. The Storie Index considers other factors such as slope and texture to arrive at a rating.

The California Department of Conservation, Division of Land Resource Protection maintains the FMMP and monitors the conversion of farmland to and from agricultural use through its Important Farmland Inventory System. Farmlands are divided into the following categories based on their suitability for agriculture:

Prime Farmland. This land has the best combination of physical and chemical characteristics for crop production. When treated and managed, its soil quality, growing season, and irrigation supply produce sustained high crop yields.

Unique Farmland. This land does not meet the criteria for Prime Farmland or Farmland of Statewide Importance, but has produced specific crops with high economic value.

Farmland of Statewide Importance. This is land that does not qualify as Prime Farmland but has a good combination of irrigation and physical and chemical characteristics for crop production.

Farmland of Local Importance. This land is either currently producing crops or has the capability to produce crops, but does not meet the criteria of the categories above.

Grazing Land. This is land with vegetation that is suitable for grazing livestock.

Other Lands. This land does not meet the criteria of any of the other categories.

Additional categories used in the FMMP mapping system are “urban and built-up lands,” and “lands committed to nonagricultural use.” The mapping system uses a minimum mapping unit size of 10 acres. FMMP classifications are based on soil quality and irrigation status.[8] They differ

[7] U.S. Department of Agriculture, Natural Resources Conservation Service, *Farmland Protection Policy Act*, http://www.nrcs.usda.gov/programs/fppa/, accessed October 2010.

[8] California Department of Conservation, *Farmland Mapping & Monitoring Program*, http://conservation.ca.gov/dlrp/fmmp/Pages/Index.aspx, accessed October 2010.

from general plan and zoning designations because they are used to evaluate the type and amount of farmlands, rather than to designate land-use type or place restrictions on development or use. Instead, the FMMP uses these designations as part of its neutral reporting program that classifies land based on its suitability for agriculture. The FMMP also produces a biannual report on the amount of land converted from agricultural to nonagricultural use. The U.S. Department of Agriculture Soil Conservation Service (SCS), now the Natural Resource Conservation Service (NRCS), has not mapped soils in the Project area; therefore no soils in the area are currently designated as agricultural soils. Similarly, the California Resources Agency's FMMP does not cover the Project area. None of the lands in the vicinity of the Project are designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance.

Williamson Act

The Williamson Act (California Land Conservation Act of 1965, Section 51200), was adopted in order to encourage the preservation of the State's agricultural lands and to discourage its conversion to urban uses. In order to preserve agricultural uses, this Act established an agricultural preserve contract procedure through which any county or city within the State taxes landowners of Agricultural Preserve contract land at a lower rate using a scale based on the actual use of the land for agricultural purposes, as opposed to its unrestricted market value. In return, the owners guarantee that these properties will remain under agricultural production for a 10-year period. This contract is renewed automatically unless a Notice of Non-Renewal is filed by the owner. In this manner, each agricultural preserve contract (at any given date) is always operable at least 9 years into the future.

Williamson Act contracts can be cancelled earlier than the 10-year period upon approval of the appropriate local jurisdiction, which must make findings that cancellation is in the public interest or is consistent with the purposes of the California Land Conservation Act. Generally, the landowner must also pay a fee equal to 12½ percent of the property value.[9] Neither the Project site nor the surrounding areas are under Williamson Act contracts.

4.2.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines*, Appendix G, a project may be deemed to have a significant effect on the environment with respect to agricultural and forest resources if it would:

- Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use;
- Conflict with existing zoning for agricultural use or a Williamson Act contract;

[9] California Department of Conservation, *Williamson Act 2006*, http://www.consrv.ca.gov/dlrp/lca/Pages/Index.aspx, accessed October 2010.

- Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g)), timberland (as defined by Public Resources Code Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104(g);
- Result in the loss of forest land or conversion of forest land to non-forest use; or
- Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use or conversion of forest land to non-forest use.

Methodology

The analysis identifies agriculture and forest land use designations in the Project area and assesses the Project's consistency with those designated land uses. The analysis also identifies the Project's potential to affect existing agricultural uses. The analysis does not employ the California Agricultural LESA Model developed by the Department of Conservation since no existing agricultural land or designated Prime or Important Farmland would be converted to non-agricultural uses.

Groundwater Conservation and Recovery Component

Farmland Conversion

Significance Threshold

Would the Project convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

Impact Analysis

Because the NRCS has not mapped soils in the Project area, no soils in the area have been designated as agricultural soils, and the FMMP of the California Resources Agency does not cover the Project area. Therefore, neither the Project site nor the surrounding areas have been designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance. A soils study performed on part of the Project site in 1986 found the soils to be predominantly loamy sands and sandy loams. Shallow, naturally cemented soils known as caliche are not known to occur locally in the Project area.[10] Therefore, the Groundwater Conservation and Recovery Component of the proposed Project would result in no impact to Prime Farmland, Unique Farmland, or Farmland of Statewide Importance.

Mitigation Measures

None required.

[10] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement Volume I*, September 2001, page 5-3.

Significance Conclusion

No impact.

Agricultural Zoning or Williamson Act Contract

Significance Threshold

Would the proposed Project conflict with existing zoning for agricultural use or a Williamson Act contract?

Impact Analysis

As described above, 9,600 acres of land in the Project vicinity and 2,295 acres of land within the Project boundaries are zoned for agriculture. The Project would construct extraction wells, pumps and motors, well piping and collector piping, access/maintenance roads, and power distribution facilities on a portion of the lands zoned as AG within the proposed Project site. The wells and the pipelines linking the Project wellfield would be placed outside of and along the edge of the cultivated sections to the maximum extent feasible, in order to avoid long-term impacts to agricultural lands. This is consistent with current zoning of the land and the irrigation system currently in place.

In general, construction of the underground piping and manifold system and power distribution facilities, with minor restrictions along the pipeline corridors to maintain access and for safety reasons, would not preclude lands zoned as AG from continuing to support active agricultural operations. Nor would the Project necessarily eliminate the existing agricultural activities. Agriculture operations may remain active so long as the total groundwater extraction is limited to the 50-year average of 50,000 AFY. Following construction, approximately 0.25 to 0.5 acre around each well would be kept clear for purposes of maintenance and operations, similar to any agricultural well. If agricultural operations are eliminated with implementation of the Project in order to minimize water extractions, or as a result of market conditions, this would not be inconsistent with the agricultural zoning of the property or the current entitlement, which governs the agricultural operation at the property. Therefore, construction and operation of the Project facilities would not conflict with the existing AG zoning.

The proposed Project site and the surrounding areas are not under Williamson Act contracts. Therefore, the Groundwater Conservation and Recovery Component of the proposed Project would not require the cancellation of any Williamson Act contracts.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Forest Zoning

Significance Threshold

Would the proposed Project conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g)), timberland (as defined by Public Resources Code Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104(g)?

Impact Analysis

The Project site is not located on or near any forest land, and the proposed Project would not conflict with any existing forest-land zoning. The Groundwater Conservation and Recovery Component of the Project would have no impact on existing zoning of forest land.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Forest Land Conversion

Significance Threshold

Would the proposed Project result in loss of forest land or conversion of forest land to non-forest use?

Impact Analysis

As mentioned above, the proposed Project is not located on any forest land and would not result in the loss of forest land or convert forest land to non-forest use. Therefore, the Groundwater Conservation and Recovery Component of the Project would have no impact on forest land.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Agricultural Uses

Significance Threshold

Would the proposed Project involve other changes in the existing environment which, due to their location or nature, could result in the conversion of Farmland to non-agricultural use or forest

land to non-forest use?

Impact Analysis

The majority of the Project area is undeveloped, with the exception of approximately 1,600 acres of active agricultural lands located in the northwest portion of the Cadiz Property (Sections 21, 27, and 33 of Township 5N, Range 14E). There are currently seven groundwater production wells located in the central portion of the Cadiz Property that supply irrigation water for the existing agricultural operation. The wells are located in Sections 21, 22, 27, 28, and 33 of Township 5N, Range 14E. Historically, approximately 5,000 to 6,000 acre-feet of water has been used on an annual basis to irrigate the agricultural operations. This annual usage was reduced beginning in 2007 in connection with the removal of approximately 500 acres of vineyard that had reached the end of its commercial life. Based on the current crop mix, the agricultural operations are using approximately 1,800 -1,900 acre-feet of water per year. For the Groundwater Conservation and Recovery Component of the Project, all seven wells would be upgraded and diesel engines currently used to power the wells would be converted to natural gas. Five of the seven wells would become part of the Project wellfield manifold system. The existing agricultural operations may be eliminated to ensure that no more than the 50-year average of 50,000 AFY is extracted. However, the agricultural lands would remain zoned for AG and could be returned to agricultural operations at the end of the Project term.

Curtailment of agriculture could also result from various other factors, including the economic viability of agricultural products grown at the Cadiz Valley Agricultural Development site, the availability of a farm-worker labor force, climate conditions, and other agricultural considerations such as the presence or absence of pests. In the event agricultural acreage is removed from production, existing provisions contained in the County of San Bernardino Mitigation Monitoring and Compliance Program (SCH #890202) ensures such land is maintained to prevent soil erosion and any potential for wind-mobilized dust. If agricultural activities were curtailed, Cadiz would still be subject to the same soil erosion protection measures. Therefore, potential impacts to agricultural operations would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Farmland Conversion

Significance Threshold

Would the Project convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

Impact Analysis

NRCS has not mapped soils in the Project area, and no soils in the area have been designated as agricultural soils. Therefore, neither the Project site nor the surrounding areas have been designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance. The Imported Water Storage Component of the Project would have no impact on Prime Farmland, Unique Farmland, or Farmland of Statewide Importance.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Agricultural Zoning and Williamson Act Contract

Significance Threshold

Would the proposed Project conflict with existing zoning for agricultural use or a Williamson Act contract?

Impact Analysis

As described above, 9,600 acres of land in the Project vicinity and 2,295 acres of land within the Project site are zoned AG. The San Bernardino Development Code defines the AG land-use zoning designation as land that provides sites for commercial agricultural operations, agriculture support services, rural residential uses, and similar and compatible uses. The Imported Water Storage Component of the Project would expand the Project wellfield. Some of the wellfield area may be within lands zoned as AG. The wells and the pipelines linking the Project wellfield would be placed outside of and along the edge of the cultivated sections, to the maximum extent feasible, in order to avoid direct impacts to agricultural lands. Approximately 0.25 to 0.5 acre around each well would be kept clear for purposes of maintenance and operations. As with the Groundwater Conservation and Recovery Component, expansion of the wellfield under the Imported Water Storage Component would not preclude lands zoned as AG, with minor restrictions along the pipeline corridors to maintain access and for safety reasons, from continuing

to support active agricultural operations. The proposed spreading basins and most of the expanded wellfield would be located in areas that are not zoned AG. Therefore, construction and operation of the Project facilities would not conflict with the existing AG zoning.

The proposed Project site and the surrounding areas including along the existing natural gas pipeline alignment are not under Williamson Act contracts. Therefore, the Imported Water Storage Component of the proposed Project would not require the cancellation of any Williamson Act contracts.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Forest Zoning

Significance Threshold

Would the proposed Project conflict with existing zoning for, or cause *re-zoning* of, forest land (as defined in Public Resources Code Section 12220(g)), timberland (as defined by Public Resources Code Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104(g)?

Impact Analysis

The proposed Project is not located on or near any forest land, and the Project would not conflict with any existing forest-land zoning. The Imported Water Storage Component of the Project would have no impact on existing zoning of forest land.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Forest Land Uses

Significance Threshold

Would the proposed Project result in the loss of forest land or conversion of forest land to non-forest use?

Impact Analysis

As with forest zoning, the proposed Project is not located on any forest land and would not result in the loss of forest land or convert forest land to non-forest use. Therefore, the Imported Water Storage Component of the Project would have no impact on forest land.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Agricultural Uses

Significance Threshold

Would the proposed Project involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use or forest land to non-forest use?

Impact Analysis

As described above, the majority of the Project area is undeveloped, with the exception of approximately 1,600 acres of active agricultural lands located in the northwest portion of the Cadiz Property (Sections 21, 27 and 33 of Township 5N, Range 14E). Approximately 240 acres of land within the Project site are currently farmed. The Imported Water Storage Component would not result in the conversion of any agricultural lands not affected by the Groundwater Conservation and Recovery Component. No additional impacts to agricultural lands beyond those discussed above under the Groundwater Conservation and Recovery Component would result during construction or operation of the Imported Water Storage Component. Impacts are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Mitigation Measure Summary Table

Table 4.2-2 presents the impacts and mitigation summary for Agriculture and Forestry Resources.

TABLE 4.2-2
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Farmland Conversion	None required	No impact
Agricultural Zoning and Williamson Act Contract	None required	Less than significant
Forest Zoning	None required	No impact
Forest Land Conversion	None required	No impact
Agricultural Uses	None required	Less than significant
Imported Water Storage Component		
Farmland Conversion	None required	No impact
Agricultural Zoning and Williamson Act Contract	None required	Less than significant
Forest Zoning	None required	No impact
Forest Land Conversion	None required	No impact
Agricultural Uses	None required	Less than significant

4.3 Air Quality

The purpose of this Section is to identify existing air quality conditions within the Project area, analyze potential impacts to air quality associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Emissions of greenhouse gases resulting from the proposed Project and their potential to affect climate change are presented and discussed in Section 4.7, Greenhouse Gas Emissions. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.3.1 Air Quality Overview

Criteria Air Pollutants

The Federal Clean Air Act (FCAA) requires the U.S. Environmental Protection Agency (EPA) to identify National Ambient Air Quality Standards (national standards) to protect public health and welfare. National standards have been established for ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, respirable particulate matter (PM10 and PM2.5), and lead. These pollutants are called "criteria" air pollutants. California has adopted more stringent ambient air quality standards for the criteria air pollutants (referred to as state ambient air quality standards) and has adopted air quality standards for some pollutants for which there is no corresponding national standard. The criteria pollutants are described below:

Ozone. Ozone is produced in the atmosphere through a complex series of photochemical reactions involving reactive organic gases (ROG) and nitrogen oxides (NOx). Ozone is not emitted directly into the atmosphere, but is a secondary air pollutant, requiring strong sunlight for approximately three hours to be produced. Short-term exposure to ozone can irritate the eyes and cause constriction of the airways that can result in health problems particularly for individuals with existing respiratory diseases.

Carbon Monoxide (CO). Elevated CO concentrations are caused by vehicular traffic and generally occur as a local effect near roadways and intersections, although under inversion conditions, CO concentrations may be distributed more uniformly over a larger area. When inhaled at high concentrations, CO keeps oxygen from reaching the brain and heart causing acute system failure. CO concentrations have declined dramatically in California as a result of cleaner burning vehicle engines.

Respirable Particulate Matter (PM10 and PM2.5). PM10 is particulate matter that is 10 microns or less in diameter. PM2.5 is particulate matter 2.5 microns or less in diameter. PM10 and PM2.5 represent fractions of particulate matter that can be inhaled into the lungs and can cause adverse health effects. Large dust particles (diameter greater than 10 microns) settle out rapidly and are easily filtered by human breathing passages. The remaining fraction of particles, PM10 and PM2.5, are a health concern particularly at levels above the federal and state ambient air quality standards. PM2.5 (including diesel exhaust particles) is thought to have greater effects on human health than PM10.

Nitrogen Dioxide (NO_2). NO_2 is a reddish brown gas that is a by-product of combustion processes. Automobiles and industrial operations are the main sources of NO_2. Aside from its contribution to ozone formation, nitrogen dioxide can increase the risk of acute and chronic respiratory disease and reduce air visibility. NO_2 may be visible as a coloring component of a brown cloud on high pollution days, especially in conjunction with high ozone levels.

Sulfur dioxide (SO_2). SO_2 is a combustion product of sulfur-containing fuels such as coal and diesel. SO_2 is also a precursor to the formation of atmospheric sulfate. SO_2 can contribute to atmospheric sulfuric acid formation that could precipitate downwind as acid rain. Fuels used in California are generally low in sulfur and as a result SO_2 air pollution is generally not significant in the State.

Lead. Lead is emitted into the atmosphere from combustion of lead-containing fuels. Over-exposure to lead has a range of adverse neurotoxin health effects that are most toxic to children. The phase-out of leaded gasoline in California has resulted in dramatically decreased levels of atmospheric lead. Ambient lead concentrations in the Project area meet both the federal and State standards.

Non-Criteria Air Pollutants

Toxic Air Contaminants

Toxic Air Contaminants (TACs) are airborne substances that are capable of causing short-term (acute) or long-term (chronic or carcinogenic, i.e., cancer causing) adverse human health effects. TACs include both organic and inorganic chemical substances. They may be emitted from a variety of common sources including gasoline stations, automobiles, dry cleaning facilities, industrial operations, and painting operations. The current State of California list of TACs includes over 200 compounds, including particulate emissions from diesel-fueled engines.

Odorous Emissions

Though offensive odors from stationary sources rarely cause any physical harm, they still remain unpleasant and can lead to public distress generating citizen complaints to local governments. The occurrence and severity of odor impacts depend on the nature, frequency, and intensity of the source; wind speed and direction; and the sensitivity of receptors. Odorous sources can include wastewater treatment plants, food processing and rendering facilities, chemical plants, composting facilities, landfills, waste transfer stations, and dairies.

Air Quality Standards

Table 4.3-1 presents current national and State ambient air quality standards and provides a brief discussion of the related health effects and principal sources for each pollutant.

Pursuant to the 1990 FCAA Amendments, the EPA classifies air basins (or portions thereof) as "attainment" or "nonattainment" for each criteria air pollutant, based on whether or not the national standards have been achieved. **Table 4.3-2** shows the current attainment status of the Mojave Desert Air Basin (MDAB), where the Project is located. Air quality in the MDAB meets all federal ambient air quality standards except for PM10. However, State ozone standards for the entire MDAB are in nonattainment due largely to influences from the adjacent south coast air basin.

TABLE 4.3-1
CALIFORNIA AND NATIONAL CRITERIA AIR POLLUTANT STANDARDS, EFFECTS, AND SOURCES

Pollutant	Averaging Time[a]	State Standard	National Standard	Pollutant Health and Atmospheric Effects	Major Pollutant Sources
Ozone	1 hour	0.09 ppm	---	High concentrations can directly affect lungs, causing irritation. Long-term exposure may cause damage to lung tissue.	Formed when reactive organic gases (ROG) and nitrogen oxides (NOx) react in the presence of sunlight. Major sources include on-road motor vehicles, solvent evaporation, and commercial / industrial mobile equipment.
	8 hours	0.07 ppm[b]	0.075 ppm		
Carbon Monoxide	1 hour	20 ppm	35 ppm	Classified as a chemical asphyxiant, carbon monoxide interferes with the transfer of fresh oxygen to the blood and deprives sensitive tissues of oxygen.	Internal combustion engines, primarily gasoline-powered motor vehicles.
	8 hours	9.0 ppm	9 ppm		
Nitrogen Dioxide	1 hour	0.18 ppm	0.100 ppm	Irritating to eyes and respiratory tract. Colors atmosphere reddish-brown.	Motor vehicles, petroleum refining operations, industrial sources, aircraft, ships, and railroads.
	Annual Avg.	0.030	0.053 ppm		
Sulfur Dioxide	1 hour	0.25 ppm	0.075 ppm	Irritates upper respiratory tract; injurious to lung tissue. Can yellow the leaves of plants, destructive to marble, iron, and steel. Limits visibility and reduces sunlight.	Fuel combustion, chemical plants, sulfur recovery plants, and metal processing.
	24 hours	0.04 ppm	---		
Respirable Particulate Matter (PM10)	24 hours	50 μg/m3	150 μg/m3	May irritate eyes and respiratory tract, decreases in lung capacity, cancer and increased mortality. Produces haze and limits visibility.	Dust and fume-producing industrial and agricultural operations, combustion, atmospheric photochemical reactions, and natural activities (e.g., wind-raised dust and ocean sprays).
	Annual Avg.	20 μg/m3	---		
Fine Particulate Matter (PM2.5)	24 hours	---	35 $\mu g/m^3$	Increases respiratory disease, lung damage, cancer, and premature death. Reduces visibility and results in surface soiling.	Fuel combustion in motor vehicles, equipment, and industrial sources; residential and agricultural burning; Also, formed from photochemical reactions of other pollutants, including NOx, sulfur oxides, and organics.
	Annual Avg.	12 $\mu g/m^3$	15 $\mu g/m^3$		
Lead	Monthly Avg.	1.5 $\mu g/m^3$	---	Disturbs gastrointestinal system, and causes anemia, kidney disease, and neuromuscular and neurological dysfunction.	Present source: lead smelters, battery manufacturing & recycling facilities. Past source: combustion of leaded gasoline.
	Quarterly	---	1.5 $\mu g/m^3$		
Hydrogen Sulfide	1 hour	0.03 ppm	No National Standard	Nuisance odor (rotten egg smell), headache and breathing difficulties (higher concentrations).	Geothermal Power Plants, Petroleum Production and refining.
Sulfates	24 hour	25 $\mu g/m^3$	No National Standard	Breathing difficulties, aggravates asthma, reduced visibility.	Produced when sulfates react with the SO2 in the air.
Visibility Reducing Particles	8 hour	Extinction of 0.23/km; visibility of 10 miles or more	No National Standard	Reduces visibility, reduced airport safety, lower real estate values, discourages tourism.	See PM2.5.

ppm = parts per million; $\mu g/m^3$ = micrograms per cubic meter.
… = No Standard.

a The averaging time is the interval of time over which the sample results are reported.
b This concentration was approved by the Air Resources Board on April 28, 2005 and became effective May 17, 2006.

SOURCE: California Air Resources Board, *Ambient Air Quality Standards*, September 2010, page 1; California Air Resources Board, *ARB Fact Sheet: Air Pollution Sources, Effects and Control,* http://www.arb.ca.gov/research/health/fs/fs2/fs2.htm, accessed January 2011.

TABLE 4.3-2
MOJAVE DESERT AIR BASIN ATTAINMENT STATUS

	Designation/Classification	
Pollutant	**Federal Standards**	**State Standards**
Ozone – one hour	No Federal Standard[a]	Nonattainment/Moderate
Ozone – eight hour	Attainment/Unclassified[b]	Nonattainment
PM10	Nonattainment	Nonattainment
PM2.5	Attainment/Unclassified	Unclassified
CO	Attainment/Unclassified	Attainment
Nitrogen Dioxide	Attainment/Unclassified	Attainment
Sulfur Dioxide	Attainment/Unclassified	Attainment
Lead	Attainment	Attainment
Hydrogen Sulfide	No Federal Standard	Unclassified
Sulfates	No Federal Standard	Attainment
Visibility Reducing Particles	No Federal Standard	Unclassified

a The Federal One Hour Ozone National Ambient Air Quality Standard was revoked on June 15, 2005.
b An unclassified designation means that the area is unspecified.

SOURCE: California Air Resources Board, *Area Designation Maps,* http://www.arb.ca.gov/desig/adm/adm.htm, accessed January 2011.

4.3.2 Environmental Setting

The Project site is situated predominantly in undeveloped remote desert lands. The area is located on broad alluvial fans stretched between steep mountain ranges. The area is sparsely developed with some agricultural, residential, and mining developments, but for the most part is remote desert open space. The following sections describe the regional and local setting.

Regional Setting

San Bernardino County is divided into three regions including the western valley, the mountains, and the high desert. The Project would be located in the high desert region within the MDAB. The MDAB is comprised of four air districts: 1) the Kern County Air Pollution Control District (KCAPCD), 2) the Antelope Valley Air Quality Management District (AVAQMD), 3) the Mojave Desert Air Quality Management District (MDAQMD), and 4) the eastern portion of the South Coast Air Quality Management District (SCAQMD). The Project lies entirely within the MDAQMD, which includes the desert valleys in eastern San Bernardino County and the eastern portion of Riverside County.

The MDAB is comprised of sparsely populated desert open space consisting of rugged mountain ranges interspersed with broad alluvial valleys draining to central dry lake beds or ultimately to the Colorado River. Many of the lower mountain ranges rise from 1,000 to 4,000 feet above the valley floor, exceeding elevations of 7,000 feet above mean sea level. Prevailing winds in the MDAB are out of the west and southwest. However, air quality in the Cadiz Valley is affected by winds from the northwest trending southeastward. Periodic high wind events lift sand and dust into the air primarily from the edges of Bristol Dry Lake. Over the years, sand has been

transported southward in the valley forming dunes at the south end of the Cadiz Valley known as the Cadiz Dunes.[1]

Climate and Meteorology

Meteorological conditions such as wind speed, direction, and air temperature gradients interact with physical landscape features to determine the movement and dispersal of criteria air pollutants. During summer months, a Pacific Subtropical High Cell that sits off the coast generally influences the MDAB, inhibiting cloud formation and encouraging daytime solar heating. The MDAB is rarely influenced by cold air masses moving south from Canada and Alaska, as these frontal systems are weak and diffuse by the time they reach the desert. Most desert moisture arrives from infrequent warm, moist, and unstable air masses from the south. The MDAB averages between three and seven inches of precipitation per year (from 16 to 30 days with at least 0.01 inches of precipitation). The MDAB is classified as a dry-hot desert climate, with portions classified as dry-very-hot desert to indicate that at least three months of the year maximum average temperatures reach more than 100.4° Fahrenheit (F).[2] Local meteorological conditions are greatly affected by the topography of the region. Regionally, wind direction is primarily from the west, west-southwest, and southwest due to the proximity of the MDAB to the coast. However, locally within the Cadiz Valley, wind direction is from the northwest to the southeast as evidenced by sand deposits in the Cadiz Dunes.

Local Air Quality

The California Air Resources Board (CARB) and the MDAQMD regional air quality monitoring network provide information on ambient concentrations of non-attainment criteria air pollutants in the MDAB. The MDAQMD monitors air quality conditions at nine locations throughout the MDAB. The Joshua Tree National Monument monitoring station is located approximately 40 miles southwest of the Project site and the Victorville monitoring station is approximately 100 miles to the west. **Table 4.3-3** presents a three-year summary of air quality data collected at the monitoring stations for ozone and particulate matter. Table 4.3-3 also includes a comparison of monitored air pollutant concentrations with the state and national ambient air quality standards. The table shows that ozone concentrations in the area have stayed relatively stable while PM10 has declined in 2009 and 2010 in the Project vicinity.

Sensitive Receptors

Some land uses are considered more sensitive to changes in air quality than others, depending on the population groups and the activities involved. CARB has identified the following typical groups who are most likely to be affected by air pollution: children under 14, the elderly over 65 years of age, athletes, and people with cardiovascular and chronic respiratory diseases. According to the MDAQMD, sensitive receptors include residences, schools, playgrounds, child care centers, and medical facilities.

1 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California*, August 2011.
2 Mojave Desert Air Quality Management District, *CEQA and Federal Conformity Guidelines*, February 2009.

TABLE 4.3-3
AMBIENT AIR QUALITY IN PROJECT VICINITY (2008–2010)

		Monitoring Data by Year		
Pollutant	**Standard[a]**	**2008**	**2009**	**2010**
Ozone – Joshua Tree National Monument				
Highest 1 Hour Average (ppm)[b]		**0.140**	**0.121**	**0.119**
Days over State Standard	0.09	36	24	19
Highest 8 Hour Average (ppm)[b]		**0.110**	**0.104**	**0.105**
Days over National Standard	0.075	72	59	53
Days over State Standard	0.070	108	90	90
Particulate Matter (PM10) – Victorville				
Highest 24 Hour Average ($\mu g/m^3$)[b] – State Measurement		**72**	**51**	40
Est. Days over State Standard[c]	50	NA	6.1	0
Highest 24 Hour Average ($\mu g/m^3$)[b] – National Measurement		77	53	44
Est. Days over National Standard[c]	150	0	0	0
State Annual Average ($\mu g/m^3$)[b]	20	NA	**23.9**	18.7

a Generally, state standards and national standards are not to be exceeded more than once per year.
b ppm = parts per million; μg/m3 = micrograms per cubic meter.
c PM10 and PM2.5 are not measured every day of the year. Number of estimated days over the standard is based on 365 days per year.
Values in **bold** are in excess of at least one applicable standard. NA = Not Available.

SOURCE: California Air Resources Board, *Summaries of Air Quality Data, 2008 through 2010*, http://www.arb.ca.gov/adam, accessed January 2011.

Because the Project area is sparsely populated, there are very few sensitive receptors in proximity to the Project. The nearest sensitive receptors to the proposed Project facilities are three or four residences located approximately 3.3 miles north of the Project site near the corner of Cadiz Road and National Trails Highway. The small community of Amboy (population less than 20) is located approximately 10 miles to the west on Highway 66. No other sensitive receptor is located in the Project area for over 10 miles.

4.3.3 Regulatory Framework

Regulation of air pollution is achieved through both national and state ambient air quality standards and through emissions limits on individual sources of air pollutants. Local air quality management districts (AQMDs) and air pollution control districts (APCDs) are responsible for demonstrating attainment with state air quality standards through the adoption and enforcement of Attainment Plans.

Federal

The FCAA, enforced by the EPA, requires each state to prepare an air quality control plan referred to as the State Implementation Plan (SIP). The FCAA Amendments require states containing areas that violate the national standards to revise their SIPs to incorporate additional control measures to reduce air pollution. Failure to submit an approvable SIP or to implement the plan within mandated timeframes can result in sanctions. MDAQMD has an approved SIP for PM10 and ozone covering the Project area.

Regulation of TACs, termed Hazardous Air Pollutants (HAPs) under federal regulations, is achieved through federal, state and local controls on individual sources. The FCAA Amendments require the EPA to identify National Emission Standards for Hazardous Air Pollutants (NESHAPs) to protect public health and welfare. These substances include certain volatile organic chemicals (VOCs), pesticides, herbicides, and radionuclides that present a tangible hazard to humans.

State

California Clean Air Act

CARB is the State agency responsible for the coordination and administration of both state and federal air pollution control programs within California. CARB undertakes research, sets CAAQS, provides technical assistance to local AQMDs and APCDs, compiles emission inventories, develops suggested control measures and provides oversight of local programs.

CARB manages air quality, regulates mobile emissions sources, and oversees the activities of county APCDs and regional AQMDs. CARB establishes state ambient air quality standards and vehicle emissions standards. Local AQMDs are responsible for compliance with the California Clean Air Act (CCAA).

California has adopted ambient standards that are more stringent than the federal standards for the criteria air pollutants. These are shown in Table 4.3-1. Under the CCAA, patterned after the FCAA, areas have been designated as attainment or nonattainment with respect to the State standards. Table 4.3-2 summarizes the attainment status with California standards in the Project vicinity.

Toxic Air Contaminants

The State Air Toxics Program of 1983 regulates TACs. A total of 243 substances have been designated TACs under California law which include the 189 (federal) HAPs. The Air Toxics "Hot Spots" Information and Assessment Act of 1987 (AB 2588) seeks to identify and evaluate risk from air toxics sources; however, AB 2588 does not regulate air toxics emissions. "High-priority" facilities are required to perform health risk assessments and, if specific thresholds are violated, are required to notify the public.

In August of 1998, CARB identified particulate emissions from diesel-fueled engines (diesel particulate matter, or DPM) as TACs. CARB set a goal of reducing emissions and associated health risks by 75 percent in 2010 and by 85 percent in 2020. The program would require diesel-fueled engines to use catalyzed diesel particulate filters and ultra low sulfur diesel fuel.

CARB published the *Air Quality and Land Use Handbook: A Community Health Perspective* in 2005[3] to provide guidelines to help the most vulnerable receptors. The handbook highlights recent studies that show that public exposure to air pollution can be substantially elevated near freeways and certain other facilities (i.e., distribution centers, rail yards, chrome platers, etc.).

[3] California Air Resources Board, *Air Quality and Land Use Handbook: A Community Health Perspective*, April 2005, pages 1 – 32.

However, the health risk is greatly reduced with distance, so CARB made recommendations for keeping appropriate distances between sources of air pollution and sensitive land uses, such as residences.

Regional

Mojave Desert Air Quality Management District

The MDAQMD has jurisdiction over the desert portion of San Bernardino County and the far eastern end of Riverside County. The applicable MDAQMD attainment plan to the Project area is the *MDAQMD 2004 Ozone Attainment Plan (State and Federal)*[4]. This *Ozone Attainment Plan* included the latest assumptions regarding population, vehicle activity, and industrial activity and addressed existing and forecast ozone precursor-emitting activities within the MDAQMD through 2007. The MDAQMD's primary means of implementing this air quality plan is by adopting and enforcing rules and regulations.[5]

Activities of the proposed Project would be subject to MDAQMD rules and regulations, including:

- *Rule 403 Fugitive Dust:* A person shall not cause or allow the emissions of fugitive dust from any transport, handling, construction, or storage activity so that the presence of such dust remains visible in the atmosphere beyond the property line of the emission source. (Does not apply to emissions emanating from unpaved roadways open to public travel or farm roads. This exclusion shall not apply to industrial or commercial facilities).
- *Rule 402 Nuisance:* A person shall not discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health, or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property.
- *Rule 1103 Cutback and Emulsified Asphalt*: A person shall not manufacture for sale nor use for paving, road construction, or road maintenance any a) rapid cure cutback asphalt; b) medium cure cutback asphalt; or c) slow cure cutback asphalt containing more than 0.5 percent by volume of VOC which evaporates at 260 degrees Celsius. A person shall also not manufacture for sale nor use for paving, road construction, or road maintenance any emulsified asphalt containing more than three (3) percent by volume of VOC which evaporates at 260 degrees Celsius.

The MDAQMD thresholds of significance for construction activities are shown in **Table 4.3-4** on the following page.

4 Mojave Desert Air Quality Management District, *2004 Ozone Attainment Plan (State and Federal), April 2004.*
5 Mojave Desert Air Quality Management District, *Rule Book: Regulation IV –Prohibitions, Regulation XI – Source Specific Standards*, http://www.mdaqmd.ca.gov/index.aspx?page=138, accessed November 2011.

TABLE 4.3-4
MDAQMD AIR EMISSIONS SIGNIFICANCE THRESHOLDS FOR CONSTRUCTION ACTIVITIES

Pollutant	Pounds Per Day	Tons Per Year
NOx	137	25
VOC (ROG)	137	25
PM10	82	15
PM2.5	82	15
CO	548	100

SOURCE: Mojave Desert Air Quality Management District, *CEQA and Federal Conformity Guidelines,* February 2009, page 10.

4.3.4 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to air quality if it would:

- Conflict with or obstruct implementation of the applicable air quality plan;
- Violate any air quality standard or contribute substantially to an existing or projected air quality violation;
- Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or State ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors);
- Expose sensitive receptors to substantial pollutant concentrations; or
- Create objectionable odors affecting a substantial number of people.

In addition to these thresholds provided in the *CEQA Guidelines*, MDAQMD has established guidance that a project is considered to have a significant impact on sensitive receptors if it proposes to locate any of the following land uses near sensitive receptors:

- Any industrial project within 1,000 feet,
- A distribution center (40 or more trucks per day) within 1,000 feet,
- A major transportation project (50,000 or more vehicles per day) within 1,000 feet,
- A dry cleaning using perchloroethylene within 500 feet, or
- A gasoline dispensing facility within 300 feet.

In addition, MDAQMD has established numeric emissions thresholds of significance for criteria air pollutants as shown in Table 4.3-4. The 2009 MDAQMD CEQA Guidelines conclude that a project would result in a significant operational air quality impact if any of the following occur:

- Direct or indirect emissions that exceed the significance thresholds set forth in Table 4.3-4;
- A project would not be compatible with MDAQMD air quality goals and policies;
- On-site stationary sources emit carcinogenic or toxic air contaminants that individually or cumulatively exceed the maximum individual cancer risk of ten in one million or an acute or chronic hazard index of 1.0; or
- Hazardous materials associated with on-site stationary sources result in an accidental release of air toxic emissions or acutely hazardous materials posing a threat to public health and safety.

Methodology

The analyses of construction activities include analyses of regional emissions and local emissions of ROG, NOx, CO, PM10, PM2.5, and CO2. CARB-approved URBEMIS 2007 emissions model was utilized to determine emissions from construction equipment and haul trucks. EMFAC 2007 was utilized to determine emissions associated with worker and employee trips during construction and operations. Emissions estimates are compared to the MDAQMD thresholds of significance to determine whether construction or operation of the proposed Project would result in a significant impact to local air quality.

For post-construction operations, the analysis addresses regional emissions of CO, VOC, Nox, PM10 as well as local area concentrations of a specific pollutant, CO, generated by well sources. Emission factors based on SCAQMD BACT standards for natural gas turbines, as well as AP-42 emission factors for stationary gas turbines, were incorporated into the analysis to estimate the operational emissions of the Project.

Lead emissions are not included in the analysis. The Basin is currently in compliance with State and federal lead standards.

Groundwater Conservation and Recovery Component

Consistency with Air Quality Management Plans

Significance Threshold

Would the proposed Project conflict with or obstruct implementation of the applicable air quality plan?

Impact Analysis

The 2009 MDAQMD CEQA Guidelines states that a project is non-conforming if it conflicts with or delays implementation of any applicable attainment or maintenance plan. A project is conforming if it complies with all applicable MDAQMD rules and regulations, complies with all proposed control measures of the applicable plan, and is consistent with the growth forecasts in the applicable plan. The MDAQMD has approved attainment plans for PM10 and ozone. The PM10 attainment plan identifies dust control measures to be included in MDAQMD Rules that would reduce construction dust emissions. Both Attainment Plans conclude that compliance with the MDAQMD adopted Rules and Regulations will achieve the desired air quality results.

The proposed Project infrastructure consists of 34 wells, a conveyance pipeline, a CRA tie-in facility, and an intermediate pump station which do not include residential development or large local or regional employment centers normally associated with increases in concentrations of pollutants. Thus, the proposed Project would not result in significant population or employment growth that could increase local concentrations of air pollutants and would be consistent with local growth forecasts. Although the Project would exceed thresholds of significance for NOx during construction as discussed below, these temporary emissions would not conflict with the local air quality plan to control long-term ambient ozone levels. Since the Project would comply with all control measures identified in the plan for construction activities, it would be consistent with the attainment plan (see **AQ-1 through AQ-4** below).

Mitigation Measures

Implement Mitigation Measures **AQ-1 through AQ-4**.

Significance Conclusion

Less than significant with mitigation.

Air Quality Standards

Significance Threshold

Would the proposed Project violate any air quality standard or contribute substantially to an existing or projected air quality violation?

Impact Analysis

Construction emissions for the Project are based on both current emission factor data and the magnitude of development for the Project. The total amount of construction, the duration of construction and the intensity of construction activity could have a substantial effect upon the amount of construction emissions, concentrations and the resulting impacts occurring at any one time. As such, the emission forecasts provided reflect a specific set of conservative assumptions based on the expected construction scenario wherein the majority of construction is occurring over a two-year period.

Short Term Construction Emissions

Project construction activities would produce criteria pollutant emissions as a result of using heavy-duty construction equipment. Mobile source emissions would also be produced from construction worker vehicle trips to and from the Project site (see Appendix E). In addition, fugitive dust emissions would be generated from excavation activities and vehicle travel on paved and unpaved surfaces. The Groundwater Conservation and Recovery Component includes construction of approximately 34 wells, a conveyance pipeline, a CRA tie-in facility, and an intermediate pump station. Emissions were modeled in URBEMIS 2007 using the estimated list of construction equipment (see Table 3-4). The results of the analysis are summarized in **Table 4.3-5** (URBEMIS 2007 output sheets are included in Appendix E1).

Construction equipment exhaust would include fugitive dust (PM10 and PM2.5) emissions from construction that would vary from day to day depending on the level of activity, the equipment being operated, silt content of the soil, and the prevailing weather. Larger-diameter dust particles (i.e., greater than 30 microns) generally fall out of the atmosphere within several hundred feet of construction sites and do not represent a significant health hazard.

Fine Particulate Matter (e.g., PM2.5) is mostly derived from combustion sources, such as automobiles, trucks and other vehicle exhaust, as well as from stationary sources. These particles are either directly emitted or are formed in the atmosphere from the combustion of gasses such as NOx and SOx combining with ammonia. PM2.5 components from material in the earth's crust, such as dust, are also present with the amount varying in different locations. Fine Particulate Matter is associated with adverse health effects and generally remain airborne until removed from the atmosphere by moisture.

The total emissions listed in Table 4.3-5 are for worst case construction activities with mitigation applied to reduce dust and NOx emissions. The emissions estimates include combustion as well as excavation and grading emissions. Grading is assumed to be necessary over the entire construction footprint of the wellfield and conveyance facility to establish final contours.

TABLE 4.3-5
CONSTRUCTION EMISSIONS FROM GROUNDWATER CONSERVATION AND RECOVERY COMPONENT (lbs per day)[a]

Project Component	ROG	NO_x	CO	PM10	PM2.5
Wellfield Construction (including mobilization, site clearing and grading, drilling, site access, and demobilization)	18	**155**	89	6	6
Conveyance Pipeline / CRA Tie-in (including mobilization, site clearing and grading, excavation, backfilling, site access, and demobilization)	20	**145**	273	9	7
Storage Reservoir/ Pump Station (including mobilization, site clearing and grading, excavation, backfilling, site access, and demobilization)	14	115	57	**105**	26
Construction Employee Trips	7	92	63	2	2
Unmitigated Total	59	**507**	482	**122**	41
Mitigated Total	59	**433**	482	38	18
MDAQMD Thresholds of Significance	137	137	548	82	82
Significant after Mitigation (Yes or No)?	No	**Yes**	No	No	No

a Project construction emissions estimates were made using URBEMIS2007, version 9.2. 4. See Appendix E1 for more information.

Values in **bold** are in excess of the applicable MDAQMD significance threshold. NA = Not Available

SOURCE: ESA, 2011.

As depicted in Table 4.3-5, construction of the wellfield and pipeline would emit significant amounts of NOx due to the heavy, diesel-fueled equipment required for construction. PM10 emissions associated with the wellfield and pipeline would be below the MDAQMD thresholds of significance after mitigation as shown in Table 4.3-5. Construction of a forebay (if required) would

result in significant PM10 emissions if unmitigated. Implementation of Mitigation Measures **AQ-1 through AQ-4** would ensure compliance with Rule 403. Table 4.3-5 shows both mitigated and unmitigated emissions estimates. The resulting PM10 emissions after mitigation would be less than significant. However, NOx emissions during construction would remain significant and unavoidable.

Operation – Mobile Sources

Operation of the Project is anticipated to result in minimal vehicular trips, consisting of less than three trucks per day travelling less than 20 miles each on average. These trips account for on-site employees conducting routine maintenance and monitoring of the wellfield and pipeline. Wells and pumps are highly automated requiring infrequent maintenance. The pipelines would be largely underground and serviced on an as-needed basis. Daily emissions from these on-road vehicles would be substantially less than the significance thresholds.

Natural Gas to Power Pumps

Depending on the wellfield configuration, there would be between approximately 22 and 34 wells in operation. For purposes of this analysis, it is assumed that the wells would operate simultaneously 24-hours per day 365 days per year. The electric motors used to operate the wells would range from 1,000 to 1,250 hp using natural gas engines supplied by locally available natural gas. Two configurations may be used including installing engines at each wellhead, or constructing a centralized generator that supplies the entire wellfield with electricity. The MDAQMD requires permits to operate new internal combustion engines. Therefore, each natural gas engine would require a permit from MDAQMD prior to initiation of the Project.

The amount of electrical energy required to operate the wellfield would be approximately 30,800,000 kWh per year, and the amount necessary to power the intermediate pump station (if required) would be approximately 22,000,000 kWh per year, totaling 52,800,000 kWh per year, or 513 billion Btu per year.[6] **Table 4.3-6** shows the estimated emissions from natural gas engine operations. No emissions would exceed MDAQMD thresholds; therefore natural gas engine operational emissions would be less than significant.

If electricity from the grid is used to power the Project, emissions would be generated at offsite power generation facilities, but no additional emissions would be generated on site within the Cadiz Valley. Offsite power would be generated by a wide network of power generating facilities that include fossil-fuel burning and renewable energy sources. Each generator is permitted to generate power under the CAA. If power from the grid is used, the proposed Project would add additional load to the grid, but the emissions associated with the additional power generation

6 RBF Consulting, *Power Requirements Analysis Technical Memorandum, Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California, Phase* 1, November 2010. Natural gas consumption rates were obtained by using a 40% conversion efficiency for natural gas generators (thermal energy to electrical energy) and a 30% conversion efficiency for natural gas engines (thermal energy to mechanical energy). The natural gas engines that are used for the Project would be reciprocating (or internal combustion) natural gas engines, which typically offers energy efficiencies ranging from 25 to 45 percent (California Energy Commission, *California Distributed Energy Resource Guide,* http://www.energy.ca.gov/distgen/equipment/reciprocating_engines/-reciprocating_engines.html, accessed November 2011). Data shown are for 50,000 AFY. Electricity and natural gas use would be 72,700,000 kWh/year and 683 billion BTU/year, respectively, assuming 100,000 AFY.

would be spread throughout the Western U.S., and would not result in significant air quality impacts or violations of the CAA.

TABLE 4.3-6
OPERATIONAL EMISSIONS FROM NATURAL GAS ENGINES
(lbs per day)

Project Component	VOC	NO_x	CO	PM10
Pump Station	1.76	6.31	9.22	4.52
Wellfield at 50,000 AFY	1.84	6.63	9.68	4.75
Wellfield at 75,000 AFY	3.04	10.91	15.94	7.82
Wellfield and Pump Station (50,000 AFY)	3.60	12.94	18.91	9.28
Wellfield and Pump Station (75,000 AFY)	4.79	17.22	25.16	12.34
MDAQMD Thresholds of Significance	137	137	548	82
Significant (Yes or No)?	No	No	No	No

See Appendix E for the modeling outputs.

SOURCE: ESA, 2011.

Conversion of Existing Diesel Engines

Currently, the agricultural operations on the Cadiz Property utilize seven existing wells for irrigation. Each well is powered with diesel engines. As part of the Project, five of the seven Cadiz irrigation wells would be incorporated into the Project wellfield (Wells 21S, 27N, 27S, 28 and 33) and converted to natural gas power. In addition, the two agricultural wells not incorporated into the Project wellfield and the well Test Well-1 (TW-1) would also be converted to natural gas. This would substantially reduce existing NOx emissions associated with the diesel engines. The emissions estimates provided in Table 4.3-6 include five converted agricultural wells.

Operation – Agricultural Dust

The Project would operate in conjunction with existing agricultural operations. If agricultural activities are terminated as a result of the Project, the existing fields would be fallowed. Dust emissions from fallowed fields could increase the overall dust emissions in the valley under current conditions. The agricultural activities are subject to County and MDAQMD management practices to minimize dust emissions. Currently, over one square mile of agricultural land at the Cadiz Ranch is in a fallowed state as a result of normal agricultural operations. The agricultural operator is required by the County and the MDAQMD's Rule 403 to manage fallowed lands in a manner that protects from excessive dust emissions. If the Project increases the amount of fallowed land at the Cadiz Ranch, the agricultural operator would be subject to these same conditions. Compliance with County and MDAQMD requirements to manage dust emissions from fallowed land would minimize emissions and result in a less than significant impact to air quality.

Dry Lake Bed Dust Emissions

During the operation of the Project, water levels would be lowered in the wellfield area. The effect of the drawdown would extend toward the Bristol and Cadiz Dry Lakes. See Section 4.8, Hydrology and Water Quality for details on the groundwater drawdown. An analysis was conducted to evaluate whether the Dry Lake surfaces would be adversely affected from the lowering of groundwater levels.[7] The analysis found that surface soils on Bristol and Cadiz Dry Lakes form crusts when dried and that the crusts resist wind erosion. The analysis concludes that the crusty soil on the surface of the Dry Lakes does not rely on groundwater to maintain its integrity, but rather the dominant salts in the soils form a crust when dried. This crusting mechanism minimizes airborne dust from the Dry Lake surfaces.

The tendency for dust and sand to be lofted into the air during windy weather conditions is regulated by both the surface soil type and the amount of vegetation holding the soil in place. The natural salts in the surface soils at the Bristol and Cadiz Dry Lakes form crusts as they dry out. The dominant salt species on these Dry Lakes are sodium chloride and calcium chloride, which tend to bind into a hard crusty surface material when dry, forming a "self-healing" crust that is generally resistant to wind erosion. By comparison, the salt species in the Owens Dry Lake (a terminal lake that has experienced dust emissions due to reduction of surface water) is comprised mostly of carbonate, bicarbonate, and sulfate that tends to break apart when dried out, forming loose, fluffy soils that are easily lofted into the air by the wind.[8]

Appendix E3 includes a 2011 summary report on the analysis characterizing the soils on the Bristol and Cadiz Dry Lake surfaces. The analysis reports sample results of the chemical composition of the Dry Lakes' surface soil. The analysis notes that the Bristol and Cadiz Dry Lakes have likely been Dry Lakes for most of their existence of thousands of years. Furthermore, groundwater levels across the eastern portion of the Bristol Dry Lake are greater than 10 feet below ground surface. The surface crust is naturally dry and does not rely on moisture from surface water or from capillary action from the groundwater for the prevention of dust emissions. The groundwater becomes shallower (less than 10 feet bgs) on the western portion of Bristol Dry Lake and at the northern edge of Cadiz Dry Lake. In these locations, soil samples indicate that the dominant salt species are chlorides that create crusts when desiccated and exhibit resistance to wind erosion. If groundwater levels decrease in these areas, the surface soils would behave similar to the eastern portion of the Bristol Dry Lake currently, which retains a crusty, wind-resistant surface even when groundwater depths are greater than 60 feet. Based on this analysis, reduction in groundwater levels beneath the Dry Lake would not alter the Dry Lake surface conditions or increase dust emissions in the valley.

The GMMMP prepared for the Project to provide for the adaptive management of the basin includes seven measures to monitor Project operations and potential effects on critical resources. The measures are presented in Chapter 6 of the GMMMP and are referred to as Project Design Features in this EIR. Although no potentially significant impact to air quality from lakebed dust

7 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California,* August 2011.

8 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California,* August 2011.

would occur as a result of the Project, as a conservative monitoring protocol, the GMMMP provides for verification monitoring of air quality in the Cadiz Valley. The Project Design Feature from the GMMMP that pertains to verification air quality monitoring is listed below.

- GMMMP Project Design Feature 6.8 – Air Quality

The GMMMP requires that FVMWC install one nephelometer down-wind from Bristol Dry Lake and one down-wind of Cadiz Dry Lake to establish a set of baseline data of visibility in the valley. In addition, the GMMMP requires FVMWC to conduct annual visual observations at four points on the Dry Lakes to record surface soil conditions. The visual observations will note soil texture and record susceptibility to wind erosion. Photographs of the soil will be taken. This data will record conditions over time on the Dry Lake surface.

The Action Criteria and Corrective Measures for this project design feature is summarized in **Tables 4.3-7**.

TABLE 4.3-7
GMMMP PROJECT DESIGN FEATURE 6.8 – AIR QUALITY

Action Criteria	Corrective Measures

1. Changes in air quality that exceed baseline conditions over a five-year moving average	• Modification of Project operations to re-establish baseline level air quality levels. Modifications to Project operations would include one or more of the following:
	  • Reduction in pumping from Project wells;
	  • Revision of pumping locations within the Project wellfield;
	  • Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

SOURCE: CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011.

This Project Design Feature is part of the project description**Mitigation Measure AQ-5** would ensure that the Project Design Feature is implemented and the corrective measure identified in the GMMMP would be implemented if action criteria are exceeded. Impacts to air quality resulting from the proposed Project would be less than significant with mitigation.

Operational Air Emissions Summary

In summary, the Project would not result in operational emissions that would exceed MDAQMD's thresholds of significance. The Project-generated emissions would not be anticipated to result in a substantial contribution to a violation of national standards, state standards, or the nonattainment status. As a result, air emissions impacts would be less than significant.

Mitigation Measures

AQ-1: Construction and operation of the proposed Project shall be conducted in compliance with applicable rules and regulations set forth by the Mojave Desert Air Quality Management District.

AQ-2: The following dust control measures shall be implemented during construction:

- All soil excavated or graded shall be sufficiently watered to prevent excessive dust. Watering shall occur as needed with complete coverage of disturbed soil areas.
- Watering shall take place a minimum of twice daily on unpaved/untreated roads in areas with active operations.
- Areas disturbed by clearing, earth moving, or excavation activities shall be minimized at all times.
- Stockpiles of soil or other fine loose material shall be stabilized by watering or other appropriate method such as non-toxic soil binders to prevent wind-blown fugitive dust.
- On-site vehicle speed on unimproved roads shall be limited to 15 miles per hour.
- Streets adjacent to the Project site shall be kept clean and Project-related accumulated silt shall be removed.

AQ-3: The following measures shall be implemented during construction of the proposed Project:

- All equipment shall be maintained as recommended by manufacturer's manuals.
- Idling engines shall be shut down when not in use for over 30 minutes.
- Electric equipment shall be used whenever possible in lieu of diesel or gasoline powered equipment.
- All construction vehicles shall be equipped with proper emissions control equipment and kept in good and proper running order to substantially reduce NOx emissions.
- On-road and off-road diesel equipment shall use diesel particulate filters if permitted under manufacturer's guidelines.
- The Project shall develop a plan demonstrating that the off-road equipment (more than 50 horsepower) to be used in the construction Project (i.e., owned, leased, and subcontractor vehicles) would achieve a Project-wide fleet-average 20 percent NOx reduction and 45 percent PM reduction compared to the most recent CARB fleet average. Acceptable options for reducing emissions include the use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, add-on devices such as particulate filters, and/or repowering off-road engines/equipment with Tier 2 or Tier 3 engines that operate within allowable emission ranges and as a result, would achieve emission reductions.

AQ-4: All trucks hauling dirt, sand, soil, or other loose materials are to be covered.

AQ-5: The Project Design Feature in Chapter 6.8 of the GMMMP shall be implemented to verify air quality. If changes in air quality occur that exceed baseline conditions over a five-year moving average, the following corrective measures shall be implemented:

- Modification of Project operations to re-establish baseline level air quality levels. Modifications to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells;
  - Revision of pumping locations within the Project wellfield;
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

Significance Conclusion

Even after mitigation, NOx short-term construction emissions would remain significant and unavoidable. Long-term operational emissions would be less than significant.

Sensitive Receptors

Significance Threshold

Would the proposed Project expose sensitive receptors to substantial pollutant concentrations?

Impact Analysis

Sensitive populations are more susceptible to the effects of air pollution than is the general population. Sensitive populations (sensitive receptors) that are in proximity to localized sources of toxins and CO are of particular concern. Here, the Project area is sparsely populated. The nearest sensitive receptors to the proposed Project facilities are three or four residences located approximately 3.3 miles north of the Project site near the corner of Cadiz Road and National Trails Highway. The small community of Amboy is located approximately 10 miles to the west on Highway 66, and is populated by less than 20 people. No other sensitive receptor is located in the Project area for over 10 miles.

Carbon Monoxide Hotspots

Carbon Monoxide (CO) emitted from car engines can create localized pockets of high concentrations known as "hot spots." These hot spots are generally associated with slow moving traffic in confined or busy intersections. As shown in Table 4.3-3 above, the MDAB is in attainment for CO. CO hot spots are not generally a concern in the open desert environment. Furthermore, CO concentrations have declined dramatically in California due to the retirement of older polluting vehicles, fewer emissions from new vehicles, and improvements in fuels.

Operational emissions from mobile sources are estimated to be less than three trucks monitoring the wellfield and pipeline at any given time. Due to the small number of daily trips, and the lack of traffic congestion in the area, the effect of Project-related traffic on local CO concentrations along roadways and at intersections would be minimal and would not adversely affect local sensitive receptors. Because of its rural character with large open space, the Project would not generate traffic at volumes that could result in excessively slow speeds in confined areas that would warrant conducting a CO hot spot analysis. Thus, the short-term construction and long-term operational mobile-source impact of the Project on CO concentrations would be less than significant.

Toxic Air Contaminants

Construction of the Project would result in short-term diesel exhaust emissions that include diesel particulate matter (DPM). DPM are designated TACs emitted from heavy-duty diesel-powered equipment. The dose to which sensitive receptors are exposed is the primary factor used to determine health risk. Dose is a function of the concentration of a substance or substances in the environment and the extent of exposure that person has with the substance. Dose is positively correlated with time, meaning that a longer exposure period would result in a higher dose level for the maximally exposed individual. Thus, the risks estimated for a maximally exposed individual are higher if a fixed exposure occurs over a longer period of time. While Project construction would generate DPM emissions from the use of off-road diesel equipment required for site grading and excavation and other construction activities because of the large distances between the construction areas and sensitive receptors, exposure levels would be minimized. Also, the temporary nature of the emissions that limit overall dose levels, DPM from construction activities would not be anticipated to result in the exposure of sensitive receptors to levels that exceed applicable standards.

In addition, the long-term operation of the Project would not result in any toxic air emissions. Conversion of the existing diesel-fueled engines to natural gas would reduce the DPM emissions in the Project area. As a result, exposure of sensitive receptors to toxic air emissions from the Project would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Objectionable Odors

Significance Threshold

Would the proposed Project create objectionable odors affecting a substantial number of people?

Impact Analysis

Types of land uses that typically pose potential odor problems include agriculture, wastewater treatment plants, food processing and rendering facilities, chemical plants, composting facilities, landfills, waste transfer stations, and dairies. In addition, the occurrence and severity of odor impacts depend on numerous factors, including the nature, frequency, and intensity of the source; wind speed and direction; and the presence of sensitive receptors. No part of the Project would include or generate sources of potential odors for two reasons. First because the Project site is located over three miles from nearest residences and is over 10 miles from foot travel or hiking areas. And second because the Project will be putting and taking water from the groundwater basin, it is not treating the existing waters. Moreover, the well pumps would be powered by

natural gas or electricity, not diesel, and therefore no diesel fumes or odors would be emitted. Therefore, odor emissions resulting from the Project would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Cumulative Impact

Significance Threshold

Would the proposed Project result in a cumulatively considerable air quality impact?

Impact Analysis

A cumulative impact occurs when two or more individual effects, considered together, are considerable or would compound or increase other environmental impacts. Cumulative impacts can result from individually minor but collectively significant impacts, meaning that the project's incremental effects are considerable when viewed in connection with the effects of past, current, and probable future projects. The geographic area that is considered when evaluating cumulative air quality impacts is the Mojave Desert Air Basin. Notably, any project that would individually have a significant air quality impact would also be considered to have a significant cumulative air quality impact.

Short-Term Construction Emissions

Implementation of Mitigation Measures **AQ-1 through AQ-4** for the proposed Project would ensure implementation of the MDAQMD requirements to control fugitive dust at construction sites and limit construction dust and vehicle and equipment emissions. As discussed above, even with implementation of Mitigation Measures **AQ-1 through AQ-4**, the Project would exceed MDAQMD significance thresholds for NOx. This would result in a significant and unavoidable air quality impact during the two-year construction period. Because the Project construction alone would exceed significance thresholds established by the MDAQMD, when considered in conjunction with overlapping construction projects in the MDAQMD, its contribution to cumulative air quality impacts may be "cumulatively considerable" even with implementation of mitigation measures.

Long Term Operational Emissions

Project operations would not create emissions that would exceed the MDAQMD thresholds due to minimal daily operational trips and low emissions from engine operations. Long-term Project operations would not result in significant cumulative impact.

Mitigation Measure

Implement Mitigation Measures **AQ-1 through AQ-4**.

Significance Conclusion

Though operational emissions would not be cumulatively considerable, short term construction activities would exceed MDAQMD standards and would therefore result in a significant and unavoidable cumulative impact even after mitigation.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Consistency with Air Quality Management Plans

Significance Threshold

Would the proposed Project conflict with or obstruct implementation of the applicable air quality plan?

Impact Analysis

The 2009 MDAQMD CEQA Guidelines state that a project is non-conforming if it conflicts with or delays implementation of any applicable attainment or maintenance plan. A project is conforming if it complies with all applicable MDAQMD rules and regulation, complies with all proposed control measures that are not yet adopted from the applicable plan, and is consistent with the growth forecasts in the applicable plan. The Project does not include residential development or large local or regional employment centers in the MDAB and thus, would not result in significant population or employment growth that could increase concentrations of air pollutants in the MDAB. The MDAQMD has approved attainment plans for PM10 and ozone. The PM10 attainment plan identifies dust control measures to be included in MDAQMD Rules that would reduce construction dust emissions. Both Attainment Plans conclude that compliance with the MDAQMD adopted Rules and Regulations will achieve the desired air quality results.

Similar to the Groundwater Conservation and Recovery Component, temporary construction emissions associated with the expanded wellfield, existing natural pipeline appurtenances, and spreading basins would not conflict with the local air quality plan to control long-term ambient ozone and PM10 levels. The Project would comply with control measures identified in the plan for construction activities. As a result, the Project would be consistent with the local air quality plan.

Mitigation Measures

Implement Mitigation Measures **AQ-1 through AQ-4**.

Significance Conclusion

Less than significant with mitigation.

Air Quality Standards

Significance Threshold

Would the proposed Project violate any air quality standard or contribute substantially to an existing or projected air quality violation?

Impact Analysis

Short Term Construction Emissions

The Imported Water Storage Component would construct a CRA diversion structure, pump station, spreading basins, existing natural gas pipeline appurtenances, and an expansion of the wellfield (10 to 15 new wells). Due to uncertainty about when and where these additional facilities and pipelines may be constructed, air quality impacts have not been quantified in the same manner as they have for the Groundwater Conservation and Recovery Component. However, construction of the expanded wellfield would likely utilize similar equipment as that used for the Groundwater Conservation and Recovery Component. As summarized in Table 4.3-5, it is anticipated that expansion of the wellfield during construction would emit significant amounts of NOx due to the heavy diesel-fueled equipment required for construction. Therefore NOx emissions during construction of the expanded wellfield would likely also be significant and unavoidable. Construction of the spreading basins for the Imported Water Storage Component would utilize construction equipment similar to the forebay analyzed for the Groundwater Conservation and Recovery Component. As with construction of the forebay, PM10 emissions associated with construction of spreading basins may result in significant PM10 emissions that would be reduced to less than significant levels with Mitigation Measures **AQ-1 through AQ-4**.

Operation

Implementation of the Imported Water Storage Component would not substantially increase mobile source emissions since it would result in minimal new vehicular trips to maintain and operate the expanded system. The operational emissions associated with the well pumps would increase commensurate with the number of new wells, but would not be expected to increase significantly. As is expected for the Groundwater Conservation and Recovery Component, the MDAQMD would require permits to operate internal combustion engines in the Imported Water Storage Component. If electricity from the grid is used in place of natural gas to power wells and pumps, emissions would be generated at distant power plants where the power is created. In addition, as with the Groundwater Conservation and Recovery Component, the Imported Water Storage Component would not result in increased dust emissions off the Dry Lakes. Therefore, air emissions resulting from operation of the Imported Water Storage Component would be less than significant.

Mitigation Measures

Implement Mitigation Measures **AQ-1 through AQ-4**.

Significance Conclusion

Significant and unavoidable for NOx emissions during construction even with mitigation. Operational emissions would be less than significant.

Sensitive Receptors

Significance Threshold

Would the proposed Project expose sensitive receptors to substantial pollutant concentrations?

Impact Analysis

Due to the distance between construction activities and sensitive receptors (over three miles), construction of the Imported Water Storage Component would not emit air pollutants in quantities that could pose health concerns to local sensitive receptors. The potential for adverse health impacts to sensitive receptors to occur is a function of pollutant concentrations and duration of exposure. The distances to local residences and local wind patterns provide substantial dilution opportunities for pollutants emitted during construction. Furthermore, the temporary construction emissions would not result in long-term exposure to pollutants. Therefore, similar to the Groundwater Conservation and Recovery Component, this impact would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Objectionable Odors

Significance Threshold

Would the proposed Project create objectionable odors affecting a substantial number of people?

Impact Analysis

Similar to the Groundwater Conservation and Recovery Component, no part of the Imported Water Storage Component would emit odors that could create nuisance conditions in addition to the fact that the expanded well-field and spreading basins would also be at least three miles away from the nearest population. Therefore, odor emissions resulting from the Project would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Cumulative Impact

Significance Threshold

Would the proposed Project result in a cumulatively considerable air quality impact?

Impact Analysis

A cumulative impact occurs when two or more individual effects, considered together, are considerable or would compound or increase other environmental impacts. Cumulative impacts can result from individually minor but collectively significant impacts, meaning that the project's incremental effects are considerable when viewed in connection with the effects of past, current, and probable future projects. The geographic area that is considered when evaluating cumulative air quality impacts is the Mojave Desert Air Basin. Notably, any project that would individually have a significant air quality impact would also be considered to have a significant cumulative air quality impact.

Short Term Construction Impacts

Due to uncertainty about when and where these additional facilities and pipelines may be constructed, air quality impacts have not been quantified in the same manner as they have for the Groundwater Conservation and Recovery Component. However, construction of the expanded wellfield would likely utilize similar equipment as that used for the Groundwater Conservation and Recovery Component. Implementation of Mitigation Measures **AQ-1 through AQ-4** for the proposed Project would ensure implementation of the MDAQMD requirements to control fugitive dust at construction sites and limit construction dust and vehicle and equipment exhaust emissions. As discussed above, even with implementation of Mitigation Measures **AQ-1 through AQ-4**, the Project would exceed MDAQMD significance thresholds for NOx. This would result in a significant and unavoidable air quality impact during the approximately 18-month construction period. Because the Project construction alone would exceed significance thresholds established by the MDAQMD, when considered in conjunction with overlapping construction projects in the MDAQMD, its contribution to cumulative air quality impacts are cumulatively considerable.

Long Term Operational Emissions

Project operations would not create emissions that would exceed the MDAQMD thresholds due to minimal daily operational trips and low emissions from engine operations. Long-term Project operations would result in a less-than-significant cumulative impact.

Mitigation Measure

Implement Mitigation Measures **AQ-1 through AQ-4**.

Significance Conclusion

Though operational emissions would not be cumulatively considerable, short term construction activities would exceed MDAQMD standards and would therefore result in a significant and unavoidable cumulative impact even after mitigation.

Mitigation Measure Summary Table

Table 4.3-8 presents the impacts and mitigation summary for Air Quality.

TABLE 4.3-8
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Consistency with Air Quality Management Plans	**AQ-1 through AQ-5**	Less than significant with mitigation
Air Quality Standards	**AQ-1 through AQ-5**	NOx short-term construction emissions would remain significant and unavoidable. Long-term operational emissions, however, would be less than significant
Sensitive Receptors	None required	Less than significant
Objectionable Odors	None required	Less than significant
Cumulative Impact	**AQ-1 through AQ-5**	Short term construction emissions would be significant and unavoidable
Imported Water Storage Component		
Consistency with Air Quality Management Plans	**AQ-1 through AQ-5**	Less than significant with mitigation
Air Quality Standards	**AQ-1 through AQ-5**	NOx construction emissions would be significant and unavoidable. Operational emissions would be less than significant
Sensitive Receptors	None required	Less than significant
Objectionable Odors	None required	Less than significant
Cumulative Impact	**AQ-1 through AQ-5**	Short term construction emissions would be significant and unavoidable

4.4 Biological Resources

The purpose of this Section is to identify existing biological resources within the Project area, analyze potential biological impacts associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. The analysis below is supported by two survey reports conducted by Circle Mountain Biological Consultants, Inc. (CMBC): *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment* (Biological Technical Report) and *Streambed Delineation.* These reports are included in Appendix F of the Draft EIR. In addition, ESA (Environmental Science Associates) conducted a Rare Plant Survey of the pipeline alignment that is summarized in the Rare Plant Survey Report also included in Appendix F. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.4.1 Environmental Setting

Regional Setting

The Project is located in San Bernardino County in the southeastern portion of California. San Bernardino County is divided into three distinct regions: the western valley region, the mountain region, and the desert region. The largest of the three, the Desert Planning Region, contains 93 percent of the land area within San Bernardino County (18,735 square miles) and is defined as the area extending north to the boundaries with Kern and Inyo counties, east to the State borders of Nevada and Arizona, and west to the boundary with Los Angeles County. The Desert Planning Region is subdivided into the high desert and the low desert.[1] Major roadway corridors in the Project vicinity include Interstate 40 (I-40), US 66, and SR 62.

The Project area is regionally located in the Sonoran Desert ecological region, Cadiz-Vidal Valley subsection.[2] This subsection consists mainly of alluvial fans and basin floors in the Cadiz, Palen, Rice, and Vidal Valleys and the lower part of Ward Valley. The climate is very hot and arid. The predominant natural plant communities in this subsection are Creosote bush series and Creosote bush-white bursage series. Black bush series occurs at higher elevations in the Iron Mountains while the Mesquite series occurs on the basin floors. Mixed saltbush series is also common throughout this subsection.

Local Setting

The Project is located in a generally undeveloped region of the eastern Mojave Desert approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles

1 County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, page I-15.
2 Miles, S.R. and C.B. Goudey, *Ecological Subregions of California,* USDA Forest Service Technical Report R5-EM-TP-005, 1997.

northeast of Twentynine Palms. (see Figure 3-1). The Project area consists of an arid landscape with sparsely vegetated mountain ranges and broad valleys, bajadas,[3] and scattered dry lakes.[4] Land uses in the Project vicinity consist of open space and undeveloped natural areas, with scattered, isolated development including salt mining operations on the Bristol and Cadiz Dry Lakes, agricultural operations on Cadiz Property, scattered structures near the communities of Amboy and Cadiz, and utility and transportation corridors crossing large expanses of the desert.

The Fenner Valley is a large northeast to southwest trending valley that intersects Cadiz Valley at the Fenner Gap located between the Marble and Ship Mountains. The Fenner Watershed is within a topographically closed drainage system that includes four main Watersheds: Bristol, Cadiz, Orange Blossom Wash, and Fenner.[5] These Watersheds are considered one drainage system because all surface and groundwater within these Watersheds drains to a central lowland area (i.e., Bristol and Cadiz Dry Lakes). The Bristol, Cadiz, Orange Blossom Wash, and Fenner basin system is separated from the surrounding drainage basins by topographic divides (generally mountain ranges).

The total area of the Bristol, Cadiz , Orange Blossom Wash, and Fenner groundwater basin system is approximately 2,710 square miles. Fenner Watershed itself is approximately 1,000 square miles. The Fenner Valley is bounded by granitic mountain ranges reaching heights over 7,500 feet. The Fenner Gap is at 900 feet NGVD.

Groundwater ranges from approximately 270 to 400 feet bgs in the northeastern portion of the Project area to 180 feet bgs in the southwest, becoming shallower with proximity to the Dry Lakes.[6]

Ephemeral surface water runoff within the Fenner Watershed flows into Schulyer Wash, which is located within the proposed wellfield and spreading basin areas (see Figure 3-14) and is the principal drainage in the Fenner Valley Watershed. It then flows through Fenner Gap to either the Bristol or Cadiz Dry Lakes.

Vegetation Communities and Wildlife Habitats

Vegetation communities are assemblages of plant species that occur together in the same area, which are defined by species composition and relative abundance. These plant communities can be generally correlated to habitats for wildlife. Four native plant communities would be impacted by the proposed Project. These communities are Mojave creosote bush scrub, Mojave wash scrub, stabilized or partially stabilized desert dunes, and stabilized or partially stabilized desert sand fields. In addition, two non-native plant communities, agriculture and disturbed, occur in the wellfield at the north end of the Project site. These plant communities are described below. Plant communities are described according to Holland's *Preliminary Description of the Terrestrial*

3 A bajada is a broad, sloping depositional deposit caused by coalescing alluvial fans.
4 County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report*, February 2007, page IV-7.
5 GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 3.
6 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163,* November 1999, page 46.

Communities of California (1986), Skinner and Pavlik's *Inventory of Rare and Endangered Vascular Plants of California* (1997), and Sawyer and Keeler-Wolfe's *A Manual of California Vegetation* (1995).

Mojave Creosote Bush Scrub

Mojave creosote bush scrub, dominated by creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*), is characterized by widely spaced, tall shrubs, usually separated by bare ground. This community is found from Death Valley south across the Mojave Desert to the Little San Bernardino Mountains and east to northwest Arizona and southern Nevada. It is the dominant plant community below 3,000 to 4,000 feet amsl in this region.

This plant community occurs on well-drained, secondary soils with very low available water holding capacity on slopes, fans and valleys. If rainfall is sufficient, growth occurs during spring or rarely in summer or fall. Temperature is growth limiting in winter, whereas available moisture is growth-limiting in other seasons. The plants within the community do not rely on the availability of groundwater for survival, but rather rely on infrequent rainfall. Following wet winters, there may be colorful displays of ephemeral annual species in late March and April in the intervening openings between shrubs. Other, less numerous annual species appear following summer thundershowers.

Common species within creosote bush scrub in upland areas, including throughout the wellfield areas, the northern portions of the pipeline alignment north of Old Woman Mountains, and southern reaches of the pipeline alignment south of Danby Lake include creosote bush, burrobush, cheesebush (*Hymenoclea salsola*), desert tea (*Ephedra californica*), honeysweet (*Tidestromia oblongifolia*), white rhatany (*Krameria grayi*), and big galleta (*Pleuraphis rigida*). Biological soil crusts (cryptobiotic soils) comprise a specialized community within Mojave creosote bush scrub. They form over long periods of time by weaving soil components together to stabilize desert surfaces, which protects the topsoil from water and wind erosion. They are comprised of cynobacteria, lichen, and moss, which create a fertile layer in which plants are able to grow in arid climates. The protective layer created by soil crusts also absorbs and retains moisture.[7] The typical distribution of cryptobiotic soil in this habitat type ranges from sparse to dense.

Mojave Wash Scrub

Mojave wash scrub is an open community with a scattered to locally dense overstory of low, shrubby, small-leaved trees. This community occurs on sandy bottoms of wide canyons, incised arroyos of upper bajadas and sandy, braided, shallow washes of the lower bajadas, usually below about 5,000 feet amsl (1,610 meters). It is found throughout the Mojave Desert region.

Mojave wash scrub occurs in washes throughout the proposed Project area. Dominant perennials occurring alongside the well-developed washes include several species of milkweeds (*Asclepias* ssp.), sweetbush (*Bebbia juncea*), rayless encelia (*Encelia fructescens*), arrow weed (*Pluchea*

7 Belnap, Jayne, *Cryptobiotic Soils: Holding the Place in Place*, http://geochange.er.usgs.gov/sw/impacts/biology/crypto/, accessed September 2011.

sericea), desert willow (*Chilopsis linearis* ssp. *arcuata*) (only in a few wellfield areas), bladderpod (*Isomerus arborea*), ditaxis (*Ditaxis neomexicana*), catclaw acacia (*Acacia greggii*), palo verde (*Cercidium floridum*) (south of Old Woman Mountains), smoke tree (*Psorothamnus spinosus*), desert lavender (*Hyptis emoryi*), sandpaper plant (*Petalonyx thurberi*), and Cooper's strangler (*Orobanche cooperi*).

Stabilized or Partially Stabilized Desert Dunes

Stabilized and partially stabilized desert dunes are characterized by desert sand accumulations that are stabilized or partially stabilized by evergreen and/or deciduous shrubs, including creosote bush, scattered low annuals, and perennial grasses. This community occurs below approximately 4,000 feet amsl (1,210 meters). These dunes are able to retain water just below the sand surface, allowing perennial vegetation to survive long drought periods. The community is not reliant on groundwater for survival. The vegetation cover increases as the dunes become progressively more stabilized. This plant community integrates with active desert dunes, stabilized or partially stabilized sand fields, sandier phases of creosote bush scrub, or desert wash scrub.

This community is found east of Danby Dry Lake along the ARZC ROW. Dominant plant species within this community include four-winged saltbush (*Atriplex canescens*), allscale (*Atriplex polycarpa*), desert holly (*Atriplex hymenelytra*), and Torrey's sea-blight (*Suaeda moquinii*).

Stabilized or Partially Stabilized Desert Sand Fields

Stabilized and partially stabilized sand fields are characterized by desert sand accumulations that are now obviously worked into dune formations. This community occurs below approximately 5,000 feet amsl (1,520 meters) elevation on flat sand accumulations throughout the Desert Region. Vegetation cover in this community can vary from sparse cover of widely spaced shrubs and herbs to newly closed shrub canopies. This community is similar to and intergrades with stabilized and partially stabilized desert dunes, but has much reduced sand microrelief. It is often found on the toe of bajada slopes.

This community is found in association with the Desert Dunes listed above, east of Danby Dry Lake along the ARZC ROW. Dominant plant species include Dicoria (*Dicoria canescens*), desert Spanish needles (*Palafoxia linearis*), devil's lantern (*Oenothera deltoides*), plicate coldenia (*Tiquilia plicata*), desert camas (*Zidagenus brevibracteatus*), and desert lily (*Hesperocallis undulata*).

Agriculture

Cadiz Inc. maintains an active agricultural operation on its property within the proposed wellfield area. The agricultural operation presently includes grapes, lemons, and seasonal vegetables, as well as fallow fields and turf. Some of the potential staging areas for Project construction are located within fallow fields.

Disturbed Areas

Disturbed areas occur in the wellfield area. These areas are sparsely vegetated with some native, but primarily non-native, weedy species. These areas are adjacent to existing agriculture in the

proposed wellfield area and may have formerly been row crops. The following invasive species were identified in the area and are indicative of moderately-to-heavily degraded habitats: velvet rosettes (*Psathyrotes ramosissima*), Saharan mustard (*Brassica tournefortii*), tansy (*Descurainia pinnata*), flixweed (*Descurainia sophia*), London rocket (*Sisymbrium irio*), Russian thistle (*Salsola tragus*), red-stemmed filaree (*Erodium cicutarium*), little trumpet (*Eriogonum trichopes*), Jimsonweed (*Datura wrightii*), and puncture vine (*Tribulus terrestris*).

Rocky Substrate

There are three places where substrates along the ARZC ROW are influenced by the proximity of mountainous areas, which in turn support several plant species that are entirely restricted to those areas or nearly so. The two main influences are Ship Mountains to the north and Old Woman Mountains near the center, with Kilbeck Hills in the vicinity of Chubbuck having somewhat less influence. The three cactus species—barrel cactus (*Ferocactus cylindraceus*), silver cholla (*Opuntia echinocarpa*), and beavertail cactus (*Opuntia basilaris*)—are more common in these areas than elsewhere. These species are also present in the wellfield areas along with pencil cholla (*Opuntia ramosissima*). Pencil cholla was not observed within the ARZC ROW.

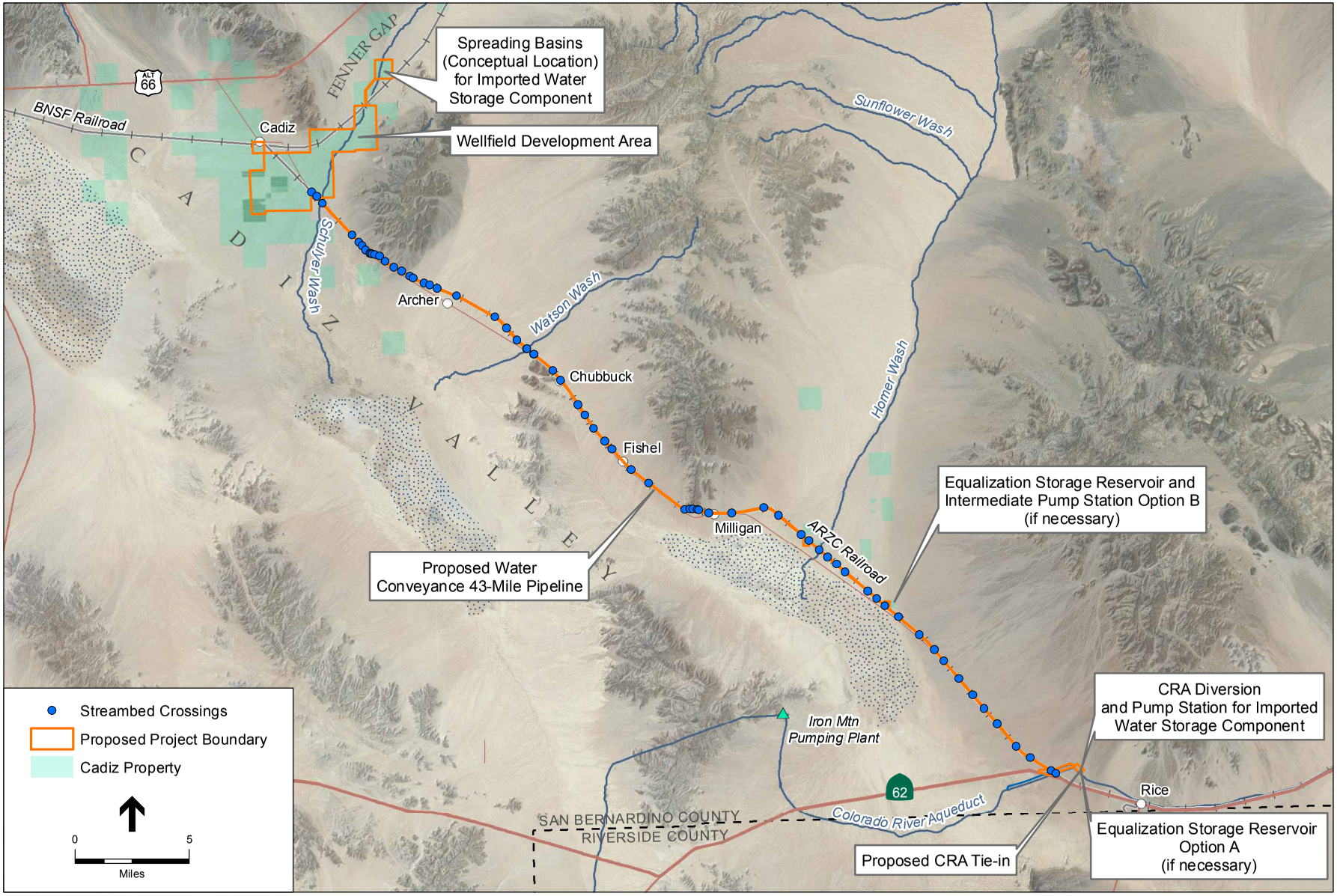
Jurisdictional Resources

Wetlands and Other Waters of the U.S.

A streambed delineation was conducted by CMBC between September 20 and October 17, 2010 in conjunction with focused surveys for desert tortoise, burrowing owl, and other biological resources. The washes were categorized based on substrates and associated plant communities. The most common type of washes are associated with sandy substrates and wash adapted plant species (referred to here as “sandy washes”); a second type of washes are associated with cobble substrates and creosote bush scrub (“cobbly washes”); and a third type of washes are associated with sandy substrates and saltbush scrub (“saltbush washes”). **Figure 4.4-1** identifies the location of the washes along the ARZC ROW.

There are 37 “sandy washes” in the pipeline ROW that are typically wide (10 to 100+ feet), sandy-bottomed streambeds vegetated by wash-adapted species such as smoke trees (*Psorothamnus spinosus*), wash rabbitbrush (*Chrysothamnus paniculatus*), rayless encelia, cheesebush, and sandpaper plant. They occur along the pipeline alignment north of Ship Mountains, between Ship and Old Woman mountains, and along the southern reaches of the proposed pipeline. With the exception of one crossing that passes through a culvert, all of these washes pass under bridge-like trestles (see Appendix C for all trestle locations along the ARZC railroad).

There are 15 “cobbly washes” in the pipeline ROW that are typically narrow (5 to 60 feet), with rocky-to-cobble substrates. These streambeds are typically vegetated by upland species associated with creosote bush scrub, including creosote bush, burrobush, sweetbush, desert lavender, and Acton encelia (*Encelia actoni*). These washes are either associated with Ship Mountains or Old Woman Mountains, which are responsible for the associated cobble substrates. Most of these crossings pass through one- or two-holed corrugated pipe culverts.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.4-1

Streambed Crossings

Finally, there are 15 "saltbush washes," in the pipeline ROW that are similar to the "cobbly washes" except they have sandy bottoms and are vegetated by saltbush scrub rather than creosote bush scrub. These are intermediate in widths (10 to 70 feet) and vegetated by allscale, fourwinged saltbush, Torrey's sea-blight, and indigo bush (*Psorothamnus emoryi*), among some of the same plants found along red washes. All of these streambed crossings are located east of Danby Lake, and all pass beneath trestles rather than culverts.

In summary, there are approximately 70 washes and drainages crossing the pipeline alignment. All of these streams flow east-to-west, and in many places have created washes and washlets along the eastern side of the ARZC railroad. This flow of water impeded by the existing rail line has resulted in enlarged perennial plants on the eastern side of the tracks, including many wash-adapted species associated with the "sandy washes" described above. Where these washes are associated with trestles beneath the train tracks, they serve as focal points for many common and several special-status wildlife species. None of the ephemeral washes are classified as wetlands.

Since the Cadiz Valley is a closed basin draining entirely to dry lake beds that do not have hydraulic connection with navigable waters of the U.S., it is assumed that these washes are not themselves waters of the U.S. However, the USACE is solely responsible for determining jurisdictional status of ephemeral washes.

Consistent with the Project's conservative approach with protecting existing resources, and in an abundance of caution, a network of observation wells would be utilized to monitor Project impacts, including a new well, Danby-1, which would be installed in the Danby Watershed. this Danby-1 observation well would be used to demonstrate that impacts on groundwater levels do not extend beyond the Cadiz Watershed on the east. This well would provide information on regional groundwater level conditions and is expected to provide additional background monitoring and information groundwater level changes that may be due to climatic variations as well.

Similar to Danby-1 observation well, one new observation well, Piute-1, would be installed in the Piute Wash Watershed, north of the Fenner Watershed, and is tributary to the Colorado River. This new well would be installed on property owned by Cadiz and would also be used as a "background" observation well to monitor undisturbed groundwater levels in an adjacent watershed, to provide information on groundwater level variations due to climatic variations only. In addition, this would serve to demonstrate that the Project would not impact groundwater that is tributary to the Colorado River. Installation of this well would likely require a nationwide permit from the Army Corps of Engineers, which could trigger a Section 7 consultation with the USFWS or other compliance with the Endangered Species Act.

The Piute Wash Watershed is tributary to the Colorado River. Groundwater flow from this Watershed ultimately discharges to the Colorado River, so it is a part of the water resource of the Colorado River. As discussed above, it would be an adverse impact if this groundwater flow was impacted by Project Operations. The Piute-1 observation well would provide data on groundwater levels in this basin. In addition, the Piute-1 well is located approximately equi-distance from the

next southerly well from the proposed Goffs observation well, so this well can be compared to these observations to assess groundwater level differences between these wells, if any.

Common Plant and Wildlife Species

A comprehensive list of plant and wildlife species observed or identified by sign during field surveys of the Project area can be found appended to the Biological Technical Report prepared by CMBC and included in Appendix F1. The tables list 17 reptile, 53 bird, and 13 mammal species, as well as 106 plant species.

Creosote bush and burrobush were the most abundant plant species observed within the proposed Project areas. Most commonly encountered reptile species included the side-blotched lizard (*Uta stansburiana*) and western whiptail (*Cnemidophorus tigris*).

A diverse group of bird species were observed throughout the proposed Project areas and included several resident species, incidental seasonal visitors or migrants, and species attracted to agricultural areas and water sources. Some common year-round residents observed and likely to nest in the area included the red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), chukar (*Alectoris chukar*) (only in mountainous areas), Gambel's quail (*Callipepla gambelii*) (mostly in washes), mourning dove (*Zenaida macroura*), greater roadrunner (*Geococcyx californianus*), Say's phoebe (*Sayornis saya*), verdin (*Auriparus flavipes*), rock wren (*Salpinctes obsoletus*) (in mountainous areas), and black-throated sparrow (*Amphispiza bilineata*).

All mammal species observed or determined present by sign, with the exception of pallid bats, are considered relatively common to remote desert areas. These included the round-tailed ground squirrel (*Spermophilus tereticaudis*), antelope ground squirrel (*Ammospermophilus leucurus*), various kangaroo rat species (*Dipodomys* spp.), Botta pocket gopher (*Thomomys bottae*), desert wood rat (*Dipodomys deserti*), black-tailed hare (*Lepus californicus*)), and Audubon cottontail (*Sylvilagus audubonii*). Predators determined to be present included coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), and bobcat (*Lynx rufus*).

Special-Status Species

Special-status species are plants and animals that are legally protected under state and federal Endangered Species Acts or other regulations and are considered sufficiently rare by the scientific community to qualify for such listing. These species are in the following categories:

- Plants or animals listed or proposed for listing as threatened or endangered under the federal Endangered Species Act (FESA) (50 Code of Federal regulations [CFR] 17.12 [listed plants], 17.11 [listed animals] and various notices in the Federal Register [FR] [proposed species]).
- Plants or animals that are candidates for possible future listing as threatened or endangered under the FESA (61 FR 40, February 28, 1996);

- Plants or animals listed or proposed for listing by the State of California as threatened or endangered under the California ESA Endangered Species Act (CESA) (14 California Code of Regulations [CCR] 670.5);
- Plants listed as rare or endangered under the California Native Plant Protection Act (California Fish and Game Code, Section 1900 et seq.);
- Plants that meet the definitions of "rare" and "endangered" under CEQA. CEQA Section 15380 provides that a plant or animal species may be treated as "rare or endangered" even if not on one of the official lists (State CEQA Guidelines, Section 15380);
- Plants considered under the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Lists 1A, 1B, and 2 in CNPS 2008);
- Plants listed by CNPS as plants about which more information is needed to determine their status and plants of limited distribution (Lists 3 and 4 in CNPS 2010), which may be included as special-status species on the basis of local significance or recent biological information;
- Animal species of special concern to the California Department of Fish and Game (CDFG); and
- Animals fully protected in California (California Fish and Game Code, Sections 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians]).

Table 4.4-1 lists the special-status wildlife and plant species with the potential to occur within the Project study area or to be affected by Project implementation. Information on the listing status, habitat requirements, and potential for occurrence within the Project study area is also provided. The list of species included in these tables was compiled based on review of a United States Fish and Wildlife Service (USFWS) list of federal endangered or threatened species occurring in San Bernardino County, as well as a search of the California Natural Diversity Database (CNDDB) and CNPS on-line database in December of 2010. The database search included the following 7.5 minute quadrangles: Arica Mountains, Cadiz Summit, Cadiz Lake Northwest, Cadiz Lake Northeast, Chubbuck, Milligan, East of Milligan, Danby Lake, and Sablon. Several special-status species not included in the above-mentioned quads, but listed in CMBC's Biological Technical Report, have also been added to the table as they have been observed within the Project area during field visits. Other species specifically requested for inclusion by CDFG have also been added.

Table 4.4-1's "Potential to Occur in the Study Area" category is defined as follows:

- **Low Potential:** The Project site and/or immediate area do not support suitable habitat or only provide limited habitat for a particular species. In addition, the known range for a particular species may be outside of the immediate Project area.
- **Medium Potential:** The Project site and/or immediate area provide suitable habitat for a particular species, and habitat for the species may be affected by the Project.

- **High Potential:** The Project site and/or immediate area provide ideal habitat conditions for a particular species, and/or known populations occur in immediate area or within the potential area of impact.

Special-status Wildlife

The only formally-listed species with a medium to high potential to occur within the proposed Project area is the desert tortoise (*Gopherus agassizii*).

The following is a list of special-status wildlife species that have a medium to high potential to occur within the Project area based on their habitat requirements:

- Mojave fringe-toed lizard (*Uma scoparia*)
- Golden eagle (*Aquila chrysaetos*)
- Long-eared owl (*Asio otus*)
- Burrowing owl (*Athene cunicularia)*
- Mountain plover (*Charadrius montanus*)
- Northern harrier (*Circus cyaneus*)
- Loggerhead shrike (*Lanius ludovicianus*)
- LeConte's thrasher (*Toxostoma lecontei*)
- Pallid bat (*Antrozus pallidus*)
- Southern grasshopper mouse (*Onychomys torridus ramona*)
- Nelson's bighorn sheep (*Ovis canadensis nelsoni*)
- Yuma mountain lion (*Puma concolor browni*)
- American badger (*Taxidea taxus*)

In addition to the above-mentioned, special-status wildlife species, the following species are tracked by CNDDB and/or other agencies and have a medium to high potential to occur within the Project area: Cooper's hawk, sharp-shinned hawk, ferruginous hawk, merlin, and prairie falcon.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Reptiles			
Gopherus agassizii **Desert tortoise**	FT/CT/--	Inhabits semi-arid grasslands, gravelly desert washes, canyon bottoms and rocky hillsides from near sea level to approximately 3,500 ft. Tortoises north and west of the Colorado River inhabit valleys and on alluvial fans. In the Sonoran Desert of Arizona, however, the tortoises tend to live on steep, rocky hillside slopes in Palo Verde and Saguaro Cactus communities. Mojave and Sonoran deserts of southeastern California, southern Nevada, south through Arizona into Mexico.	High – Suitable habitat is present throughout the study area and tortoise sign has been observed and recorded as occurring throughout the Project area during the 2010 surveys.
Uma scoparia **Mojave fringe-toed lizard**	--/CSC/--	Found in fine, loose, wind-blown sand in sand dunes, dry lakebeds, riverbanks, desert washes, sparse alkali scrub, and desert scrub. Shrubs or annual plants may be necessary for arthropods found in their diet.	High – Potential habitat present along portions of the ARZC ROW. Species was observed during 2010 field surveys east of Danby Dry Lake within sandfields created by prevailing winds from the west associated with the Dry Lake.
Birds			
Accipiter cooperii **Cooper's hawk**	--/--/--	Woodlands, generally of open, interrupted, or marginal type. Nests in riparian areas and oak woodlands, forages at woodland edges.	High – Study area does provide suitable habitat. Species was observed during the wellfield surveys, however they are more likely to use the site for foraging rather than nesting.
Accipiter striatus **Sharp-shinned hawk**	--/--/--	Found in ponderosa pine, black oak, riparian deciduous, mixed conifer, and Jeffrey pine habitats, but prefers riparian areas. North-facing slopes with plucking perches are critical requirements and usually nests within 275 feet of water.	High – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Two were observed in agricultural areas during 1999 field surveys.
Aquila chrysaetos Golden eagle	--/CFP/--	Nests on cliffs of all heights and in large trees near open areas. Occurs in rolling foothills, mountain terrain, sage-juniper flats, and rugged open habitats with canyons and escarpments. Preys mostly on small mammals.	Medium – Study area does provide suitable foraging habitat and this species was observed west of the Iron Mountains during field surveys conducted in 1999. Species is not expected to nest in the Project area.
Asio otus Long-eared owl	--/CSC/--	Found in riparian bottomlands grown to tall willows and cottonwoods and belts of like oak paralleling stream courses. Requires adjacent open land productive of mice and the presence of old nests of crows, hawks, or magpies for breeding.	Medium – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Observed west of Iron Mountain in smoke tree wash during 1999 field surveys.
Athene cunicularia **Burrowing owl**	--/CSC/--	Found in open, dry annual or perennial grasslands, deserts, and scrublands characterized by low-growing vegetation. Subterranean nester, dependent upon burrowing mammals, most notably the California ground squirrel.	High – Study area does provide suitable habitat and the species was observed during 2010 field surveys.
Buteo regalis **Ferruginous hawk**	--/--/--	Found in open grasslands, sagebrush flats, desert scrub, low foothills and fringes of pinyon-juniper habitats. Eats mostly lagomorphs, ground squirrels, and mice.	High – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Two were observed in agricultural areas during 1999 field surveys.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Buteo swainsonii Swainson's hawk	--/CT/--	Open grasslands, sagebrush flats, desert scrub, low foothills, and fringes of pinyon-juniper habitats. Eats mostly lagomorphs, ground squirrels, and mice.	Low – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Study area outside species' known range.
Chaetura vauxi Vaux's swift	--/CSC/--	Habitat consists of open sky over woodlands, lakes, and rivers. Nests in tree cavities.	Low – Study area provides limited suitable habitat and although a single bird was observed passing over the southern portion of the ARZC ROW in late September, Vaux's swifts are not likely to nest in the Project area and minimal foraging habitat is available.
Charadrius alexandrinus nivosus Western snowy plover	FT/CSC/--	Flat sandy beaches, salt flats, and sandy areas with minimal vegetation, nests in sandy depressions. May also nest on gravelly substrate. Has been known to nest near sewage ponds as well.	Low – Although not recorded, study area does provide limited suitable habitat around Danby Lake.
Charadrius montanus Mountain plover	--/CSC/--	Found in short grasslands, freshly plowed fields, newly sprouting grain fields, and sometimes sod farms. Likes short vegetation, bare ground, and flat topography. Prefers grazed areas and areas with burrowing rodents.	Medium – Although not reported in the area, potentially suitable habitat is present in fallow agricultural areas. Not observed during 2010 field surveys.
Circus cyaneus Northern harrier	--/CSC/--	Found in coastal salt and fresh-water march. Nests and forages in grasslands, from salt grass in desert sink to mountain cienagas. Likes to nest on ground in shrubby vegetation, usually at marsh edge. Nests are built of a large mound of sticks in wet areas.	Medium – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Observed near Iron Mountains during 1999 field surveys.
Empidonax traillii extimus Southwestern willow flycatcher	FE/CE/--	Riparian woodlands in Southern California, especially in low brushy vegetation in wet areas.	Low – Study area does not provide suitable habitat.
Falco columbarius Merlin	--/--/--	Found in seacoasts, tidal estuaries, open woodlands, savannahs, edges of grasslands and deserts, farms, and ranches. For roosting in open country, clumps of trees or windbreaks are required.	Medium – Study area provides suitable habitat for foraging and species may incidentally occur, but would not nest in the Project area. Not observed during 2010 field surveys.
Falco mexicanus **Prairie falcon**	--/--/--	Prefers open country, especially arid, in summer including alpine tundra to shortgrass prairie and high desert. In winter it is more widespread, ranging to low deserts and occasionally to towns. Nests on cliff ledges, so breeding adults are local during the breeding season.	High - 5 prairie falcons observed along the ARZC ROW and 6 observed during surveys of the wellfields. Prairie falcons were observed chasing mourning doves near the lime orchard in Section 27 and likely depredate birds throughout the Project area, where there is suitable foraging habitat. They likely nest in the Ship and Old Woman Mountains, but would not nest in the immediate Project area.
Lanius ludovicianus **Loggerhead shrike**	--/CSC/--	Broken woodlands, savannah, pinyon-juniper, Joshua tree, and riparian woodlands as well as desert oases, scrub, and washes. Prefers open habitats with scattered shrubs, trees, posts, fences, utility lines, or other perches for hunting.	High – Study area does provide suitable nesting and foraging habitat. Shrike sign was observed during 2010 field surveys. Occurs throughout the Project area, would nest in larger trees particularly alongside washes and is one of several species that may actively seek out railroad trestles for various resources, including perch sites and foraging.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Toxostoma lecontei **LeConte's thrasher**	--/CSC/--	Inhabits desert flats with sparse bushes, mostly saltbush (*Atriplex*) or creosote bush.	High - All sandy-bottom, well-developed washes with streamside growth are considered ideal habitats for this species, which will both nest and forage in such habitats. Individual LeConte's thrashers were observed in two places, including 1 along the east side of Danby Lake and 1 at the conceptual spreading basins. The species is very secretive and likely more common than observed.
Mammals			
Antrozous pallidus **Pallid bat**	--/CSC/--	Usually roosts in small colonies of 20 or more individuals in rock crevices and buildings, but occasionally roosts in caves, mines, and tree cavities. Distributed from south-central British Columbia to central Mexico and frequents arid regions with rocky outcroppings, particularly near water.	High – Suitable habitat is present within the study area along the ARZC ROW. The species was observed during surveys conducted in 1999 and 2010.
Corynorhinus townsendii Townsend's big-eared bat	--/CSC/--	Found throughout California in a wide variety of habitats, most commonly in mesic sites. Roosts in the open, hanging from walls and ceilings. Rosoting sites are limiting and they are extremely sensitive to human disturbance.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.
Euderma maculatum Spotted bat	--/CSC/--	Found in a wide variety of habitats from arid deserts and grasslands through mixed conifer forests. Feeds over water and along washes almost entirely on moths. Needs rock crevices in cliffs or caves for roosting.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.
Eumops perotis californicus Western mastiff bat	--/CSC/--	Found in many open, semi-arid habitats, including conifer and deciduous woodlands, coastal scrub, grasslands, chaparral, etc. Roosts in crevices in cliff faces, high buildings, trees, and tunnels.	Low – Observed foraging at Iron and Ship Mountains and Kilbeck Hills during 1999 field surveys.[8] Not observed during 2010 field surveys.
Macrotus californicus California leaf-nosed bat	--/CSC/--	Found in Sonoran and Mojave Desert scrub habitats in the Colorado River valley in Southern California, Nevada, and Arizona and throughout western Mexico.	Low – Suitable habitat may be present along the ARZC ROW, however the species has not been observed during field surveys conducted in 1999 and 2010.
Myotis occultus Arizona myotis	--/CSC/--	Found in lowlands of the Colorado River and adjacent desert mountain ranges. Roosts in tree hollows, rock crevices, under bridges, etc.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.

[8] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources,* 1999, pages 43-44.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Myotis thysanodes Fringed myotis	--/CSC/--	Found in a wide variety of habitats, optimal habitats are pinyon-juniper, valley fooothill hardwood, and hardwood-conifer. Uses caves, mines, buildings, or crevices for roosts and maternity colonies.	Low – Suitable habitat present at Ship Mountains. Maternity colony reported 15 miles north of wellfields.[9] Not observed during 2010 field surveys.
Myotis velifer Cave myotis	--/CSC/--	Found in lowlands of the Colorado River and adjacent mountain ranges. Requires caves or mines for roosting.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.
Nyctinomops femorosaccus Pocketed free-tailed bat	--/CSC/--	Found in a variety of arid areas in Southern California; pine-juniper woodlands, desert scrub, palm oasis, desert wash, and desert riparian. Prefers rocky areas with high cliffs.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.
Nyctinomops macrotis Big free-tailed bat	--/CSC/--	Found in low-lying arid areas in Southern California. Needs high cliffs or rocky outcrops for roosting sites. Feeds principally on large moths.	Low – Project area within species range. Not observed during 1995, 1999, or 2010 field surveys.
Onychomys torridus ramona Southern grasshopper mouse	--/CSC/--	Found in desert areas, especially scrub habitats with friable soils for digging. Prefers low to moderate shrub cover. Feeds almost exclusively on arthropods, especially scorpions and orthopteran insects.	Medium – Suitable habitat present in all Project areas. Not observed during 2010 field surveys.
Ovis canadensis nelsoni Nelson's bighorn sheep	--/--/--	Preferred habitat of bighorn is primarily on or near mountainous terrain above the desert floor. Females tend to choose particularly steep, safe areas for bearing and initial rearing of lambs.	Medium – Suitable habitat is present within the adjacent mountain ranges. Species may come down to the desert floor to forage during winter months. Species has been reported from Marble, Old Woman, and Turtle Mountains.
Puma concolor browni Yuma mountain lion	--/CSC/--	Found in low elevations in the Colorado River Valley of California. Live in dense bottomland vegetation and also found in adjacent, rocky uplands.	Medium – Suitable habitat present in Ship, Iron, and Old Woman Mountains and Kilbeck Hills. Not previously observed during field surveys.
Taxidea taxus **American badger**	--/CSC/--	Most abundant in drier open stages of most shrub, forest, and herbaceous habitats. Needs sufficient food, friable soils, and open, uncultivated ground. Preys on burrowing rodents.	High – Suitable habitat is present within the study area ,and as part of the burrowing owl habitat assessment conducted in 2010, surveyors collected UTM coordinates for 53 badger digs along the ARZC ROW and 59 digs in the surveyed wellfield areas.
Plants			
Androstephium breviflorum Small-flowered androstephium	--/--/2.2	Found in creosote bush scrub and desert dunes. 255 – 1510 m.	Medium – Suitable habitat present throughout study area. Species was observed west of Iron Mountains during 1995 field surveys.
Arctomecon merriamii White bear poppy	--/--/2.2	Found in rocky soils in creosote bush scrub. 460 – 1500 m.	Low – Study area outside species' range, and study area is below the elevational range for this species.

[9] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources,* 1999, page 44.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Astragalus insularis var. *harwoodii* Harwood's milk-vetch	--/--/2.2	Annual herb found in sandy or gravelly soils in desert dunes Mojavean desert scrub. 0 – 710 m. Blooms January-May.	Medium – Suitable habitat is present within the desert dunes in the Mojavean desert scrub habitat within the study area. Species has been observed and recorded within 5 miles of the study area, however none were observed within the study area.
Astragalus lentiginosus var. *borreganus* Borrego milk-vetch	--/--/4.3	Found in sandy soils in creosote bush scrub. 25 – 255 m.	Medium – Suitable habitat is present in western portion of wellfield area and sandy areas along ARZC ROW, particularly near Danby Lake. Species was observed in 1995 east of Iron Mountain Pumping Plant and Cadiz Lake in sand field areas.
Castela emoryi Crucifixion thorn	--/--/2.3	Deciduous shrub along gravelly washes, slopes, and plains in creosote bush scrub. 85 – 575 m.	Low - As a large shrub occurring in washes, this plant would have been found if present within the ARZC ROW. Not observed during 1995 or 1999 field surveys.
Colubrina californica Las animas colubrina	--/--/2.3	Evergreen shrub found in creosote bush scrub. 10 – 945 m.	Low – As a large shrub occurring in washes, this plant would have been found if present within the ARZC ROW. Not observed during 1995 or 1999 field surveys.
Coryphantha alversonii Alverson's foxtail cactus	--/--/4.3	Found in rocky to cobbly soils in creosote bush scrub. 70 – 1440 m.	Medium – Suitable habitat is present in wellfield area Section 17 and where Ship and Old Woman Mountains approach ARZC ROW. Species observed west of Iron Mountain in 1995.
Cryptantha costata Ribbed cryptantha	--/--/4.3	Found in sandy soils in creosote bush scrub. 55 - 470 m.	Medium – Suitable habitat is present east of Danby Lake near ARZC ROW. Species was found in 1995 at Cadiz Lake and in areas of stabilized dunes, but not along Cadiz Road.
Cryptantha holoptera Winged cryptantha	--/--/4.3	Found in sandy to rocky soils in creosote bush scrub. 95 -1130 m.	Medium – Suitable habitat is present throughout study area. Not observed during 1995 or 1999 field surveys.
Cynanchum utahense Utah vine milkweed	--/--/4.2	Found in dry sandy, gravelly soil in creosote bush scrub. 140 - 1340 m.	Medium – Suitable habitat is present throughout study area. Not observed during 1995 or 1999 field surveys.
Echinocereus engelmannii var. *howei* Howe's hedgehog cactus	--/--/1B.1	Found in creosote bush scrub. 405 – 730 m.	Low – Study area is below the elevational range for this species.
Eriastrum harwoodii Harwood's eriastrum	--/--/1B.2	Annual herb found on desert dunes. 200 – 915 m. Blooms March-June. Known from fewer than 20 occurrences.	Low – Suitable habitat may be present along the desert dunes.
Linanthus arenicola Sand linanthus	--/--/--	Found in well-aerated sandy soils on the valley floors, particularly near high mountains and along the courses of the larger desert rivers and washes. 121 – 1500 m.	Low – Potentially suitable habitat present east of Danby Dry Lake.
Linanthus maculates Little San Bernardino Mountains linanthus	--/--/1B.2	Found in sandy soils in creosote bush scrub and in the vicinity of Joshua Tree. 185 – 1840 m.	Low – Study area well outside species' known range.
Matelea parvifolia Spear-leaf matelea	--/--/2.3	Found in dry rocky soils in creosote bush scrub. 415 – 1035 m.	Low – Study area is below the elevational range for this species.

TABLE 4.4-1
SPECIAL-STATUS SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Scientific Name Common Name	Listing Status: Federal/State/ CNPS	General Habitat	Potential to Occur in the Study Area
Monardella robisonii Robison's monardella	--/--/1B.3	Found in pinyon-juniper woodland. 575 – 1420 m.	Low – Study area outside species' range and study area is below the elevational range for this species. Suitable habitat not present within ESA 2011 survey area.
Nemacaulis denudata var. *gracilis* Slender cottonheads	--/--/2.2	Found in sandy slopes above drainage at 475 m.	Medium – Suitable habitat along ARZC ROW and western portion of wellfield area. Found in Arica Mountains in 2010.
Opuntia basilaris var. *brachyclada* Short-joint beavertail cactus	--/--/1B.2	Found in creosote bush scrub. 405 – 1700 m.	Low – Study area outside species' range and study area is below the elevational range for this species.
Penstemon albomarginatus white-margined beardtongue	--/--/1B.1	Perennial herb found on desert dunes (stabilized) and Mojavean desert scrub (sandy). Blooms March-May. 640 – 1065 m. Known in CA from fewer than 20 occurrences.	Low – Study area does not provide suitable habitat and study area is below the elevational range for this species.
Penstemon stephensii Stephen's beardtongue	--/--/1B.3	Found in carbonate or rocky soils in creosote bush scrub. 1065 – 1745 m.	Low – Study area is below the elevational range for this species.
Physalis lobata Lobed ground- cherry	--/--/2.3	Found in decomposed granite in creosote bush scrub. 470 – 755 m.	Low – Study area is below the elevational range for this species. Suitable substrate not observed within ESA 2011 survey area.
Salvia greatae Orocopia sage	--/--/1B.3	Found in broad alluvial bajadas and fans beside washes in creosote bush scrub. 35 – 760 m.	Low – Suitable habitat may be present within wellfield area Section 17 and where Ship and Old Woman Mountains approach ARZC ROW. Found in Marble Mountains in 1978.
Sphaeralcea rusbyi var. *eremicola* Rusby's desert-mallow	--/--/1B.2	Found in creosote bush scrub. 920 – 1420 m.	Low – Study area is below the elevational range for this species.

SOURCE: U.S. Fish and Wildlife Service, *2010 List of Federal Endangered or Threatened Species for San Bernardino County*, 2010; California Department of Fish and Game, Biogeographic Data Branch, California Natural Diversity Database, Rarefind Computer Program (Version 3.1.0), September 5, 2010; California Native Plant Society, *Inventory of Rare and Endangered Plants* http://www.rareplants.cnps.org/, accessed November 2010.
KEY:

Federal: (USFWS)
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
FC = Candidate for listing by the Federal Government

State: (CDFG)
CE = Listed as Endangered by the State of California
CT = Listed as Threatened by the State of California
CR = Listed as Rare by the State of California (plants only)
CSC = California Species of Concern
CFP = California Fully Protected Species

CNPS: (California Native Plant Society)
List 1A = Plants presumed extinct in California
List 1B = Plants rare, threatened, or endangered in California and elsewhere
List 2 = Plants rare, threatened, or endangered in California but more common elsewhere
List 3 = Need more information
List 4 = Plants of limited distribution
0.1 = Seriously endangered in California
0.2 = Fairly endangered in California
0.3 = Not very endangered in California

– = No Listing

The following is a brief description of the special-status wildlife species identified as having a medium or high potential for occurrence based on nearby occurrences and/or the presence of suitable habitat.

Reptiles

Desert tortoise (Gopherus agassizii)

Listed as a state and federally threatened species, the desert tortoise inhabits semi-arid grasslands, gravelly desert washes, canyon bottoms, and rocky hillsides. It is native to the Mojave desert and Sonoran desert of the southwestern United States and northern Mexico. It is a completely terrestrial desert or semidesert species, requiring firm, but not hard, ground for construction of burrows (in banks of washes or compacted sand) or uses shelters among rocks and exposed, eroded caliche layers in walls of washes. The desert tortoise frequents desert oases, riverbanks, washes, dunes, and rocky slopes.[10]

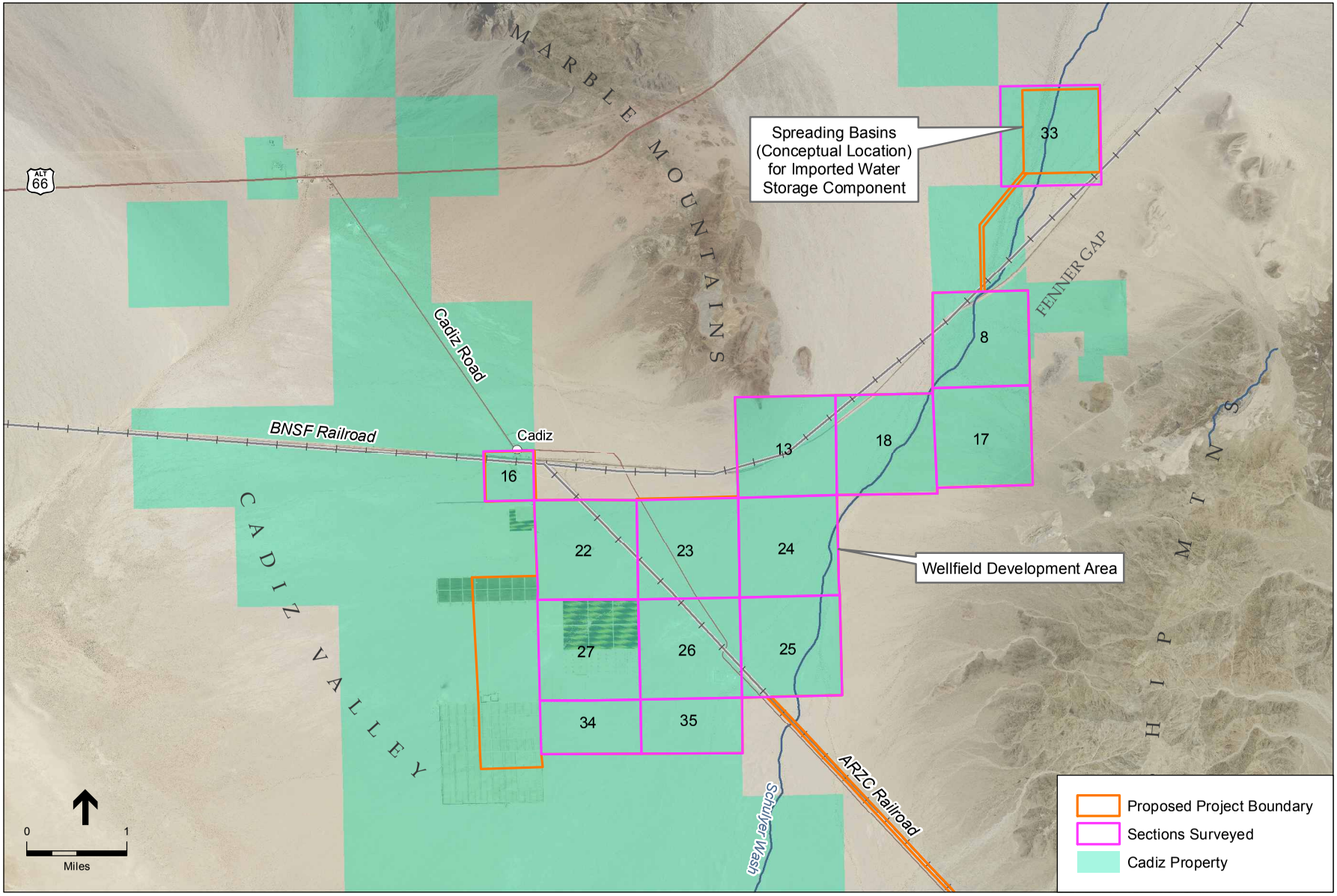
During CMBC's 2010 Desert Tortoise Survey, CMBC found desert tortoise scat, carcasses, and a burrow along the northern portion of the water conveyance pipeline within the ARZC ROW. The burrow found was not considered to be active. All evidence of living tortoises was found between the north end of the ARZC ROW and Old Woman Mountains, with carcasses found to the south.[11] Tortoises may be absent or occur in very low densities south of Old Woman Mountains and are not considered common anywhere along the ARZC ROW, apparently occurring in low densities along northern reaches. CMBC concluded that tortoises most likely do not reside along the ARZC ROW, but may occasionally enter into the ARZC ROW portion of the Project.

In the proposed wellfield area, evidence of living tortoises was restricted to Sections 17 and 18, with carcasses found in Sections 8 and 35. **Figure 4.4-2** shows the Sections within the wellfield and conceptual spreading basin area surveyed by CMBC in 2010.[12] The carcass found in Section 35 appears to have died in the early 1940s and was the only tortoise sign found in the central and western portions of the proposed wellfield area. CMBC concludes that tortoises are most likely to be encountered in the eastern portion of the wellfield area (particularly Section 17 and 18, and perhaps Section 8) and least likely to be encountered elsewhere. Though not detected at the conceptual spreading basin area, habitats there are among the least impacted and most suitable, and tortoise(s) may occur there in the future, if not already.

10 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources*, 1999, page 37.

11 Circle Mountain Biological Consultants, *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project, San Bernardino County, California*, Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, Los Angeles, November 2010.

12 Circle Mountain Biological Consultants, *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project, San Bernardino County, California*, Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, Los Angeles, CA, November 2010, Figure 7.



SOURCE: USDA, 2009; ESRI, 2010; Cadiz Inc., 2011; San Bernardino Co., 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.4-2

Sections Surveyed for Desert Tortoise
Within the Proposed Wellfield Area

The desert tortoise critical habitat finalized in 1994 (See discussion of 1994 critical habitat below under 4.4.2 Regulatory Framework and **Figure 4.4-3**) extends from the north through the upper Fenner Valley and Southward into the Ward Valley. With respect to the Project facilities, the critical habitat ends just north of the wellfield and extends southward but ends before reaching the ARZC ROW. The Groundwater Conservation and Recovery Component of the Project would be located adjacent to but outside of designated critical habitat for the desert tortoise (Figure 4.4-3). However, the observation well within the Piute Wash Watershed would be located within desginated critical habitat, and the Imported Water Storage Component would include some facilities, such as the recharge basin, within designated critical habitat.

Mojave fringe-toed lizard *(Uma scoparia)*

The Mojave fringe-toed lizard is a California Species of Concern and a BLM-sensitive species. This species is found in desert regions of Southern California. It uses fine, loose, wind-blown deposits in sand dunes and other sandy habitats. Rodent burrows and bases of shrubs are also used for cover. This species was observed during surveys conducted by CMBC in 2010. Suitable habitat is only present along the pipeline route where loose sandy habitat is present east of Danby Dry Lake.

Birds

Golden eagle (*Aquila chrysaetos*)

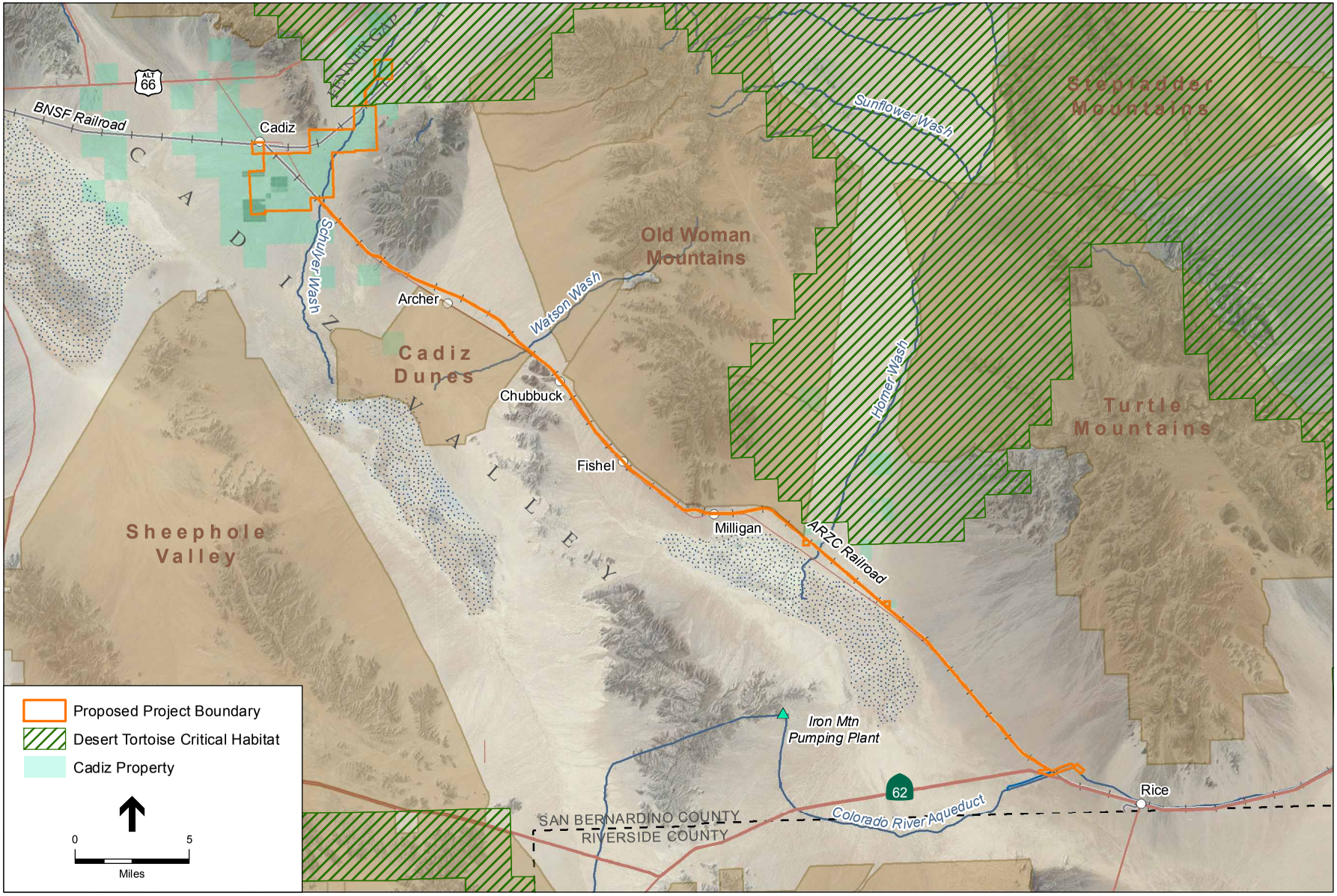
The golden eagle is a raptor species that is fully protected in California. The golden eagle is an uncommon, permanent resident and migrant throughout California (except in the center of the Central Valley where it is a winter visitor). Golden eagles nest in open areas on cliffs and in large trees, often constructing multiple nests in one breeding territory.[13] They forage in open terrain such as grasslands, deserts, savannahs, and early successional stages of forest and shrub habitats.[14]

Although in 2010 there was no evidence of the golden eagle, during the 1999 surveys it was observed foraging within the vicinity of the proposed Project area. Therefore, this species may incidentally occur in the area and occasionally forage there, but would not likely nest in the Project area.

Long-eared owl (*Asio otus*)

Listed as a California Species of Concern, the long-eared owl is a raptor species that requires the presence of old nests of crows, hawks, or magpies for breeding. The long-eared owl was observed west of Iron Mountains in a smoke tree wash during field surveys conducted in 1999. And although the study area provides suitable habitat for foraging and this species may incidentally occur, long-eared owls are not expected to nest in the Project area due to the lack of suitable nesting habitat.

13 Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds*, California Department of Fish and Game, 1990, page 732.
14 Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds*, California Department of Fish and Game, 1990, page 732.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.4-3

Desert Tortoise Critical Habitat

Burrowing owl (*Athene cunicularia hypugaea*)

Listed as a California Species of Concern, western burrowing owls nest in burrows in the ground, often in old ground squirrel burrows or badger dens. They can dig their own burrows but prefer deserted excavations of other animals. They are also known to use artificial burrows. Burrowing owls in northern California are thought to migrate, whereas burrowing owls within central and Southern California are predominantly nonmigratory. They are found in open, dry grasslands, agricultural and range lands, and desert habitats often associated with burrowing animals. They can also inhabit grass, forb, and shrub stages of pinyon and ponderosa pine habitats. Burrowing owls can be found at elevations ranging from 200 feet below sea level to 9,000 feet. In California, the highest elevation where this species is found is 5,300 feet in Lassen County. The burrowing owl commonly perches on fence posts or on top of mounds outside its burrow. They tend to be opportunistic feeders, feeding primarily on large arthropods, mainly beetles and grasshoppers, as well as small mammals, especially mice, rats, gophers, and ground squirrels. The burrowing owl hovers while hunting, and after catching its prey, returns to a perch on a fence post or the ground. Burrowing owls are primarily crepuscular (active at dusk and dawn), but will hunt throughout a 24-hour period. Nesting season begins in late March or April.

Surveys conducted by CMBC found burrowing owls and burrows with owl sign throughout all proposed Project areas, along the pipeline route, wellfield area, and spreading basin area.

Mountain plover (*Charadrius montanus*)

The mountain plover is listed as a California Species of Concern found in freshly plowed fields, newly sprouting grain fields, and sod farms. This species prefers grazed areas and areas with burrowing rodents.

The mountain plover was not observed during field surveys conducted in the Project areas. However, potential suitable habitat can be found in the wellfield area and potential staging areas where fallow agriculture is present.

Northern harrier (*Circus cyaneus*)

The northern harrier, listed as a California Species of Special Concern, prefers to nest on the ground in shrubby vegetation on nests built of a mound of sticks near wet areas. This species nests and forages in grasslands, from salt grass in desert sinks and coastal and freshwater marshes to mountain meadows. The northern harrier nests on the ground in shrubby vegetation.

This species was observed near the Iron Mountains during field surveys conducted in 1999 by CMBC, but was not observed in 2010. Therefore, the northern harrier may incidentally occur in the Project area and forage there, but is not expected to nest in any of the proposed Project areas.

Loggerhead shrike (*Lanius ludovicianus*)

Loggerhead shrikes, listed as a California Species of Special Concern, breed mainly in shrublands or open woodlands with grass cover and areas of bare ground. They require tall shrubs or trees (also use fences or power lines) for hunting perches, territorial advertisement, and pair maintenance; open areas of short grasses, forbs, or bare ground for hunting; and large shrubs or

trees for nest placement. They also need impaling sites for prey manipulation or storage, which can include sharp, thorny, or multistemmed plants and barbed-wire fences.[15]

Loggerhead shrikes hunt by perching on appropriate substrates and scanning the area, taking prey primarily from the ground but occasionally in flight, and often impaling prey for easier manipulation or for storage for later consumption. The diet of loggerhead shrikes varies seasonally and includes arthropods (especially grasshoppers, crickets, beetles, and caterpillars), reptiles, amphibians, small rodents, and birds.

Shrikes were identified by sight and sign during CMBC's surveys. Shrikes were observed along the proposed pipeline route and within the wellfield areas. Since shrikes regurgitate distinctive pellets that can be readily identified in the field, loggerhead shrikes were identified at several locations (including under train trestles and at bundled railroad ties). Loggerhead shrikes apparently occur throughout all proposed Project areas, would nest in larger trees particularly alongside washes, and may actively seek out railroad trestles for various resources, including perch sites and foraging.

LeConte's thrasher (*Toxostoma lecontei*)

LeConte's thrasher, listed as a California Species of Special Concern, is an uncommon resident of the deserts of the American Southwest and northwestern Mexico and inhabits some of the most desolate environments on the continent preferring desert flats with sparse bushes, mostly saltbush (*Atriplex*) or creosote bush.[16]

Individual LeConte's thrashers were observed in two places, including one along the east side of Danby Dry Lake and one at the conceptual spreading basins, during field surveys conducted by CMBC in 2010. The species is very secretive and likely more common than observed. Two were reported in Schulyer Wash and one at an undisclosed place in the conceptual spreading basins during surveys conducted in 1999.[17] All sandy-bottom, well-developed washes with streamside growth are considered ideal habitats for this species which will both nest and forage in such habitats. LeConte's thrasher has the potential to occur throughout all proposed Project areas.

Common Raptor Species

Common raptor species, such as the Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), ferruginous hawk (*Buteo regalis*), merlin (*Falco columbarius*), and prairie falcon (*Falco mexicanus*) are not considered special-status species because they are not rare or protected under the FESA or CESA. However, nests of these species are still protected under the MBTA and Section 3503.5 of the California Fish and Game Code. All species are on CDFG's Watch List and the ferruginous hawk and prairie falcon are also a USFWS Bird of Conservation Concern. The large birch trees located in the northeast corner of the Project area could provide potential nesting habitat for common raptors that occur in the Project region.

15 Shuford, W.D., and Gardali, T., *California Bird Species of Special Concern,* February 2008.
16 Sheppard, J. M., *Le Conte's Thrasher (Toxostoma lecontei)*, January 1996.
17 Circle Mountain Biological Consultants, *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project, San Bernardino County, California,* Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, Los Angeles, CA, November 2010.

No Cooper's hawks were observed along the proposed pipeline route, but several were observed within the wellfield area. Sharp-shinned hawks and ferruginous hawks have been observed within agricultural fields in the wellfield areas. Prairie falcons were observed along the proposed pipeline route and within the wellfield area. Merlins have not been previously observed at any of the proposed Project areas.

Migratory Birds

A large number of common bird species are migratory and fall under the jurisdiction of the MBTA. A comprehensive list of MBTA species that could occur in the Project study area is too lengthy to provide here, but includes such familiar species as northern mockingbird (*Mimus polyglottos*), mourning dove (*Zenaida macroura*)), and western kingbird (*Tyrannus verticalis*). Numerous migratory bird species have the potential to nest within the Project site. The nests of all migratory birds are protected under the MBTA.

Mammals

Pallid bat (*Antrozous pallidus*)

Pallid bats, listed as a California Species of Special Concern, are distributed from south-central British Columbia to central Mexico and frequent arid regions with rocky outcroppings, particularly near water. The gregarious species usually roosts in small colonies of 20 or more individuals in rock crevices and buildings, but occasionally roosts in caves, mines, and tree cavities. It feeds chiefly on large prey that is taken on the ground or perhaps less frequently in flight within a few meters of the ground or from surfaces of vegetation.[18]

During surveys conducted in 1999, a pair of pallid bats was observed at an active night roost at a train trestle east of Kilbeck Hills.[19] Based on the 2010 survey, it is believed that pallid bats are much more common in the Project area along the ARZC ROW than previously noted. Surveyors closely inspected approximately 70 train trestles for the presence or evidence of pallid bats. Surveyors observed bats at 13 different trestles located along the entire length of the rail line, and bat guano was observed at 9 additional trestles.

At least four different types of trestles, including cement, wood, a combination of the two, and corrugated culverts, can be found along the ARZC ROW. Pallid bats were mostly observed at the cement and wood trestles, less at the combined type, and never in the corrugated culverts. Surveyors also checked a half-dozen similar trestles along the BNSF line in the wellfield areas but did not find any bats or guano. CMBC concludes that the heavy train traffic on the BNSF line compared to only two or three trips per day on the ARZC line could preclude bats from the BNSF but not the ARZC ROW.

---

18 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources,* 1999.

19 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources,* 1999. 19 California Department of Fish and Game, Natural Diversity Database, *Special Vascular Plants, Bryophytes, and Lichens List*, January 2010, page 71.

Southern Grasshopper Mouse (*Onychomys torridus ramona*)

The Southern grasshopper mouse is found in desert scrub habitats with friable soils that are suitable for digging. It prefers low to moderate shrub cover and feeds almost exclusively on arthropods, especially scorpions and orthopteran insects. Although there is suitable habitat present throughout the Project areas, it was not observed during 2010 field surveys.

American badger (*Taxidea taxus*)

American badgers, listed as a California Species of Special Concern, are carnivorous, eating fossorial rodents, reptiles, insects, earthworms, eggs, birds, and carrion. Their diet shifts in response to prey abundance. Badgers are active year-round, although they do experience periods of torpor during the winter.[20] American badgers are present in most shrub, forest, and herbaceous habitats where friable soils are present. They are most abundant in drier, open areas including grasslands, savannahs, and mountain meadows near the timberline. Badgers dig burrows for cover; they frequently use old burrows, but some badgers will dig a new burrow each night during the summer.[21]

American badgers were historically residents of California, except in the humid coastal areas of Del Norte and northern Humboldt Counties.[22] Currently, they survive in low numbers in the periphery of the Central Valley, adjacent lowlands of eastern Monterey, San Benito, and San Luis Obispo Counties, and coastal areas south of Mendocino County. They have been extirpated from much of Southern California.[23]

No American badgers or primary burrow systems were observed during CMBC surveys in 2010; however, evidence of their foraging (digs) was apparent throughout all the proposed Project areas surveyed.

Nelson's bighorn sheep (*Ovis Canadensis nelsoni*)

Nelson's bighorn sheep prefers habitat primarily on or near mountainous terrain above the desert floor. Bighorn sheep habitat designated by BLM surrounds the proposed Project areas (see **Figure 4.4-4**). They generally avoid the valley floors except to cross from one mountain range to the other. Figure 4.4-4 identifies areas potentially used by bighorn sheep to migrate between mountain habitats.

Nelson's bighorn sheep have not been observed during field surveys, but suitable habitat is present within the adjacent and surrounding mountain ranges. This species may enter the Project site and the surrounding desert area while foraging during winter months.

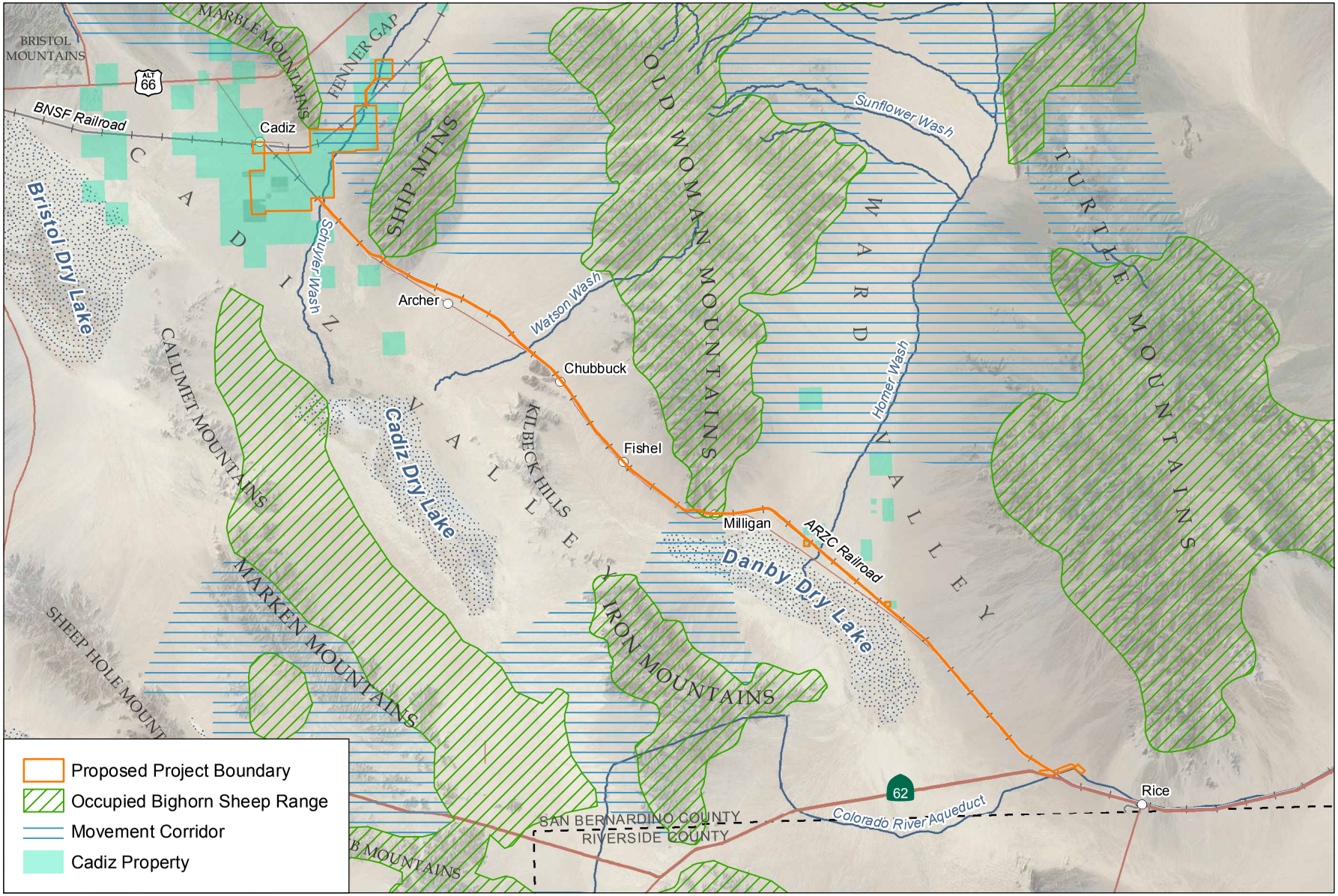
---

20 Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds,* California Department of Fish and Game, 1990.

21 Williams, D. F., *Mammalian Species of Special Concern in California*, June 1986, page 59; Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds*, California Department of Fish and Game, 1990.

22 Williams, D. F., *Mammalian Species of Special Concern in California*, June 1986, page 59; Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds*, California Department of Fish and Game, 1990.

23 Williams, D. F., *Mammalian Species of Special Concern in California*, June 1986, page 59.



SOURCE: Nothern and Eastern Colorado Desert Coordinated Management Plan; ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.4-4

Bighorn Sheep Range and Movement Corridor

Yuma Mountain Lion (*Puma concolor browni*)

The Yuma Mountain Lion is found in low elevations in the Colorado River Valley of California. It lives in dense bottomland vegetation and also found in adjacent, rocky uplands. Although there is some suitable habitat present in Ship, Iron, and Old Woman Mountains and in the Kilbeck Hills, it has not previously been observed during field surveys. This species may enter the Project area and the surrounding desert area while foraging.

Special-Status Plants

The following is a list of special-status plant species with a CNPS List 2[24] status that have a medium to high potential to occur within the Project area based on their habitat requirements:

- Small-flowered endrostephium (*Androstephium breviflorum*)
- Hardwood's milk-vetch (*Astragalus insularis* var. *harwoodii*)
- Slender cottonheads (*Nemacaulis denudata* var. *gracilis*)

In addition to the above-mentioned special-status plant species, the following List 4 species[25] have a medium to high potential to occur within the Project area: Borrego milk-vetch, Alverson's foxtail cactus, ribbed cryptantha, winged cryptantha, and Utah vine milkweed. No native plant species that are known to be phraeatophytic (relying on groundwater for survival) were found during field surveys within the Project area.

The following is a brief description of the special-status CNPS List 2 species identified as having a medium or high potential for occurrence, based on nearby occurrences and/or the presence of suitable habitat.

Small-flowered endrostephium (*Androstephium breviflorum*)

Small-flowered androstephium, listed by CNPS as fairly endangered in California, is a perennial bulbiferous herb found on desert dunes and desert scrub. This species blooms between March and April. [26]

Suitable habitat for this species is present throughout the Project area and was observed west of the Iron Mountains in 1995.

Harwood's milk-vetch (*Astragalus insularis* var. *harwoodii*)

Harwood's milk-vetch, listed by CNPS as fairly endangered in California, is an annual herb found on desert scrub below 930 feet and on sandy or gravelly desert dunes. The range of this species extends from Southern California and Arizona, down to Mexico.[27]

24 Plants rare, threatened, or endangered in California but more common elsewhere.
25 Plants of limited distribution.
26 California Native Plant Society, *Inventory of Rare and Endangered Plants*, http://www.rareplants.cnps.org/, accessed June 2011.
27 California Native Plant Society, *Inventory of Rare and Endangered Plants*, http://www.rareplants.cnps.org/, accessed June 2011.

Suitable habitat for Harwood's milk-vetch is present within the desert dunes along the proposed pipeline route and the wellfield area. In 2010, this species was observed and recorded within the vicinity of the Project area between Danby Dry Lake and Cadiz Road.

Slender cottonheads (*Nemacaulis denudata* var. *gracilis*)

Slender cottonheads is listed by CNPS as fairly endangered in California and is an annual herb. This species blooming period is March through May, and it can be found on coastal dunes, desert dunes, or Sonoran desert scrub.[28]

Suitable habitat for this species can be found within the ARZC ROW and along the western portions of the wellfield area. Slender cottonheads were found in the Arica Mountains in 2010.

Sensitive Habitats

Sensitive habitats are designated by CDFG as any area in which plant or animal life or their habitats are either rare or especially valuable or may contain "rare and endangered" species. Sensitive habitats in the Project area include Mojave wash scrub and stabilized or partially stabilized desert dunes or desert sand fields found along the ARZC ROW. These plant communities are considered sensitive by the CDFG.

Wildlife Movement Corridors

Wildlife movement corridors are considered an important ecological resource by various agencies (CDFG, USFWS, United States Forest Service [USFS]) and under CEQA. Movement corridors may provide favorable locations for wildlife to travel between different habitat areas such as foraging sites, breeding sites, cover areas, and preferred summer and winter range locations. They may also function as dispersal corridors allowing animals to move between various locations within their range.

Wildlife movement corridors vary greatly in their overall significance. Studies on wildlife movement corridors suggest that major drainages, canyon bottoms and ridgetops, as well as areas that provide important resources for wildlife, are the most important for wildlife movement. In general, two types of corridors exist. Regional corridors allow for movement between large, often widely separated areas. These may connect national forests, mountain ranges or other major wildlife use areas. Local wildlife corridors allow dispersion between smaller, generally more adjacent areas, such as between canyons or ridges or between important resource areas.

BLM has designated several regional wildlife movement corridors connecting occupied bighorn sheep habitat on the Project site and in the Project vicinity (see Figure 4.4-4). A movement corridor connecting occupied bighorn sheep habitat between the Marble Mountains and the Ship Mountains to the southeast traverses the Project spreading basin and wellfield areas. This corridor is bisected by the mainline of the BNSF, Historic Route 66 and other roads. Schulyer Wash, which occurs southeast of the Project spreading basins, is a likely stopping point for wildlife that may be traveling between the Marble and Ship Mountains. Schulyer Wash also appears to be an

[28] California Native Plant Society, *Inventory of Rare and Endangered Plants*, http://www.rareplants.cnps.org/, accessed June 2011.

important resource to tortoises. Tortoises may use this wash as a travel corridor, and/or they are relying on resources provided by the wash, apparently concentrating their use in this area.

Another regional movement corridor connects occupied bighorn sheep habitat between the Old Woman Mountains and the Iron Mountains to the south. This corridor crosses Danby Dry Lake and is bisected by the ARZC rail line and Cadiz Rice Road. A larger regional movement corridor connects the Iron Mountains and the Calumet Mountains to the west. The power transmission line running north-south across Danby Dry Lake crosses suitable habitat at the southern edge of the Iron Mountains.

4.4.2 Regulatory Framework

The following discussion describes the various federal, State, and local laws and regulations that prescribe consideration of species and habitats that may be found in the proposed Project area.

Federal

Federal Endangered Species Act

The Federal Endangered Species Act (FESA) protects threatened and endangered plants and animals and their critical habitat. Candidate species are those proposed for listing; these species are usually treated by resource agencies as if they were actually listed during the environmental review process. Procedures for addressing impacts to federally listed species follow two principal pathways, both of which require consultation with the USFWS. The first pathway, Section 10(a) incidental take permit, applies to situations where a non-federal government entity must resolve potential adverse impacts to species protected under the FESA. The second pathway, Section 7 consultation, applies to projects directly undertaken by a federal agency or private projects requiring a federal permit or approval.

USFWS produced an updated list of candidate species for listing in June 2002 (Federal Register: Volume 67, Number 114, 50 CFR Part 17). Candidate species are regarded by USFWS as candidates for addition to the "List of Endangered and Threatened Wildlife and Plants." Although candidate species are not afforded legal protection under the FESA, they typically receive special attention from federal and State agencies during the environmental review process.

The desert tortoise (Mojave population) was listed as Threatened under the FESA in 1990. Critical habitat and a recovery plan, together with a supplement identifying proposed Desert Wildlife Management Areas, were put in place in 1994. The 2011 Revised Recovery Plan was created to resolve key uncertainties about threats and management in order to improve the recovery potential, but it does not modify or expand the 1994 Critical Habitat designation or the Desert Wildlife Management Areas (DWMAs) for the desert tortoise. These DWMAs were designed to provide reserves or protected areas for the desert tortoise. The 1994 Recovery Plan described strategies for recovering the desert tortoise. These strategies included the identification of six recovery units, recommendations for a system of DWMAs within the recovery units, and development and implementation of specific recovery actions. The revised strategy within the 2011 Recovery Plan builds upon the foundation of the 1994 Recovery Plan by emphasizing

partnerships to direct and maintain focus on implementing recovery actions and incorporates a system to track implementation and effectiveness of the recovery actions. The goal of the plan is to recover and eventually delist the desert tortoise from the Threatened species list.[29]

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) of 1918 enacts the provisions of treaties between the United States, Great Britain, Mexico, Japan, and the Soviet Union and authorizes the U.S. Secretary of the Interior to protect and regulate the taking of migratory birds. It establishes seasons and bag limits for hunted species and protects migratory birds, their occupied nests, and their eggs. Most actions that result in a taking or in permanent or temporary possession of a protected species constitute violations of the MBTA. Examples of permitted actions that do not violate the MBTA are the possession of a hunting license to pursue specific game birds, legitimate research activities, display in zoological gardens, bird banding, and other similar activities. USFWS is responsible for overseeing compliance with the MBTA, and the U.S. Department of Agriculture's Animal Damage Control Officer makes recommendations on related animal protection issues.

The Bald Eagle Protection Act

The Bald Eagle Protection Act (16 U.S.C. 668-668c) prohibits anyone without a permit issued by the Secretary of the Interior from "taking" bald and golden eagles, including their parts, nests, or eggs. The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb." In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously-used nest site during a time when eagles are not present, if, upon the eagle's return, such alterations agitate or bother an eagle to a degree that interferes with or interrupts normal breeding, feeding, or sheltering habits and causes injury, death, or nest abandonment.

Clean Water Act (33 U.S.C. 1344)

The federal Clean Water Act (CWA) was enacted as an amendment to the federal Water Pollution Control Act of 1972 which outlined the basic structure for regulating discharges of pollutants to waters of the United States. The CWA serves as the primary federal law protecting the quality of the nation's surface waters, including lakes, rivers, and coastal wetlands. The following discussion gives background information as relevant to biological resources.

CWA Sections 404 and 401 regulate the discharge of dredged and fill materials into waters of the United States. Waters of the United States refers to oceans, bays, rivers, streams, lakes, ponds, and wetlands. Applicants must obtain a permit from the U.S. Army Corps of Engineers (USACE) for all discharges of dredged or fill material into waters of the United States, including wetlands, before proceeding with a proposed activity. The USACE defines waters of the United States as those waters having a significant hydraulic connection with navigable waters.[30] For small-scale

[29] U.S. Fish & Wildlife Service, *Revised Recovery Plan for the Mojave Population of the Desert Tortoise (Gopherus agassizii)*, May 2011.

[30] U.S. Army Corps of Engineers, *Revised Guidance on Clean Water Act Jurisdiction Following the Supreme Court Decision in Rapanos v. U.S. and Carabell v. U.S.*, December 2008.

projects affecting small areas, the USACE has established pre-approved Nationwide Permits (NWP) that apply to projects with limited effects. The purpose of the NWP Program is to streamline the evaluation and approval process for certain types of activities that have only minimal impacts to the aquatic environment. (Reissuance of Nationwide Permits, 72 Fed. Reg. at 11,095.[31]) The thresholds for complying with these permits would be verified by the USACE during a permit consultation meeting. The U.S. Environmental Protection Agency (EPA) and USACE created the *Draft Guidance on Identifying Waters Protected by the CWA* in order to clarify and describe how protected waters are identified by the two agencies.[32] Based on review of this guidance and due to the isolated nature of the washes and playas in the Cadiz Valley, these waters are likely not considered waters of the United States and therefore not subject to CWA regulations. However, the Piute observation well would be located within the Piute Wash Watershed which is a tributary to the Colorado River.

Rivers and Harbors Act of 1899

The Rivers and Harbors Act regulates projects and activities in navigable waters and harbor and river improvements. Section 10 prohibits the unauthorized obstruction or alteration of any navigable water of the United States. The construction of any structure in or over any navigable water of the United States and any work affecting the course, location, condition, or physical capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army.

Executive Order 13112 - Invasive Species

Executive Order 13112 - Invasive Species directs all federal agencies to refrain from authorizing, funding, or carrying out actions or projects that may spread invasive species. The order further directs federal agencies to prevent the introduction of invasive species, control and monitor existing invasive species populations, restore native species to invaded ecosystems, research and develop prevention and control methods for invasive species, and promote public education on invasive species. As part of the proposed action, USFWS and USACE issue permits and are responsible for ensuring that the proposed action complies with Executive Order 13112 and does not contribute to the spread of invasive species.

State

Regional Water Quality Control Board

The State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards (RWQCBs) (together “Boards”) are the principal state agencies with primary responsibility for the coordination and control of water quality. In the Porter-Cologne Water Quality Control Act (Porter-Cologne), the Legislature declared that the “state must be prepared to exercise its full power and jurisdiction to protect the quality of the waters in the state from degradation...” (California Water Code Section 13000). Porter-Cologne grants the Boards the authority to implement and enforce the water quality laws, regulations, policies, and plans to protect the groundwater and surface waters of the State. Waters of the State determined to be

[31] U.S. Army Corps of Engineers, Department of Defense, *Federal Register*, Vol.72, No. 47, March 2007.
[32] U.S. Environmental Protection Agency, *Draft Guidance on Identifying Waters Protected by the CWA*, May 2011.

jurisdictional would require, if impacted, waste-discharge permitting and/or a Clean Water Act Section 401 certification (in the case of the required USACE permit). The enforcement of the State's water quality requirements is not solely the purview of the Boards and their staff. Other agencies (e.g., the CDFG) have the ability to enforce certain water quality provisions in State law.

California Endangered Species Act

Under the California Endangered Species Act (CESA), CDFG has the responsibility for maintaining a list of endangered and threatened species (Fish and Game Code [- FGC] 2070). Sections 2050 through 2098 of the FGC outline the protection provided to California's rare, endangered, and threatened species. Section 2080 of the FGC prohibits the taking of plants and animals listed under the CESA. Section 2081 established an incidental take permit program for state-listed species. CDFG maintains a list of "candidate species" which are species that CDFG formally notices as being under review for addition to the list of endangered or threatened species.

Pursuant to the requirements of CESA, an agency reviewing a proposed project within its jurisdiction must determine whether any State-listed endangered or threatened species may be present in the project study area and determine whether the proposed project would have a potentially significant impact on such species. In addition, CDFG encourages informal consultation on any proposed project that may impact a candidate species.

Project-related impacts to species on the CESA endangered or threatened list would be considered significant. State-listed species are fully protected under the mandates of the CESA. "Take" of protected species incidental to otherwise lawful management activities may be authorized under FGC Section 2081. Authorization from CDFG would be in the form of an Incidental Take Permit.

California Fish and Game Code

Pursuant to Division 2, Chapter 6, Section 1600-1616 of the California FGC, the CDFG regulates all diversions, obstructions, or changes in the natural flow or bed, channel, or bank of any river, stream, or lake, which supports fish or wildlife. CDFG jurisdiction within altered or artificial waterways is based upon the value of those waterways to fish and wildlife. The CDFG jurisdictional limits closely mirror those of the USACE. Exceptions are CDFG's exclusion of isolated wetlands, the addition of artificial stock ponds and irrigation ditches and the addition of riparian habitat supported by a river, stream, or lake regardless of the riparian area's federal wetland status.

Fully Protected Species

Certain species are considered *fully protected*, meaning that the code explicitly prohibits all take of individuals of these species except for take permitted for scientific research. Section 5050 lists fully protected amphibians and reptiles, Section 5515 lists fully protected fish, Section 3511 lists fully protected birds, and Section 4700 lists fully protected mammals.

It is possible for a species to be protected under the California FGC, but not fully protected. For instance, Yuma mountain lion (*Puma concolor*) is protected under Section 4800 et seq., but is not a fully protected species.

Protection of Birds and Their Nests

Eggs and nests of all birds are protected under Section 3503 of the California Fish and Game Code, nesting birds (including raptors and passerines) under Sections 3503.5 and 3513, and birds of prey under Section 3503.5. Migratory non-game birds are protected under Section 3800 and other specified birds under Section 3505.

Stream and Lake Protection

CDFG has jurisdictional authority over streams and lakes and the wetland resources associated with these aquatic systems under California Fish and Game Code Sections 1600 et seq. through administration of lake or streambed alteration agreements. Such agreements do not constitute permits, but rather mutual accords between CDFG and the project proponent. California Fish and Game Code Section 1600 et seq. was repealed and replaced in October of 2003 with the new Section 1600–1616 that took effect on January 1, 2004 (Senate Bill No. 418 Sher). Under the new code, CDFG has the authority to regulate work that would "substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river lake or stream." CDFG enters into a streambed alteration agreement with the project proponent and can impose conditions to minimize and mitigate impacts to fish and wildlife resources. Because CDFG includes under its jurisdiction streamside habitats that may not qualify as wetlands under the federal CWA definition, CDFG jurisdiction may be broader than USACE jurisdiction.

A project proponent must submit a notification of streambed alteration to CDFG before construction. The notification requires an application fee for streambed alteration agreements, with a specific fee schedule to be determined by CDFG. CDFG can enter into programmatic agreements that cover recurring operation and maintenance activities and regional plans. These agreements are sometimes referred to as Master Streambed Alteration Agreements (MSAAs).

Under Fish and Game Code Section 1602 (Streambed Alteration Agreements), CDFG takes jurisdiction over the stream zone, which is defined as the top of the stream bank or the furthest extent of riparian vegetation. Within the stream zone, waters of the State of California are typically delineated to include the streambed to the top of the bank and adjacent areas that would meet any one of the three wetland parameters in the USACE definition (vegetation, hydrology, and/or soils). Whereas federal jurisdiction requires meeting all three parameters, in practice meeting one parameter, or even the presence (rather than dominance) of wetland plants in an area associated with a jurisdictional streambed would qualify an area as waters of the State of California. CDFG jurisdiction is not limited to navigable waters or tributaries to navigable waters, however, isolated wetlands and wetlands not associated with a streambed are not subject to CDFG jurisdiction.

Raptor Nests

Section 3503.5 of the California Fish and Game Code states that it is "unlawful to take, possess, or destroy any birds in the order Falconiformes (hawks and falcons) or Strigiformes (owls) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto."

Native Plant Protection Act

In addition, the Native Plant Protection Act of 1977 (FGC Section 1900 et seq.) prohibits the taking, possessing, or sale within the state of any plants with a state designation of rare, threatened, or endangered (as defined by CDFG). An exception to this prohibition in the Act allows landowners, under specified circumstances, to take listed plant species, provided that the owners first notify CDFG and give that state agency at least 10 days to come and retrieve (and presumably replant) the plants before they are plowed under or otherwise destroyed (FGC, Section 1913 exempts from "take" prohibition "the removal of endangered or rare native plants from a canal, lateral ditch, building site, or road, or other right of way." Project impacts to these species are not considered significant unless the species are known to have a high potential to occur within the area of disturbance associated with construction of the proposed project.

California Native Plant Society

The CNPS maintains a list of plant species native to California that have low numbers, limited distribution, or are otherwise threatened with extinction. This information is published in the Inventory of Rare and Endangered Vascular Plants of California. Potential impacts to populations of CNPS-listed plants receive consideration under CEQA review. The following identifies the definitions of the CNPS listings:

List 1A: Plants Believed Extinct.

List 1B: Plants Rare, Threatened, or Endangered in California and elsewhere.

List 2: Plants Rare, Threatened, or Endangered in California, but more numerous elsewhere.

List 3: Plants about Which We Need More Information - A Review List.

List 4: Plants of Limited Distribution - A Watch List.

Local

San Bernardino County Development Code

The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. The following discussion on the County Development Code is provided for context to assess the Project's consistency with the County policies.

The San Bernardino County Development Code was revised and adopted on 12 April 2007. For discussion of the applicability of the County General Plan and Development Code policies to the Project, see Section 4.10.3, Consistency with Land Use Plans (Land Use and Planning). Chapter 82.11 Biotic Resources (BR) Overlay, Section 82.11.030 states, "When a land use is proposed, or an existing land use is increased by more than 25 percent of disturbed area within a BR Overlay, the land use application shall include a biotic resources report prepared as follows, except where the Director finds that prior environmental studies approved by the County have determined that the site does not contain viable habitat. Chapter 88.01 Plant Protection and Management, Section 88.01.020 states, "The provisions of this Chapter apply to the removal and relocation of regulated trees or plants and to any encroachment (for example, grading) within the protected zone of a regulated tree or plant on all private land within the unincorporated areas of the County and on public lands owned by the County, unless otherwise specified..."

Section 88.01.060 Desert Native Plant Protection states, "This Section provides regulations for the removal or harvesting of specified desert native plants in order to preserve and protect the plants and to provide for the conservation and wise use of desert resources…"

Section 88.01.060(c) Regulated Desert Native Plants states, "The following desert native plants or any part of them, except the fruit, shall not be removed except under a Tree or Plant Removal Permit in compliance within Section 88.01.050 (Tree or Plant Removal Permits):

(1) The following desert native plants with stems two inches or greater in diameter or six feet or greater in height:

(A) *Dalea spinosa* (smoke tree).

(B) All species of the genus *Prosopis* (mesquites).

(2) All species of the family Agavaceae (century plants, nolinas, yuccas).

(3) Creosote Rings, 10 feet or greater in diameter.

(4) All Joshua trees.

(5) Any part of the following species, whether living or dead:

(A) *Olneya tesota* (desert ironwood).

(B) All species of the genus *Prosopis* (mesquites).

(C) All species of the genus *Cercidium* (palo verdes)."

Section 88.02.040 Dust Control-Desert Region states, "This Section provides regulations for disturbances to fragile desert soils in order to reduce the amount of fugitive dust that may (for long periods of time) adversely affect those who own; possess, control; or use residential parcels of land; and those who are located downwind of a residential parcel of land whose surface is being disturbed."

(a) Applicability. The provisions in this Section apply to parcels in the Desert Region that are one acre or greater in size and are utilized for residential purposes.

(b) Permit requirements. A land use permit shall not be required for grading, land clearing, or vegetation removal activities that comply with Subsection (c) (Dust control standards Desert Region), below. If more extensive grading, land clearing, or vegetation removal activities are proposed than allowed in Subsection (c), the activities shall be require approval of a Site Plan Permit in compliance with Chapter 85.08 (Site Plan Permit).

(c) Dust control standards Desert Region. Land shall be cleared or natural vegetation shall be removed only in order to provide for the installation of building pads, driveways, landscaping, agriculture, or some other structure or allowed use normally related or accessory to residential uses. No person, except as provided in this Chapter, shall commence with a disturbance of land (e.g., grading or land clearing) without first obtaining approval to assure that said disturbance would not result in a significant increase of fugitive dust. Said approval may be in the form of a development permit.

The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. The following discussion on the County Municipal Code is provided for context to assess the Project's consistency with the County policies.

4.4.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to biological resources if it would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS;
- Have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS;
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means;
- Interfere substantially with the movement of any native resident or wildlife species or with established native resident or migratory native wildlife corridors, or impeded the use of wildlife nursery sites;
- Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance; or

- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

CEQA Guidelines Section 15065, *Mandatory Findings of Significance*, directs lead agencies to find that a project may have a significant effect on the environment if it has the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of an endangered, rare, or threatened species, or eliminate important examples of the major periods of California history or prehistory. An evaluation of whether an impact on biological resources would be substantial must consider both the resource itself and how that resource fits into a regional or ecological context. The definition of "significant," as applied for this assessment, considers both the local and regional status of each resource. Substantial impacts would be those that would diminish, or result in the loss of, an important biological resource or those that would obviously conflict with local, state, or federal resource conservation plans, goals, or regulations.

CEQA Guidelines Section 15206 further specifies that a project shall be deemed to be of statewide, regional, or area-wide significance if it would substantially affect sensitive wildlife habitats including, but not limited to, riparian lands, wetlands, bays, estuaries, marshes, and habitats for rare and endangered species as defined by the Fish and Game Code Section 903.

CEQA Guidelines Section 15380 provide that a plant or animal species, even if not on one of the official lists, may be treated as "rare or endangered" if, for example, it is likely to become endangered in the foreseeable future. Additional criteria to assess significant impacts to biological resources due to the proposed project are specified in *CEQA Guidelines* Section 15382 (Significant Effect on the Environment) "*…a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance*."

A project-related impact to biological resources could take two forms, direct and indirect. Direct impacts are considered to be those that involve the loss, modification, or disturbance of natural habitats (i.e., vegetation or plant communities), which in turn, directly affect plant and wildlife species dependent on that habitat. Direct impacts also include the destruction of individual plants or wildlife, which is typically the case in species of low mobility (i.e., plants, amphibians, reptiles, and small mammals). The collective loss of individuals in these manners may also directly affect regional population numbers of a species or result in the physical isolation of populations thereby reducing genetic diversity and, hence, population stability. Indirect impacts are considered to be those that involve the effects of increase in ambient levels of sensory stimuli (e.g., noise, light), unnatural predators (e.g., domestic cats and other non-native animals), and competitors (e.g., exotic plants, non-native animals).

Indirect impacts may be associated with the construction and/or eventual habitation/operation of a project; therefore, these impacts may be both short-term and long-term in their duration. These

impacts are commonly referred to as "edge effects" and may result in changes in the behavioral patterns of wildlife and reduced wildlife diversity and abundance in habitats adjacent to project sites.

The determination of impacts in this analysis is based on both the features of the proposed Project and the biological values of the habitat and/or sensitivity of plant and wildlife species to be affected. Project design features that avoid or preserve biological resources are taken into consideration and specifically described below prior to the assessment of potential adverse impacts.

Methodology

Biological resources in the Project area were documented using a variety of sources including review of aerial photographs; contacts with technical specialists familiar with survey protocol and the biological resources in the vicinity;[33] review of prior documents and focused surveys;[34] review of the CDFG CNDDB Rare Plant and Animal Species List;[35] CDFG List of Special Plants[36] and Special Animals;[37] CNPS Inventory of Rare and Endangered Plants;[38] U.S. Fish and Wildlife Service Birds of Conservation Concern;[39] and field surveys.

Habitat mapping was based on aerial photographs and field reconnaissance. Field surveys for plants, birds and mammals, which included protocol level surveys for burrowing owl and desert tortoise, were conducted along the proposed pipeline alignment from September 20 – September 28, 2010. Field surveys, which included protocol level surveys for burrowing owl and desert tortoise, within the wellfield areas and conceptual spreading basin areas were conducted from September 29 through October 17, 2010. A rare plant survey was conducted along the pipeline alignment study area in April 2011.

Survey protocol within the proposed pipeline alignment was conducted as follows: both sides of the ARZC ROW rail line were surveyed out to 100 feet that entailed survey of three transects, spaced at 30-foot intervals on both sides of the railroad tracks. Zone of influence transects were

---

33 U.S. Fish and Wildlife Service, *Preparing for Any Action That May Occur Within the Range of the Mojave Desert Tortoise (Gopherus agassizii)*, 2010; California Department of Fish and Game, *Staff Report on Burrowing Owl Mitigation*, Memorandum from C.F. Raysbrook, October 1995.

34 Tierra Madre Consultants, Inc., *Cadiz Valley Rare Plant Surveys*, June 1999; Circle Mountain Biological Consultants, *Cadiz Groundwater Storage and Dry-Year Supply Program: Biological Resources Technical Report: Focused Desert Tortoise Survey and Special-Status Reptile Inventory*, June 1999 and updated October 1999; Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources*, 1999.

35 California Department of Fish and Game, *California Natural Diversity Data Base*, http://www.dfg.ca.gov/biogeodata/cnddb/, accessed 2010.

36 California Department of Fish and Game, Natural Diversity Database, *Special Vascular Plants, Bryophytes, and Lichens List*, January 2010.

37 California Department of Fish and Game, Biogeographic Data Branch of Natural Diversity Database, *Special Animals (883 Taxa)*, July 2009.

38 California Native Plant Society, *Inventory of Rare and Endangered Plants*, http://www.rareplants.cnps.org/, accessed February 2010.

39 U.S. Fish and Wildlife Service, Division of Migratory Bird Management, *Birds of Conservation Concern*, December 2002.

surveyed at 655-, 1,310-, and 1,970-foot intervals on both sides of the southern 20 miles. The ¾-mile stretch of the underground CRA between the southern terminus of the ROW and east to where the CRA surfaces was surveyed along 6 transects spaced at 30-foot intervals.

For desert tortoise surveys, protocol first identified by the USFWS in 1992[40] and recently revised in 2010[41] were followed that recommend transects be surveyed at 30-foot intervals throughout the Project impact area and additionally at 655-foot, 1,310-foot, and 1,970-foot intervals beyond the Project perimeter.

For burrowing owl surveys, the CDFG (1995) survey protocol for burrowing owls was followed that recommends transects be surveyed at 100-foot intervals throughout a given site with five transects spaced at 100-foot intervals surveyed in adjacent areas in potential habitat (i.e., excluding areas substantially developed for commercial, residential, industrial, and other purposes). The transect interval used for this study was ideal for detecting burrowing owls.

For Phase 2 facilities, which are conceptual spreading basin locations, surveys were on a programmatic level. This resulted in surveys of 54 linear miles within each square mile rather than 43 linear miles that would have been covered following the standard protocol for Project level analysis.

With respect to rare plant surveys which were conducted along the pipeline alignment, these were focused on 21 plant species identified through the CNDDB database search results and other research. Based upon this, it was determined to have a medium potential to occur within the pipeline route study area based on the proximity of the Project to previously recorded occurrences in the region, on-site vegetation and habitat quality, topography, elevation, soils, surrounding land uses, habitat preferences, and geographic ranges of special-status plant species known to occur in the region. For the Phase 2 programmatic analysis, rare plant surveys were not conducted within the conceptual wellfield or spreading basin areas, or within the location of the proposed observation wells. Once the expanded wellfield and spreading basin locations are finalized, rare plant surveys would be conducted to determine the presence or absence of the special-status plant species within the proposed construction areas.

More detailed information on survey methodology is provided in the Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Biological Resource Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project, San Bernardino County, California and Cadiz Valley Water Conservation, Recovery, and Storage Project Rare Plant Survey Report. Both documents can be found within Appendix F of this Draft EIR.

40 U.S. Fish and Wildlife Service, *Field Survey Protocol For Any Non-Federal Action That May Occur Within The Range of The Desert Tortoise*, January 1992.
41 U.S. Fish and Wildlife Service, *2010 List of Federal Endangered or Threatened Species for San Bernardino County*, 2010.

Groundwater Conservation and Recovery Component

Special-Status Wildlife Species

Significance Threshold

Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any wildlife species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?

Impact Analysis

Sensitive biological resources are defined as species under study for classification as threatened or endangered, or as species that have low population densities or a highly restricted range. According to data current as of 2011, 5 species of special-status plants, and 8 species of special-status wildlife have been recorded by the CNDDB within the 9-quads surrounding the proposed Project area (Arica Mountains, Cadiz Summit, Cadiz Lake Northwest, Cadiz Lake Northeast, Chubbuck, Milligan, East of Milligan, Danby Lake, and Sablon). No sensitive vegetation communities were listed for the 9-quad radius searched.

There are two distinct areas of impacts which occur during construction of the Project. First, impacts would occur in currently disturbed but undeveloped areas within the conveyance pipeline alignment and within the wellfield manifold network. The pipeline would be installed within a 100-foot wide easement. The entire 100-foot easement could be cleared and graded along the alignment. Second, within the wellfield area, the area of disturbance would be limited to the wellpad areas and utility roads connecting the system (see Table 4.4-2 for wellfield permanent impact acreage for both configurations). The roadways would be approximately 25 feet wide and would contain underground piping and electrical lines. Electric lines may also be overhead. Figures 3-6a and 3-6b identify the wellfield manifold system impact area for both proposed configurations.

Construction

Construction of the Project would result in direct and indirect impacts to wildlife species. Impacts to wildlife could occur directly or as a result of habitat loss. The following sections, divided by facilities areas, discuss the species that could be affected by construction. Following the impact discussion, mitigation measures are defined and evaluated.

Nighttime construction would impact all wildlife species, in particular nocturnal species that forage and are active at night. Construction along the pipeline alignment would occur in segments and Mitigation Measure **AES-1** would restrict lighting during such activities to be pointed downward away from critical habitat or other open space areas, as feasible, to minimize impacts to wildlife species during construction.

Noise from construction would also affect all wildlife species during day and nighttime construction activities. The indirect effects from nighttime lighting and noise would extend for some distance into the open desert following the linear construction activities. Due to the low ambient noise in the desert night, noise from construction may be heard at great distances even though the 45 dBA contour may be 1,500 feet or less from the construction area. Nighttime lights

would be visible from long distances and may attract insects from long distances. The lights and noise would also deter most wildlife. As construction activities moved down the alignment, these affects would move commensurately. At any given location, indirect effects of lighting and noise would occur for between three to eight weeks. Given the amount of open space surrounding the construction zone, most wildlife would avoid the construction zone and would not be adversely affected or limited. Furthermore, noise from the operating railroad under existing conditions has created a noise impact zone along the tracks that would be similar to the construction area of indirect effect.

Table 4.4-2 compiles acreages affected by the pipeline alignment and wellfield. Most of the Project impacts are temporary. Permanent impacts are associated with access roads along the pipeline and wellfield and wellpads for production and observation wells, totaling less than 250 acres. This assumes 25-foot wide roads. The existing active agricultural operations on the Cadiz Ranch for comparison is 1,600 acres, six times greater than the total Project permanent impact.

Reptiles

Desert Tortoise – Pipeline

Protocol-level desert tortoise surveys conducted along the pipeline alignment in September 2010 found no living tortoises within the pipeline route although tortoise sign was found in the northern portion indicating presence in neighboring areas. The survey report is included as Appendix F1. The report notes that tortoises are not common anywhere along the ARZC ROW, but apparently occur in low densities near the northern segments of the ARZC ROW. With respect to Northern segments, the surveys found 4 scat, 3 carcasses, and 1 inactive burrow within the northern portion of the ARZC ROW. However, no tortoise sign was found south of the Old Woman Mountains, and the survey report suggests that south of the Old Woman Mountains, tortoise may be absent or occur in very low densities.

TABLE 4.4-2
SUMMARY OF IMPACTS

	Temporary Impacts (acres)	Permanent Impacts (acres)
Wellfield Area (and observation wells in Watersheds)	0	83 (Configuration A) 113 (Configuration B)
North Segment of ARZC ROW	200	67
South Segment of ARZC ROW (very low probability of desert tortoise)	186	62
Observation Wells within Piute Valley Wash Watershed (includes access road)	0	1
Staging Areas (very low probability of desert tortoise)	645	0

SOURCE: ESA, 2011.

Desert Tortoise – CRA Tie-in and Forebay
The CRA tie-in and potential forebay would be located in areas where no tortoise sign was found. Based on survey results, construction in these areas would have minimal impacts to desert tortoise.

Desert Tortoise – Wellfield
Within the proposed wellfield area, evidence of living tortoises was restricted to Sections 17 and 18, with carcasses found in Sections 8 and 35 (Figure 4.4-2). No living tortoises were found within the wellfield study area, but the survey transects conducted in this 12-square mile area were not sufficiently dense to verify complete absence. Rather, the surveys in the wellfield area were designed to give an indication of tortoise density. The survey report concludes that tortoises are present in the surrounding areas at low densities and are more likely to be encountered in the eastern portion of the wellfield area (particularly Section 17 and 18, and perhaps Section 8).

The Project is being accomplished on a design build basis, which provides flexibility to ensure that a conservative approach towards the preservation of resources can be accomplished. With respect to construction of the wellfield, two configurations have been designed which would install a network of permanent access roads connecting each permanently cleared wellpad. This would result in approximately 83 acres of permanent habitat loss for Configuration A, and 113 acres of permanent habitat loss for Configuration B. Table 4.4-2 summarizes the acreage of permanent and temporary habitat impacts that would result from the Project.

Desert Tortoise - Summary of Construction Impacts
Although no living tortoises or active burrows were found within the ARZC ROW or wellfield area, individual tortoises may still be impacted if they entered the Project area during construction activities.

Common ravens are successful desert tortoise predators. Construction trash, power poles, fences, and water sources provide food and areas for raven to perch, facilitating tortoise predation. Limiting construction employee related food trash by designating enclosed disposal locations and limiting structures where raven can perch would help reduce impacts of predation on desert tortoise. Fences surrounding each well pad may provide perching substrates for ravens. Implementation of Mitigation Measure **BIO-3** would reduce potential desert tortoise predation by common ravens and other predatory species (i.e., coyotes) during construction and minimize impacts to less than significant.

Increased noise levels at the proposed Project area could potentially impact wildlife species within the proposed Project site and surrounding areas. Construction related noise would be a temporary occurrence and would be limited to the construction areas. Though 24-hour construction would occur, given the vast open space in the Project area, the construction noise would attenuate to moderate levels within a few hundred feet. Although due to the low ambient baseline condition, temporary construction noise would be audible at long distances, the noise would be at very low levels and not present a high level of disturbance. Therefore impacts from noise would be less than significant.

Implementation of Mitigation Measures **BIO-1 through BIO-4** would minimize potential direct impacts to the extent feasible. Construction of the pipeline within the ARZC ROW would occur largely in areas that are disturbed and used as access roads along the railroad. However, some areas within the easement have moderate to high habitat value. Mitigation Measure **BIO-5** would minimize impacts to habitat values by placing the alignment within the previously disturbed portions of the easement as much as possible. Most of the impacts to habitat along the pipeline would be temporary. Mitigation Measure **BIO-6** would ensure that the construction zone is restored sufficiently to support desert scrub habitat, resulting in a net acreage gain in restored habitat.

None of the temporarily or permanently affected areas are within special conservation areas or designated critical habitat for desert tortoise or areas with high habitat value or high-densities of individuals, except for the observation well within the Piute Wash Watershed, which would be within desert tortoise designated critical habitat. However, compensating at a 1:1 ratio for permanently affected habitat and at a 0.5:1 for temporarily impacted habitat as identified in Mitigation Measure **BIO-7** would ensure that impacts to desert tortoise through habitat reduction resulting from Project construction activities would be less than significant. Cadiz Inc. owns property within desert tortoise critical habitat that may be suitable as compensation. Mitigation Measures **BIO-1 through BIO-7** would reduce potential impacts to desert tortoise to less than significant levels since direct impacts would be minimized.

Mojave Fringe-Toed Lizard

The Mojave fringe-toed lizard was observed within sandfields east of Danby Dry Lake along the ARZC ROW. The sandfields located within the ARZC ROW that would be directly affected by construction are confined to small areas near Danby Dry Lake. Mohave fringe-toed lizards could be found in these areas. The species is not a listed species in the federal or State Endangered Species Acts, but they are recognized as sensitive species by CDFG and BLM. Direct impacts to the species would be considered a significant impact. Implementation of Mitigation Measures **BIO-8** would reduce impacts to the species to a less than significant level.

Birds

Raptors such as Cooper's hawk and prairie falcon may forage in the area but are not likely to nest within the Project area. Some foraging habitat could be lost to Project development in the wellfield area. However, no nest sites are located near the Project construction zone. Therefore, impacts are considered less than significant and no mitigation is required.

The golden eagle may incidentally occur in the Project area and occasionally forage there, but the species would not be expected to nest anywhere in the proposed Project area. Impacts to the golden eagle are considered less than significant and no mitigation is required.

The snowy plover is a listed species that may frequent the Danby Dry Lake. Construction of the proposed Project would not directly affect any portion of snowy plover habitat. The Danby Dry Lake is sufficiently large to provide habitat to snowy plover miles from the construction activities. Construction of the Project including the pipeline would not adversely affect the snowy plover.

LeConte's thrasher and loggerhead shrike were both observed during surveys conducted at the proposed Project facility sites. These species are associated with washes in the area such as Schulyer Wash. They are both likely to nest during the spring and have young present throughout the summer months. Mitigation Measure **BIO-9** would help reduce impacts to both species to a less than significant level by restricting the construction period outside of the breeding season and requiring buffer zones where necessary to avoid impacts.

Burrowing owls, burrows, and sign were found throughout the proposed Project site along the pipeline route and the wellfield area. Construction activities would be considered a significant impact to the species. Implementation of Mitigation Measures **BIO-10** would reduce potential impacts to a less than significant level.

The MBTA and the California Fish and Game Code consider the loss of active nests (nests with eggs or young) of all native bird species as unlawful by prohibiting the possession and destruction of birds, nests, and/or their eggs. Consequently, the loss or abandonment of nests of common bird species as a result of construction-related activities is considered a potentially significant impact and would conflict with State and federal laws. Implementation of Mitigation Measure **BIO-9** would reduce potential impacts to nesting migratory birds to a less than significant level.

Mammals

American badger sign was found throughout the proposed Project site including the wellfield area and ARZC ROW. Mitigation Measure **BIO-11** would ensure that impacts to this species would be reduced to a less than significant level.

Nelson's bighorn sheep are known to inhabit the higher elevations of the surrounding mountains. Figure 4.4-4 identifies designated bighorn sheep movement corridors that cross the Project construction areas. Movement through these corridors could be temporarily affected by construction activities. Along the ARZC ROW, construction would be limited to a few linear miles during the day time. Daily access to the construction zones would increase activities in the remote desert along the entire alignment. Nighttime construction could potentially impact wildlife movement between mountain ranges at night due to lighting and noise disturbances. The pipeline alignment would be constructed in segments and though 24-hour construction could occur, it would be localized to a specific segment, allowing for wildlife movement around the impacted area.

Conservation groups and wildlife agencies have installed man-made watering features[42] throughout the mountain ranges surrounding the proposed Project. These watering features would not be impacted by the Project. See discussion of springs within Section 4.9, Hydrology and Water Quality.

The proposed wellfield would be located within a BLM-designated bighorn sheep movement corridor. Construction at the wellfield would involve grading roads and wellpads, drilling wells,

[42] California Department of Fish and Game, *Bighorn Sheep Management Plan: South Bristol Mountains Management Unit*, 2010.

and installing underground electric and water pipelines. Electric lines may also be overhead. The new 25-foot wide roadways would not be paved or fenced. Once constructed, they would not impede wildlife movement.

No linear fencing or linear barriers would be installed as part of the Project that would impede movement by wildlife. Fences would surround well pads and potentially other structures along the pipeline ROW. However, these would not truncate habitat or create linear barriers that would impede wildlife movement. Wildlife would be able to navigate around these fences with ample space even for larger mammals such as the bighorn sheep. Temporary construction exclusion fencing would follow the construction activities but would not result in permanent barriers to wildlife movement. Well drilling would occur 24-hours a day for several weeks for each well. During these activities, construction activity would be continual and would deter wildlife in the immediate vicinity. However, the distances between well sites would leave ample room for wildlife movement from one side of the valley to the other. Construction of the proposed Project would not affect the habitat or movement of the bighorn sheep.

Pallid bats and/or pallid bat sign were observed at 22 of the 70 trestles at the washes along the ARZC ROW. The bats are thought to reproduce locally, though surveys were not conducted at a time when it could be determined whether or not trestles are being used as maternity roosts and/or winter hibernacula. Winter and spring surveys would determine trestle use and dictate mitigation measure requirements to avoid certain seasons depending on local usage. Implementation of Mitigation Measures **BIO-12** and **BIO-13** would reduce potential impacts to pallid bats to a less than significant level.

Operation

Once the pipeline is installed, maintenance activities would be minimal, resulting in minimal impacts to wildlife. If a forebay is constructed, the open water could attract wildlife including ravens and coyotes that are known to prey on desert tortoise. In addition, fencing surrounding the forebay would provide perching substrates for ravens. However, the forebay would be located in areas where no tortoises were identified in the 2010 surveys. In addition, the forebay would be located near the open CRA which is a constant source of water in the desert. Therefore, the addition of standing water in the forebay and the surrounding fence would not increase viability of ravens and coyotes due to the proximity to an already existing water source, and there would be a less than significant impact.

The wellfield area would consist of a network of well pads connected by service roads. The area is not considered to be critical habitat and has not been identified as potential conservation habitat for desert tortoise. However, daily maintenance trips could encounter desert tortoise periodically. This is similar to existing conditions where agricultural operations require periodic trips on remote roads within and near the developed lands. The likelihood of encountering desert tortoise within the proposed wellfield area is similar to existing conditions. Mitigation Measure **BIO-3** would establish a Desert Tortoise Avoidance and Protection Plan that would provide standard operating procedures to implement whenever a desert tortoise is observed in the Project area over the duration of the Project. Since the Project may affect the federally and State listed desert

tortoise, formal consultation with the USFWS would be required to comply with the federal and State Endangered Species Acts.

Overhead power lines may be constructed within the wellfield, interconnecting each wellpad along the service roads. The power lines and power poles may provide a perching substrate for raven and other bird species with the potential to prey on desert tortoise.

Operating the proposed Project would not affect other wildlife such as snowy plover, burrowing owls, raptors, nesting birds, lizards, and mammals including rodents, badgers, and bighorn sheep. Operational activities would consist of infrequent driving on access roads and well pads. The activity in the desert would not be less intensive than existing agricultural operations. Surrounding wildlife would not be significantly affected by the noise and vehicle use. The wellfield area would be located near the existing agricultural development areas. Nighttime lighting would be minimized and would not change the existing conditions substantially. Mitigation Measure **AES-2** would reduce any lighting impacts to a less than significant level. With implementation of mitigation measures including **BIO-3**, the Desert Tortoise Avoidance and Protection Plan, impacts from operations would be less than significant.

Mitigation Measures

Desert Tortoise

BIO-1: Immediately prior to construction activities, pre-construction surveys shall be conducted to document all locations of burrows and desert tortoise sightings within all proposed disturbance areas that provide potential habitat for the species. The survey protocol shall be established in coordination with USFWS.

BIO-2: A chain-link or tortoise fence (one-inch by two-inch welded wire mesh attached to the chain-link fence, with approximately two feet above-ground and one foot buried below ground) shall be installed to exclude small wildlife species from entering the active work areas in areas of documented occurrences of special-status ground dwelling wildlife as determined during pre-construction surveys by a qualified biologist or as directed by USFWS. When crossing drainages, these temporary fences must be designed and maintained to allow storm water runoff to flow past the construction site.

BIO-3: A Desert Tortoise Avoidance and Protection Plan shall be developed and adopted in consultation with the USFWS and CDFG prior to construction. Elements of the plan shall include, but are not limited to the following:

- A step-by-step protocol to be implemented whenever a desert tortoise is observed by construction or operational personnel.
- A pre-determined and pre-approved off-site relocation area if there is a need to relocate individual species during the course of Project construction.
- Flagging and delineation requirements for located burrows and areas with tortoise activity.
- An education program for all construction employees.

- Enforcement of speed limits and checking under vehicles for tortoise prior to leaving Project areas.
- Biological monitoring requirements for all ground disturbance activities.
- To prevent increased use of the Project areas by common ravens and coyotes, implementation of measures such as trash management, removal of unnatural sources of standing water, and other means. Drilling mud pits and water discharges will be controlled to minimize the duration of standing water at any one drilling site.

BIO-4: If a desert tortoise is observed in the construction zone, construction activities shall be halted in the vicinity. A pre-approved qualified biologist, authorized by USFWS and/or CDFG to handle desert tortoise, shall be contacted immediately. Work shall only continue once the authorized biologist determines there is no risk to the desert tortoise.

BIO-5: The pipeline shall be installed within previously disturbed areas of the easement to the extent feasible. During construction, previously undisturbed areas within the pipeline alignment that are not needed for construction shall be staked and flagged to prevent construction equipment access or disturbance in these areas. The cordoned off areas shall be flagged and monitored by a qualified biologist during construction activities.

BIO-6: A special-status species and sensitive habitat restoration plan shall be prepared and approved by the USFWS and CDFG prior to construction for unavoidable temporary impacts on special-status plants and sensitive habitats. The plan would include, at a minimum, the following measures:

- A salvage and replacement program for the top 12 inches of surface material and topsoil. The program shall identify soil preparation requirements, including grain size specifications that shall need to be engineered or amended on site to match to the greatest extent feasible the existing surface soil conditions.
- A salvage and replanting program for perennial special-status species.
- An invasive plant species maintenance, monitoring, and removal program.
- Success criteria that establishes yearly thresholds for growth and reestablishment of habitat.
- A five-year maintenance and monitoring plan to ensure successful implementation of the restoration plan.

BIO-7: A habitat compensation plan would be prepared and implemented that includes at a minimum the following measure:

- Purchase of compensatory mitigation lands or credits at a USFWS and CDFG approved conservation bank at a minimum 1:1 ratio for permanent habitat loss and 0.5:1 for temporary habitat loss (or that required by the USFWS and CDFG permit conditions) for preservation in perpetuity.

Mojave Fringe-toed Lizard

BIO-8: Prior to construction, surveys for Mojave fringe-toed lizard shall be conducted by a qualified biologist within the sand dunes and sand fields habitats within the ARZC ROW. If Mojave fringe-toed lizards are identified in the construction zone, the area shall be fenced during construction as described in **BIO-2** to prevent lizards from entering the construction site. Once fenced, a qualified biologist shall trap the area for lizards and release captured lizards into adjacent suitable habitat.

MBTA

BIO-9: If construction and vegetation removal is proposed for the bird nesting period of February 1 through August 31, then pre-construction surveys for nesting bird species shall begin 30 days prior to construction disturbance with subsequent weekly surveys, the last one being no more than three days prior to work initiation. The surveys shall include habitat within 300 feet (500 feet for raptors) of the construction limits. Active nest sites located during the pre-construction surveys shall be avoided and a non-disturbance buffer zone established dependent on the species and in consultation with USFWS and CDFG. This buffer zone shall be delineated in the field with flagging, stakes, or construction fencing. Nest sites shall be avoided with approved non-disturbance buffer zones until the adults and young are no longer reliant on the nest site for survival as determined by a qualified biologist.

Burrowing Owl

BIO-10: A burrowing owl survey shall be conducted pursuant to the *Burrowing Owl Survey Protocol and Mitigation Guidelines* of the California Burrowing Owl Consortium (1993) or per the *Staff Report on Burrowing Owl Mitigation* prepared by CDFG (1995). At a minimum, this survey shall include the following:

- A pre-construction survey conducted by a qualified biologist within 30 days of the start of construction. This survey shall include two early morning surveys and two evening surveys to ensure that all owl pairs have been located.
- If pre-construction surveys are undertaken during the breeding season (February 1st through July 31st) active nest burrows should be located within 250 feet of construction zones and an appropriate buffer around them (as determined by the Project biologist) shall remain excluded from construction activities until the breeding season is over.
- During the non-breeding season (August 15th through January 31st), resident owls may be relocated to alternative habitat. Owls shall be encouraged to relocate from the construction disturbance area to off-site habitat areas and undisturbed areas of the Project site through the use of one-way doors on burrows. If ground squirrel burrows, stand pipes, and other structures that have been documented during pre-construction surveys as supporting either a nesting burrowing owl pair or resident owl are removed to accommodate the proposed Project, these structures and burrows shall be relocated or replaced on or adjacent to the Project site. Relocated and replacement structures and burrows shall be sited within suitable foraging habitat within one-half

mile of the Project area. Suitable development-free buffers shall be maintained between replacement nest burrows and the nearest building, pathway, parking lot, or landscaping. The relocation of resident owls shall be in conformance with all necessary State and federal permits.

American Badger

BIO-11: A qualified biologist shall conduct focused pre-construction surveys no more than two weeks prior to construction for potential American badger dens. If no potential American badger dens are present, no further mitigation is required. If potential dens are observed, the following measures are required to avoid potential adverse effects to the American badger:

- If the qualified biologist determines that potential dens are inactive, the biologist shall excavate these dens by hand with a shovel to prevent badgers from re-using them during construction.
- If the qualified biologist determines that potential dens may be active, the entrances of the dens shall be blocked with soil, sticks, and debris for three to five days to discourage use of these dens prior to Project disturbance. The den entrances shall be blocked to an incrementally greater degree over the three- to five-day period. After the qualified biologist determines that badgers have stopped using active dens within the Project boundary, the dens shall be hand-excavated with a shovel to prevent re-use during construction.
- Construction activities shall not occur within 30 feet of active badger dens.

Pallid Bat

BIO-12: Prior to construction activities, winter and spring surveys shall be conducted to determine the nature of trestle use by pallid bats. Surveys shall follow the appropriate site-specific protocol as determined in coordination with CDFG.

BIO-13: If a special-status natal bat roost site is found within the limits of construction during pre-construction surveys, the roosts shall be staked, flagged, fenced, or otherwise clearly delineated. Roosts shall be avoided with non-disturbance buffer zones established by a qualified biologist in consultation with the USFWS and CDFG until the site is no longer in active use as a natal roost.

Implement Mitigation Measures **AES-1** and **AES-2**.

Significance Conclusion

Less than significant with mitigation.

Special-Status Plant Species

Significance Threshold

Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any plant species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?

Impact Analysis

Construction

Rare plant surveys conducted in April 2011 found no federally or State-listed species within the Project construction area. The list of plant species potentially present in the Project construction area (defined above) provided in Table 4.4-1 includes no federally or State-listed plant species. However, several CNPS-list species are included in Table 4.4-1. Mitigation Measure **BIO-14** would reduce any unknown impacts to special-status plant species within areas of the Project, to a less than significant level.

The Project may encounter areas where cryptobiotic soils occur, particularly in the wellfield areas that are relatively undisturbed. Encountering these soil types is less likely along the pipeline corridor due to previous disturbance within the ARZC ROW. The surface crusting exhibited by these soils is created by cynobacteria, lichen, and moss that weave fibers through upper soil particles to establish a cohesion that serves to bind the soils together even after the plants die.[43] Once the surface crust is broken, the soil cohesion disintegrates. As shown in Table 4.4-2, disturbed areas in the wellfield would be permanently converted to access roads and wellpads. No temporary disturbance areas would occur in the wellfield. Along the pipeline, some temporarily disturbed areas would occur. Much of this area is already disturbed by the access road that parallels the railroad. Due to the limited area affected, the Project would not substantially deplete cryptobiotic soils in the region. Impacts to these soil types would be less than significant.

Operation

Phraeatophytic vegetation utilizes deep roots to access groundwater for survival in arid locations. In the marginal areas around the Dry Lakes, few plant species can tolerate the highly alkaline soils. Some plant species have special tap-roots that can reach depths of over 30 feet below the ground surface. Groundwater depths in the wellfield area are over 100 feet below ground surface. At the eastern edge of the Bristol Dry Lake, depth to groundwater generally exceeds 60 feet below ground surface. The salt bush identified at these margin areas could not reach groundwater at these depths. Therefore, it is assumed that they rely entirely on surface moisture and would not be impacted by any change in groundwater levels as a result of the Project.[44] No phraeatophytic vegetation has been observed around the edge of the Bristol Dry Lake.

Around the northern edge of the Cadiz Dry Lake groundwater levels may be less than 30 feet below ground surface. The Schulyer Wash terminates within sand dunes in this area. The sand

[43] Belnap, Jayne, *Cryptobiotic Soils: Holding the Place in Place*, http://geochange.er.usgs.gov/sw/impacts/biology/crypto/, accessed September 2011.

[44] Hydrobio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, pages 1-7.

dunes may retain some of the surface water runoff more readily than the surrounding soils and provide greater opportunity for vegetation to take hold. However, as observed in site visits conducted HydroBio personnel for the Project,[45] vegetation in this area is sparse and does not exhibit robust growth or abundance that would occur if groundwater was accessible to plant root systems.

In areas beneath the actual Bristol and Cadiz Dry Lakes where groundwater levels are shallow—less than ten feet below ground surface—no phraeatophytic plants have been observed. As a result, any drop in groundwater levels as a result of extraction of groundwater would have no affect on the overlying vegetation. Accordingly, operation of the Project would not result in direct and indirect impacts to locally protected or special-status plant species.

Mitigation Measures

BIO-14: Prior to construction, construction zone limits shall be marked by a qualified biologist and shall be staked, flagged, fenced, or otherwise clearly delineated to ensure that the construction zone is limited to minimize impacts on special-status plant species. These limits shall be identified on the construction drawings. No earth-moving equipment shall be allowed outside demarcated construction zones unless pre-approval is obtained from a qualified biologist.

Significance Conclusion

Less than significant with mitigation.

Sensitive Habitat

Significance Threshold

Would the proposed Project have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS?

Impact Analysis

Mojave wash scrub and stabilized desert dunes/desert sand fields are designated as sensitive communities by CDFG. These plant communities occur in isolated segments along the pipeline route near Danby Dry Lake[46] and some limited areas that encroach into the ROW could be impacted during construction of the Groundwater Conservation and Recovery Component. Mitigation Measures **BIO-5** and **BIO-6** would reduce any impacts to less than significant.

The pipeline would be buried underground, with air blow-off valves located approximately every half mile visible aboveground along the route, in addition to periodic fire suppression valves.

---

45 Hydrobio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, pages 1-7.

46 Circle Mountain Biological Consultants, *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project, San Bernardino County, California,* Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, Los Angeles, CA, November 2010, Figure 8.

Much of the pipeline alignment is previously disturbed. Some marginal sand dune habitat may be affected along the edges of the easement, but the Project would avoid the mature stabilized dune habitats closer to Danby Dry Lake. Some wash habitat would be affected within each of the drainages crossed by the pipeline ROW, particularly in areas on the east side of the railroad tracks where more habitat occurs due to the lack of a service road and due to the detention of runoff created by the elevated railroad tracks.

The proposed wellfield is located within a common creosote scrub habitat, although some wash habitat may be encountered within the Schulyer Wash area. Mitigation Measure **BIO-5** would ensure that the pipeline is installed within the previously disturbed portion of the easement. Well pads and access roads would be located in areas to avoid these habitats where feasible. Mitigation Measure **BIO-6** would ensure that temporarily affected areas are restored to pre-construction conditions or better. Once constructed, the Project would have no affect on sensitive habitats.

Mitigation Measures

Implement Mitigation Measures **BIO-5** and **BIO-6**

Significance Conclusion

Less than significant with mitigation.

Wetlands

Significance Threshold

Would the proposed Project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

Impact Analysis

There are approximately 70 streambed crossings perpendicular to the approximately 43-linear mile proposed pipeline and CRA connection. These washes would be impacted by pipeline installation. The Project would impact approximately 10 acres of these washes combined, none of which exhibit wetland characteristics. Two major wash systems, including Schulyer Wash, and associated minor tributaries run northeast-to-southwest through the wellfield area and may be affected by construction of extraction wells and associated interconnecting pipelines. Site restoration required by Mitigation Measure **BIO-15** would ensure that streambeds along the washes and within the wellfield were returned to pre-construction contours, and any impacts would be reduced to less than significant.

In compliance with existing regulations, a California Fish and Game Code 1602 Streambed Alteration Agreement would be required. Terms of this agreement are expected to include measures to divert flows during construction, measures to minimize erosion, measures to minimize discharge of contaminants through proper storage of chemicals and vehicle maintenance, and site restoration performance standards.

Mitigation Measures

BIO-15: A Waters of the State Mitigation Plan shall be prepared to include with RWQCB and CDFG permit applications. Conditions of the Mitigation Plan shall include at a minimum the following measures:

- measures to divert flows during construction,
- measures to minimize construction footprint within washes,
- measures to minimize erosion,
- measures to minimize discharge of contaminants through proper storage of chemicals and vehicle maintenance, and
- post-construction site restoration performance standards.

Significance Conclusion

Less than significant with mitigation.

Wildlife Movement

Significance Threshold

Would the proposed Project interfere substantially with the movement of any native resident or wildlife species or with established native resident or migratory native wildlife corridors, or impede the use of wildlife nursery sites?

Impact Analysis

Under existing conditions, wildlife traverses the open valleys unimpeded except for the linear transportation and utility corridors that traverse the valleys. Nelson's bighorn sheep are known to traverse the valley areas connecting their preferred ranges within higher elevations. The BLM has designated several regional wildlife movement corridors connecting occupied bighorn sheep habitat. As shown in Figure 4.4-4, these designated movement areas overlay the Project area.

Movement corridors can be affected by linear structures such as highways, walls, and fences. Open-space is crucial for the survival and movement of wildlife species. The proposed Project would modify some of this land by constructing roadways and fenced well pads, but it would not restrict wildlife movement within the area. The areas between well pads would be maintained to provide unimpeded movement through the valley. The proposed pipeline route would result in temporary impacts along the already existing ROW and adjacent to railroad tracks during construction, but would not further restrict wildlife movement once construction is complete. The pipeline would be constructed in segments. Temporary exclusion fencing installed as mitigation would be erected in segments and would not impede movement across the valley. Once installed, no linear fencing would be installed that could impede wildlife movement. Therefore, no significant impact to wildlife movement would occur. Wellfield construction would be located near already existing agricultural practices and though the well pads would be fenced, as described above, it would not inhibit wildlife movement. Operational and construction related impacts to wildlife movement would be considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Local Policy or Ordinance

Significance Threshold

Would the proposed Project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

Impact Analysis

For discussion of the applicability of the County General Plan and Development Code policies to the Project, see Section 4.10.3, Consistency with Land Use Plans (Land Use and Planning). The following species are known to occur on or adjacent to the Project area and are covered under the San Bernardino County Desert Native Plant Protection Ordinance: Harwood's milk-vetch, barrel cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree. These species may be impacted by Project construction and/or operation. The San Bernardino County Desert Native Plant Protection Ordinance identifies certain species as special-status: smoke tree (*Dalea spinosa*), mesquites (*Prosopis* spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and all Joshua trees.[47] Smoke trees have been identified within the ARZC ROW. Impacts to these species would be considered less than significant with implementation of Mitigation Measures **BIO-16** and **BIO-17**.

Mitigation Measures

BIO-16: Prior to commencement of ground disturbance activities for any component of the proposed Project, a qualified biologist/arborist shall provide an inventory of the number and size of protected species within the proposed Project's impact areas. The biologist/arborist shall mark any smoke tree (*Dalea spinosa*), mesquites (*Prosopis* spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and Joshua trees within the construction zone. Removal of these plants shall be avoided if possible.

BIO-17: If avoidance of the species listed in **BIO-16** is not possible, these species shall be moved or replanted.

Significance Conclusion

Less than significant with mitigation.

---

[47] County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007.

Habitat Conservation Plan

Significance Threshold

Would the proposed Project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or State habitat conservation plan?

Impact Analysis

With the adoption of the Northern & Eastern Colorado Desert Coordinated Management Plan (NECO),[48] all lands that are outside Desert Wildlife Management Areas (DWMA), including the proposed Project area, are characterized as Category 3 Habitat, which is the lowest priority management area for viable populations of the desert tortoise.

The site is not within desert tortoise critical habitat, which was designated in 1994[49] nor is it within a DWMA as recommended in the Desert Tortoise (Mojave Population) Recovery Plan[50] and formally adopted in December 2002 as a result of NECO.[51] The southwestern boundary of the Chemehuevi DWMA coincides with the southwestern extent of Ward Valley, which approaches the ARZC ROW from the northeast. No portions of the Project area are in either Chemehuevi critical habitat or the associated DWMA.

The proposed Project would not conflict with conservation or other policies outlined therein. Furthermore, the Project would not conflict with other conservation-based policies contained in adopted conservation plans for San Bernardino County or the proposed Project area. Therefore no conflict would occur and impacts are considered to be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

48 Bureau of Land Management, *Final Environmental Impact Statement for the Proposed Northern & Eastern Colorado Desert Coordinated Management Plan, an amendment to the California Desert Conservation Area Plan 1980 and Sikes Act Plan with the CDFG*, 2002.

49 U.S. Fish and Wildlife Service, *Endangered and Threatened Wildlife and Plants: Determination of Critical Habitat for the Mojave Population of the Desert Tortoise, Federal Register 55(26):5820-5866*, Washington, D.C., 1994.

50 U.S. Fish and Wildlife Service, *Desert Tortoise (Mojave Population) Recovery Plan*, 1994, page 73 plus appendices.

51 Bureau of Land Management, *Final Environmental Impact Statement for the Proposed Northern & Eastern Colorado Desert Coordinated Management Plan, an amendment to the California Desert Conservation Area Plan 1980 and Sikes Act Plan with the CDFG*, 2002.

Special-status Wildlife Species

Significance Threshold

Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any wildlife species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. The exact location for these facilities has not been determined. In addition, a pump station would be constructed near the CRA. No additional construction would occur along the ARZC ROW. Desert tortoise was not identified as being present in the southern portion of the pipeline alignment where the pump station and CRA diversion structures would be installed as part of the Imported Water Storage Component. Therefore, impacts to desert tortoise in these areas is unlikely.

Nighttime construction impacts to wildlife species from noise and light would be similar to those of the Groundwater Conservation and Recovery Component but to a lesser extent since construction areas would be limited. Implementation of Mitigation Measures **AES-1** and **AES-2** would reduce lighting impacts to a less than significant level during construction and operations.

Desert tortoises were not observed at the conceptual spreading basin area during the 2010 surveys. However, habitat in this area was determined by CMBC to be more suitable for tortoises than the wellfield area. Furthermore, the area proposed for the recharge basin (Figure 3-14) is located within desert tortoise critical habitat, although the area does not currently support high-densities of individuals. Approximately 437 acres within designated critical habitat would be impacted by Project construction (see Figure 4.4-3). Implementation of Mitigation Measures **BIO-1 through BIO-4** would minimize potential direct impacts. Mitigation Measure **BIO-6** would ensure that the construction zone is restored sufficiently to support desert scrub habitat.

The recharge basins would provide water sources for raven and other predators that could prey on tortoise. However, the basins would not be full for more than a few weeks of the year, and would not present a permanent water source for ravens. Fencing surrounding the spreading basins would also provide a perching substrate for raven. Impacts to wildlife species would be similar to the Groundwater Conservation and Recovery Component. Implementation of Mitigation Measures **BIO-1 through BIO-13** would minimize impacts to sensitive species to less than significant.

Compensation ratios for impacts to tortoise in critical habitat may be greater than for the Groundwater Conservation and Recovery Component. Only one observation well and access road associated with the first phase of the Project would be located within the designated critical habitat areas. In the event that location is utilized for the recharge basin, permanent compensation of property in critical habitat would ensure that the Project's impacts to desert tortoise would be adequately mitigated. Mitigation Measure **BIO-18** would require a compensation plan that recognizes the effect to critical habitat.

The Existing Natural Gas Pipeline element consists of a 200-mile natural gas pipeline that traverses through the Cadiz Property north through Barstow and to Wheeler Ridge near Bakersfield, California. The segment extending from the Cadiz Property to Barstow is a 100-mile segment. Construction activities to convert the pipeline would be located within the existing right-of-way along the pipeline. However, the construction of the pump stations would require up to a two-acre site of disturbance and a five foot-by-five foot square concrete pad for the air valves that could impact habitat for special-status species. The existing pipeline rights-of-way are currently disturbed; however, the construction of the pump stations could disturb vegetation and wildlife habitat. Biological surveys would be required to quantify the value of the properties affected. Implementation of Mitigation Measures **BIO-1 through BIO-13** and **BIO-18** would reduce this impact to less than significant.

Mitigation Measures

> **BIO-18: Imported Water Storage Component.** A habitat compensation plan for preservation in perpetuity for habitat at a 1:1 minimum ratio would be prepared and implemented for loss of habitat within a designated critical habitat area for desert tortoise. The mitigation ratios would be established by USFWS.

Implement Mitigation Measures **AES-1, AES-2**, and **BIO-1 through BIO-13**.

Significance Conclusion

Less than significant with mitigation.

Special-Status Plant Species

Significance Threshold

Would the proposed Project have a substantial adverse effect, either directly or through habitat modifications, on any plant species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. Construction of the recharge basins and expanded wellfield may result in direct and/or indirect impacts to plant species listed in Table 4.4-1. Of the species with a medium or high potential of occurring in the proposed Project area, several have known occurrences within one-mile of the proposed Project area.

Once the expanded wellfield, spreading basin, and existing natural gas pipeline appurtenances locations are finalized, Rare Plant surveys would be conducted to determine the presence or absence of the special-status plant species with a medium to high potential to occur within the proposed construction areas of the Imported Water Storage Component. Mitigation Measure **BIO-14** would reduce impacts to special-status plant species to a less than significant level.

Mitigation Measures

Implement Mitigation Measure **BIO-14**.

Significance Conclusion

Less than significant with mitigation.

Sensitive Habitat

Significance Threshold

Would the proposed Project have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFG or USFWS?

Impact Analysis

The Imported Water Storage Component would expand the wellfield, extend the conveyance pipeline, and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. The expanded wellfield and recharge basins would not affect riparian habitat or other sensitive habitat areas identified by CDFG or USFWS. Once precise locations for facilities are determined, biological surveys would be conducted to evaluate the sensitivity of the habitats in the area. The wellfield and recharge basin area is dominated by Mojave creosote bush scrub. Therefore, impacts would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant

Wetlands

Significance Threshold

Would the proposed Project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. None of the facilities to be constructed under the Imported Water Storage Component would affect federally protected wetlands. The expanded wellfield, recharge basins and existing natural gas pipeline appurtenances would be located outside the wash areas within Mojave creosote bush scrub habitat. Therefore, impacts would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Wildlife Movement

Significance Threshold

Would the proposed Project interfere substantially with the movement of any native resident or wildlife species or with established native resident or migratory native wildlife corridors, or impede the use of wildlife nursery sites?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. The BLM has designated several regional wildlife movement corridors connecting occupied bighorn sheep habitat in the Project vicinity. The expanded wellfield and recharge basins would be located within the bighorn sheep movement corridor connecting the neighboring mountain ranges (Figure 4.4-4). However, the Project would not construct linear barriers that would impede movement across the valley. Although each well pad and the spreading basin would be fenced, wildlife movement would not be inhibited across the valley. Once constructed, the facilities would be infrequently visited and would not create a disturbance to wildlife movement. Impacts would be considered less than significant and no mitigation is required.

Mitigation Measures

None required**.**

Significance Conclusion

Less than significant.

Local Policy or Ordinance

Significance Threshold

Would the proposed Project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. As described above with the Groundwater Conservation and Recovery Component, the following species are known to occur on or adjacent to the Project area and are covered under the San Bernardino County Desert Native Plant Protection Ordinance: Harwood's milk-vetch, barrel

cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree. These species are unlikely to occur within the wellfield and recharge basin area. The San Bernardino County Desert Native Plant Protection Ordinance identifies certain species as having special status: smoke tree (*Dalea spinosa*), all mesquites (*Prosopis* spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and all Joshua trees.[52] For discussion of the applicability of the County General Plan and Development Code policies to the Project, see Section 4.10.3, Consistency with Land use Plans (Land Use and Planning). Impacts to these species would be considered less than significant with implementation of Mitigation Measures **BIO-16** and **BIO-17**.

Mitigation Measures

Implement of Mitigation Measures **BIO-16** and **BIO-17**.

Significance Conclusion

Less than significant with mitigation.

Habitat Conservation Plan

Significance Threshold

Would the proposed Project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or State habitat conservation plan?

Impact Analysis

The Imported Water Storage Component would expand the wellfield and construct recharge basins within the Fenner Gap. Figure 3-14 shows the conceptual location of these facilities. As similarly described above for the Groundwater Conservation and Recovery Component, the site is not located within a DWMA established in the NECO Plan. The proposed Project would not conflict with conservation or other policies outlined therein. Furthermore, the Project would not conflict with other conservation-based policies contained in adopted conservation plans for San Bernardino County or the proposed Project area. The Project would be located entirely within private property or disturbed railroad easement.

Although the proposed recharge basin would be located within the Chemehuevi designated critical habitat for desert tortoise, compensation for the property with other property in critical habitat as required in Mitigation Measure **BIO-18** would adequately mitigate the loss of habitat. Therefore, there would be no conflict with existing habitat conservation planning efforts. Impacts are considered to be less than significant.

Mitigation Measures

Implement Mitigation Measure **BIO-18.**

---

[52] County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007.

Significance Conclusion

Less than significant with mitigation.

Mitigation Measure Summary Table

Table 4.4-3 presents the impacts and mitigation summary for Biological Resources.

TABLE 4.4-3
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Special-status Wildlife Species	**AES-1, AES-2,** and **BIO-1** through **BIO-13**	Less than significant with mitigation
Special-status Plant Species	**BIO-14**	Less than significant with mitigation
Sensitive Habitat	**BIO-5** and **BIO-6**	Less than significant with mitigation
Wetlands	**BIO-15**	Less than significant with mitigation
Wildlife Movement	None required	Less than significant
Local Policy or Ordinance	**BIO-16** and **BIO-17**	Less than significant with mitigation
Habitat Conservation Plan	None required	Less than significant
Imported Water Storage Component		
Special-status Wildlife Species	**AES-1, AES-2, BIO-1 through BIO-12,** and **BIO-18**	Less than significant with mitigation
Special-status Plant Species	**BIO-14**	Less than significant with mitigation
Sensitive Habitat	None required	Less than significant
Wetlands	None required	Less than significant
Wildlife Movement	None required	Less than significant
Local Policy or Ordinance	**BIO-16** and **BIO-17**	Less than significant with mitigation
Habitat Conservation Plan	**BIO-18**	Less than significant with mitigation

4.5 Cultural Resources

The purpose of this Section is to identify existing cultural resources within the Project area, analyze potential cultural resources associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts.

In addition, another purpose of this Section is to identify potential Indian Trust Assets within the Project area, analyze potential impacts associated with development of the proposed Project, and identify mitigation measure that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analysis are derived from *Indian Trust Asset Policy and NEPA Implementing Procedures 1994.*[1]

This Section is derived from technical reports prepared by ESA[2] and Paleo Solutions, Inc.[3] These reports are included in Appendix G of the Draft EIR. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.5.1 Environmental Setting

Summary of Cultural Resources

Cultural resources are defined as prehistoric and historic sites, structures, districts, and landscapes, or any other physical evidence associated with human activity considered important to a culture, a subculture, or a community for scientific, traditional, religious, or other reason. Under CEQA, paleontological resources, although not associated with past human activity, are grouped within cultural resources. For the purposes of this analysis, cultural resources may be categorized into four groups: archaeological resources, historic resources, including architectural/engineering resources, contemporary Native American resources, and paleontological resources.

Archaeological resources are places where human activity has measurably altered the earth or left deposits of physical remains. Archaeological resources may be either prehistoric-era (before European contact) or historic-era (after European contact). The majority of such places in California are associated with either Native American or Euro-American occupation of the area. The most frequently encountered prehistoric or historic Native American archaeological sites in the State are village settlements with residential areas and sometimes cemeteries; temporary camps where food and raw materials were collected; smaller, briefly occupied sites where tools were manufactured or repaired; and special-use areas like caves, rock shelters, and rock art sites.

1 Bureau of Reclamation, *Indian Trust Asset Policy and NEPA Implementing Procedures,* August 1994, pages 7-13.
2 Environmental Science Associates, *Phase 1 Cultural Resources Assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County (CA),* January 2011.
3 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November, 2010; Kelly, I. T., and C.S. Fowler, "Southern Paiute", in *Handbook of North American Indians, Volume 11: Great Basin*, edited by Warren L. D'Azevedo, Smithsonian Institution, Washington, 1986, page 368-397.

Historic-era archeological sites may include foundations or features such as privies, corrals, and trash dumps.

Historic resources include standing structures, infrastructure, and landscapes of historic or aesthetic significance that are generally 50 years of age or older. In California, historic resources considered for protection tend to focus on architectural sites dating from the Spanish Period (1529-1822) through the early years of the Depression (1929-1930), although there has been recent attention paid to World War II (WWII) and Post War era facilities. Earlier historic resources are often associated with archaeological deposits of the same age. Some resources, however, may have achieved significance within the past 50 years if they meet the criteria for exceptional significance.

Contemporary Native American resources, also called ethnographic resources, can include archaeological resources, rock art, and the prominent topographical areas, features, habitats, plants, animals, and minerals that contemporary Native Americans value and consider essential for the preservation of their traditional values. These locations are sometimes hard to define and traditional culture often prohibits Native Americans from sharing these locations with the public.

Paleontology is a branch of geology that studies the life forms of the past, especially prehistoric life forms, through the study of plant and animal fossils. Paleontological resources represent a limited, non-renewable, and impact-sensitive scientific and educational resource. As defined in this Section, paleontological resources are the fossilized remains or traces of multi-cellular invertebrate and vertebrate animals and multi-cellular plants, including their imprints from a previous geologic period. Fossil remains such as bones, teeth, shells, and leaves are found in the geologic deposits (rock formations) where they were originally buried. Paleontological resources include not only the actual fossil remains, but also the collecting localities and the geologic formations containing those localities.

Natural Setting

The Project area is located in the Mojave Desert, which is situated within the southern Basin-and-Range geomorphic province. The terrain consists of a series of broad, shallow southeast-trending valleys. Several playas, or closed basin sinks, exist on the valley floors. North-south trending weathered mountain ranges, not usually exceeding 4,000 feet in elevation, surround the valleys. However, the New York Mountains at the northern edge of the Fenner Watershed are over 7,500 feet in elevation. The elevation of the Project area ranges from 600 feet above mean sea level (amsl) at Bristol Dry Lake to over 900 feet amsl at the Fenner Gap.

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot, with a large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower temperatures

and higher precipitation at higher altitudes. Average annual precipitation varies from about 4 inches in Bristol Valley to more than 12 inches in the New York Mountains.[4]

The primary plant community in the Mojave Desert is the creosote scrub community, which is dominated by creosote bush and white bursage. Other plant communities include the cactus scrub community, which includes barrel cactus, calico cactus, and ocotillo, and the saltbrush series, which includes saltbrush, mesquite, arrowweed, and goldenbrush. Common animals include desert cottontail, jackrabbit, kangaroo rat, packrat, chuckwalla iguana, desert tortoise, and desert quail.

The area provided many sources of food for its prehistoric inhabitants. Rodents, jackrabbits and cottontails, and occasionally deer and waterfowl would have been hunted. Mesquite, pinon nuts, live oak acorns, and Manzanita berries were all important plant food sources.[5]

Prehistoric Setting

The prehistory of the Mojave is generally described in terms of cultural "complexes." A complex is a specific archaeological manifestation of a general mode of life, characterized archaeologically by technology, particular artifacts, economic systems, trade, burial practices, and other aspects of culture. Complexes are typically associated with particular chronological periods (**Table 4.5-1**).

TABLE 4.5-1
CULTURAL COMPLEXES

Time Period	Complex	Dates
Pleistocene	Paleo-Indian	10,000 – 8,000 B.C.
Early Holocene	Lake Mojave	8,000 – 6,000 B.C.
Middle Holocene	Deadman Lake	7,500 – 5,200 B.C.
	Pinto	6,000 – 3,000 B.C.
Late Holocene	Gypsum	2,000 B.C. – A.D. 200
	Rose Spring	A.D. 200 – 1100
	Late Prehistoric	A.D. 1100 to contact

SOURCE: ESA, 2011.

Paleo-Indian (10,000-8,000 B.C.)

The Paleo-Indian period is sparsely represented in the Mojave, but is characterized primarily by large, fluted Clovis Projectile points. This limited evidence suggests that early human occupants

4 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-2, 2-3.
5 Bean, Lowell John, and Sylvia Brakke Vane, *The Native American Ethnography and Ethnohistory of Joshua Tree National Park: An Overview*, produced for the National Park Service, August 2002.

of the Mojave probably lived in small, mobile groups in temporary camps near permanent water sources.[6]

Lake Mojave Complex (8,000-6,000 B.C.)

Lake Mojave sites have been found primarily around Fort Irwin, Lake Mojave, Lake China, Rosamond Lake, and Twentynine Palms, located near extinct water sources with the margins of pluvial lakes being the preferred settlement area. Subsistence and settlement patterns are likely to have been a direct response to climatic fluctuations occurring during the Pleistocene to Holocene transition. High mobility designed to exploit ever-changing resource bases, coupled with a reliance on more permanent resources (water sources), was likely. In particular, the Lake China basin seems to have been a preferred resource location. Lake Mojave populations were organized into small, mobile groups and practiced a forager-like subsistence strategy. Sites appear to have been repeatedly occupied, with artifact assemblages from both large and small sites being functionally identical.[7]

In terms of material culture, the Lake Mojave Complex is typified by stone tools such as Lake Mojave and Silver Lake projectile points, bifaces, steep-edged unifaces, crescents, and some ground stone implements. The use of heavy projectile points, bifaces, and scrapers would suggest exploitation of large game. However, faunal assemblages and protein residue analyses from Fort Irwin represent heavy reliance on small game, such as rodents, reptiles, and lagomorphs (hares/rabbits/pikas). Ground stone wear is generally light, which suggests minor use of hard seeds. Marine shell beads and non-local lithic materials indicate trade and/or long-distance foraging. Heavily battered cobble tools are often recovered, but the nature of their use is unclear.[8]

Deadman Lake Complex (c. 7,500 to c. 5,200 B.C)

This complex is a newly proposed complex that has yet to be fully defined and recognized. Thus far, sites from the Deadman Lake Complex are geographically restricted to Twentynine Palms in the southeastern Mojave Desert and appear to overlap with the Paleo-Indian and Pinto complexes.[9] Artifact types include small- to medium-size contracting-stemmed or lozenge-shaped points, battered cobbles and core tools, bifaces, flaked tools, and milling equipment. Similar projectile points have been recovered from Ventana Cave in Arizona. Lithic materials include large quantities of coarse- to fine-grained igneous rock and smaller amounts of both local and exotic obsidian. *Olivella* shell beads are present, with both *O. biplicata* from the Pacific coast and *O. dama* from the Sea of Cortez represented.

---

6 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, pages 229-245.

7 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, pages 234-237.

8 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, pages 234-237.

9 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 239.

The Pinto Complex (6,000 to 3,000 B.C.)

Archaeological deposits dating from the Pinto Period suggest that Pinto settlement patterns consisted of seasonal occupation by small, semi-sedentary groups that were dependent upon a combination of big and small-game hunting and collection strategies, which could include the exploitation of stream or water resources. Typically, sites of this period are found along lakeshores and streams or springs, some of which are now dry, and in upland areas. Larger sites tend to be near well-watered locations, with smaller sites in other areas. In comparison to smaller sites, larger sites exhibit substantial midden deposits and greater variation in artifact types. These larger sites were probably centralized locations from which foraging parties journeyed to seasonal resources.[10]

The extent of regional mobility at this time is uncertain. A lack of lithic material diversity might indicate that foraging activities were not as expansive as in the previous complex.[11] However, *Olivella* shell beads are still present, which indicates at least some degree of contact with coastal groups.

Material culture representative of this period include roughly formed projectile points, "heavy-keeled" scrapers, choppers, and a greater prevalence of flat millingstones and manos (Warren, 1984: 410-414).[12] Pinto series projectile points appear to have been frequently reworked, suggesting they were used primarily as spear tips and not darts.[13]

Faunal assemblages are similar to those of the Lake Mojave Complex, with a slight increase in small fauna taxa coupled with a decrease in artiodactyls.[14] The rise of millingstones and manos indicates a more intensive use and processing of plant resources and site placement may have been in part based on access to plant resources. New dates indicate that intensive plant exploitation was occurring by circa 7000 B.C., which is contemporaneous with coastal California groups.[15]

At the end of the Middle Holocene, around 3000 B.C., environmental conditions became much drier and hotter, and few sites in the Mojave date to the period between 3000 and 2000 B.C.,

---

10 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 238.

11 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 238.

12 Warren, C. N., "*The Desert Region"*, In *California Archaeology*, 1984.

13 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 238.

14 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 239.

15 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, pages 238-239.

suggesting that the area may have been largely abandoned during this period of unfavorable climate.[16]

Gypsum Complex (c. 2,000 B.C. to A.D. 200)

The Late Holocene was characterized by a wetter and cooler climate than the Middle Holocene. Settlement patterns suggest small, temporary camps concentrated near streams. At the same time, we see more evidence of inter-tribal trade, particularly between the desert and the coast, and increasing social complexity.[17] The artifact assemblage associated with this period includes an increase in the prevalence of millingstones and manos, and it is believed that it was during this period that the pestle and mortar were introduced. These technological developments may point to the increased consumption of seeds and mesquite.[18] Other artifacts associated with the Gypsum Period include Elko corner-notched series, concave base Humboldt series, and contracting-stemmed Gypsum series projectile points. Ritual activities are indicated by the presence of quartz crystals, paint, and rock art.[19] Towards the end of the Gypsum period, there is evidence for the use of the bow and arrow.[20] Interestingly, there is a scarcity of Gypsum period sites in the southern and eastern extent of the Mojave Desert.[21]

Rose Spring Complex (c. A.D. 200 to 1,100)

The general cultural pattern for this period is a continuation of that of the preceding Gypsum Period. The increase in cultural complexity continued into this period and the archaeological record attests to established trade routes between desert and coastal populations by way of shell beads and steatite, as well as an introduction of Anasazi influence from the eastern Great Plains as evidenced by the appearance of turquoise and pottery.[22]

Archaeological sites from this period are more numerous and contain more well developed middens, indicating an increase in population and a more permanent settlement pattern.[23]

16 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

17 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

18 Warren, C. N., "*The Desert Region*", In *California Archaeology*, 1984, Page 416.

19 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, *Advances in understanding Mojave Desert Prehistory*, in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

20 Warren, C. N., "*The Desert Region"*, In *California Archaeology*, 1984, page 415.

21 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

22 Warren, C. N., "*The Desert Region"*, In *California Archaeology*, 1984, pages 421-422.

23 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

Additionally, evidence of structures such as wickiups and pit houses also supports more permanent settlements. Sites tend to be located near springs, washes, and lakeshores.[24]

Material culture related to this period includes large quantities of obsidian artifacts, Rose Spring and Eastgate series projectile points, knives, drills, pipes, bone awls, millingstones, manos, mortars and pestles, marine shell ornaments, slate pendants, and incised stones.[25] The bow and arrow continued in use.

The Late Prehistoric Period (A.D. 1100 to European Contact)

By the Late Prehistoric period, an extensive network of established trade routes wound their way through the desert, routing quality goods to populations throughout the Mojave Region. It is also believed that these trade routes encouraged or were the motivating factors for the development of an "increasingly complex socioeconomic and sociopolitical organization" in Late Prehistoric peoples in Southern California. Housepit village sites are prevalent during this period, as are the presence of Desert series and Cottonwood projectile points, brownware and buffware ceramics, steatite shaft straighteners, painted millingstones, and, to a lesser degree, coastal shell beads. By the end of this period, however, a decline in trade occurred and well-established village sites were abandoned, perhaps as a result of rising temperatures (known as the Medieval Climatic Anomaly).[26]

Ethnographic Setting

Mojave oral tradition, supported by archaeological evidence, suggests that the Yuman-speaking Mojave Indians were among the earliest residents in the Mojave Desert. They moved from the area approximately 500 years ago to the Colorado River where they were documented by Father Francisco Garcés, a Spanish explorer, in 1776. Another Spanish explorer, Juan de Onate, may have observed this group as early as 1604 based on his descriptions of the "Mojave" people along the Colorado River.[27]

However, at the time of European contact the Project area was occupied by the ethnohistoric Desert Chemehuevi group of the Southern Paiute. This group comprised the Southern Numic portion of the Uto-Aztecan language family.[28] The Chemehuevi inhabited the area between Needles, Blythe, Twentynine Palms, and the Colorado River, which contained the primary settlements. However, the Project is located in an area that was primarily utilized for seasonal resource exploitation or for specific resources, such as salt.

---

24 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 241.

25 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, pages 241-242; Warren, C. N., "*The Desert Region"*, In *California Archaeology*, 1984, page 420.

26 Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in understanding Mojave Desert Prehistory*", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, 2007, page 242; Warren, C. N., "*The Desert Region"*, In *California Archaeology*, 1984, pages 424-428.

27 Kroeber, A. L., *Handbook of the Indians of California*, 1925, page 3.

28 Kroeber, A. L., *Handbook of the Indians of California*, 1925, page 593.

The oral tradition of the Chemehuevi suggests that they migrated from the north and engaged the Mojave group in a long war that drove the Mojave east to the Colorado River.[29] Archaeological evidence indicates that the war ended between 250 and 500 years ago.[30]

The harsh desert environment typical of the Project area could support only the smallest groups comprised of nuclear families joined by kinship ties. These small hunter-gatherer groups moved in response to local food and water availability, typically seasonally or more frequently. The lack of resources of the area created a very diverse hunting economy where small game were important protein sources. Pronghorn sheep, mountain sheep, deer, rabbits, squirrels, desert chipmunks, and wood rats were important mammals in the local diet along with reptiles, such as desert tortoises, snakes, and lizards, and birds, eggs and insects. Agriculture was introduced to the Chemehuevi by their eastern neighbors and they cultivated crops of various types of maize and corn, squash, gourds, wheat, and potatoes along the Colorado River.[31]

The Chemehuevi utilized the paddle-and-anvil technique for their pottery, which included cooking pots, storage jars, spoons, scoops, and large vessels.[32] They also utilized twining techniques for their basketry, which were used for transporting items, winnowing and parching, seed beating, boiling water, and storage. Other artifacts associated with the Chemehuevi included the mano and milling stone (metate), mortar and pestle, digging sticks, and the sinew-backed bow with arrows of cane or willow. In addition to locally consumed trade goods, the Chemehuevi acted as "middle-men" in the long distance trade networks from groups to the west and the Pacific Coast and the Central Valley to the groups in the Southwest and along the Colorado River.

Following the Civil War, the traditional Native subsistence base was threatened by the influx of settlers and accompanying livestock. With these resources unavailable, the Chemehuevi were employed on ranches, building railroads, and in the newly opened mines.

The Chemehuevi were divided into two moieties (kinship group) represented by two songs, the Mountain Sheep Song and the Deer Song, which were each associated with different hunting areas. They generally lived in bands of two or three families, each band having a leader. The Chemehuevi were occupying the oasis of Mara (Twentynine Palms) when permanent settlement of the area by Europeans and Americans began. Livestock depleted natural resources and Euro-American settlers began to claim large pieces of land. In 1890, 160 acres were set aside for a reservation for the Chemehuevi. In 1910, 640 acres adjacent to the existing Cabazon reservation in Coachella was given jointly to the Cahuilla and the Chemehuevi, and those who remained on

29 Kroeber, A.L., *Handbook of the Indians of California*, 1925, page 3.
30 King, C., and D.G. Casebier, *Background to Historic and Prehistoric Resources of the East Mojave Desert Region*, Report prepared by Archaeological Research Unit, University of California, Riverside, Submitted to the U.S. Department of the Interior, BLM, Riverside, California, 1976, pages 17-18.
31 Kelly, I.T., and C.S. Fowler, "Southern Paiute", in *Handbook of North American Indians, Volume 11: Great Basin*, edited by Warren L. D'Azevedo, Smithsonian Institution, Washington, 1986, page 368-397.
32 Kelly, I.T., and C.S. Fowler, "Southern Paiute", in *Handbook of North American Indians, Volume 11: Great Basin*, edited by Warren L. D'Azevedo, Smithsonian Institution, Washington, 1986, page 377.

the Twentynine Palms reservation were encouraged to move there. Some went, some stayed, and others chose to settle elsewhere in California.[33]

Historic Setting

Several major trails crossed the Mojave before and at the time of Spanish contact, and continued to be used not only by the native peoples but by Euro-American explorers as well. The Yuma-Needles Trail ran from south of Yuma up the western side of the Colorado River to the Needles area. The Mojave Trail ran from Needles west across the desert to the coast. The Cocomaricopa Trail ran from Arizona through the Salton Sink and then northwest to meet the Mojave Trail near San Bernardino.[34]

The first Europeans known to have visited the Mojave were Pedro Fages in 1772 and Juan Bautista de Anza and Father Francisco Garcés in 1774.[35] In 1775, Father Garcés separated from de Anza and crossed the Mojave along the ancient Mojave Trail from Needles west to the San Gabriel Mission.

The Spanish missions that dotted the California coast never spread inland to the Mojave, and the desert remained relatively unexplored and unsettled by Europeans for much of the next century. The Romero-Estudillo Expedition of 1823-24 was an attempt by the Spanish to establish a secure route between the California Coast and Tucson; however, despite two attempts, the expedition never managed to make it as far as the Colorado River.[36]

The first recorded American visitors to the Mojave were the party of Jedediah Smith, who crossed the Mojave along the Mojave Trail in 1826. Ewing Young and Kit Carson followed his route in the 1820s and 1830s. Several American and Mexican military expeditions were conducted in the 1840s and 1850s. American involvement in the region was limited during the early 19th century, but certain figures and events made lasting impressions on the landscape. In the 1850s, Pauline Weaver, a cattleman, trapper, and guide, created a private thoroughfare through the Morongo Basin by which he herded cattle from the Cajon Pass to Arizona.[37]

California became an American state in 1850. However, little settlement occurred near the Project area during the American period due to the lack of water and other resources. What settlement did occur was related to mining or the railroads.

[33] Bean, Lowell John, and Sylvia Brakke Vane, *The Native American Ethnography and Ethnohistory of Joshua Tree National Park: An Overview*, produced for the National Park Service, August 2002.
[34] U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument*, September 1983, page 11.
[35] U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument*, September 1983, page 4.
[36] U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument*, September 1983, page 6.
[37] U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument*, September 1983, page 18.

Railroads

In the 1850s, after California achieved statehood, numerous railroad surveys were conducted in the Mojave.[38] The California Southern Railroad Company, which was organized in 1880 and became a subsidiary of the Atchison, Topeka, & Santa Fe (ATSF) Railway in 1884, constructed a line from Cadiz, California to Matthie, Arizona in 1910. On July 1, 1910, the 83 mile ATSF Parker Cutoff, as this line was known, was completed.[39] In 1916, due to the need for a rail line in closer proximity to mining sites north of Blythe, ATSF Railway began constructing a railroad from Rice to Blythe. A spur track was laid from Rice to Ripley in 1920, with operations beginning the next year. The Cadiz to Matthie line was purchased by the ARZC in 2002.[40]

The network of railroads throughout the desert created new travel corridors. Wagon trains and later automobile roads tended to parallel railroad lines in order to take advantage of the regularly spaced watering stations and railroad maintenance crew camps.[41]

Mining

In 1848, gold was discovered by James W. Marshall at Coloma, some 400 miles to the north on the American River. The gold rush began and immigrants flooded into California. Investors began seeking the construction of a transcontinental railroad to facilitate transportation to the gold-rich region. The discovery of the Comstock Lode in Nevada in 1859 shifted attention from gold to silver, and miners began to focus on the desert regions.[42] Some of the early exploration and settlement near the survey area was related to mining prospects.

The 1880s were fairly prosperous for mining in the Mojave Desert, and operations at that time were dominated by gold mining. In the 20th century, mining operations were beginning to bring out borax, zinc, and silver and they began to rework old deposits in the 1910s. Productivity fell off in the 1920s due to increased inflation, but was revived during the Great Depression and accelerated in the early 1940s to meet war-time demands. By 1956, the declining gold prices caused most small gold operations to close.[43] The Old Woman Mountains, to the east and north of the Project area, were the site of the primary mining and prospecting efforts in the vicinity. Several mines and mining settlements were set up in the area, and in the early 20th century ATSF

38 U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument,* September 1983, page 19.
39 Myrick, David, F., *Railroads of Nevada and Eastern California: Volume Two-The Southern Roads,* Howell-North Books, Berkeley, California, 1963, page 792.
40 Anonymous, Combined *Environmental and Historic Report, Arizona and California Railroad Company – Abandonment – in San Bernardino and Riverside Counties, CA (Between Rice and Ripley), Docket No. AB-1022 (Sub-No. 1X),* on file at the San Bernardino Archaeological Information Center, October 2008, page 13.
41 Warren, Elizabeth Von Till, Robert H. Crabtree, Claude N. Warren, Martha Knack, and Richard McCarty, *A Cultural Resources Overview of the Colorado Desert Planning Units,* BLM Cultural Resources Publication, Bureau of Land Management, California, 1981, page 90.
42 Vredenburgh, Larry M., *An Overview of Mining in the California Desert*, http://vredenburgh.org/mining_history/pages/mining_overview2005.htm, accessed December 2010.
43 Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert*, Canoga Park, Living West Press, 1981, pages 127-132.

Parker Cutoff serviced many of these locations, including Cadiz, Chubbuck, Milligan, Fishel, and Freda.[44] All of these settlements are within or adjacent to the Project area.

Mining and Railroad Settlements

During the early 20th century, a number of railroad siding camps and mining settlements sprung up along the railroad route. Those within the Project area include Siam, Cadiz, McCoy, Archer, Chubbuck, Kilbeck, Fishel, Milligan, Saltmarsh, and Sablon. These camps or small settlements, often located where railroad sidings occurred, primarily provided a place for people involved in local mining activities or the operation of the ATSF Parker Cutoff to live. In general, these settlements remained inhabited until about mid-20th century when they were abandoned. The abandonment was most likely related to the switch from steam-powered engines to the use of diesel fuel, because of which the regularly spaced water supply points at the sidings were no longer necessary.[45]

Historic maps document the inception of these settlements along the railroad corridor in the early 20th century. The "Relief Map of Part of Mohave Desert Region, California (Showing Desert Watering Places)," surveyed by Thompson in 1917-1918, shows the completed ATSF Railroad, the Parker Cutoff ("Parker-Phoenix Branch"), and paralleling roads. The settlements or sidings of Siam and Cadiz are shown on the map in the wellfield portion of the Project area. The settlements or sidings of McCoy, Archer, Kilbeck, Fishel, Milligan, Ward, and Sablon are depicted in the pipeline portion of the Project area. The settlement of Arica is shown but is located just southeast of the pipeline portion of the Project area. The 1925 "Map of San Bernardino County, California Showing Roads, Railroads, Springs, and Mining Districts of the Desert Portion" by J. Kremmerer shows the ATSF Railroad, including the Parker Cutoff, parallel roads, and the same settlements and sidings as the earlier map. The CRA, ATSF Railroad (including the Parker Cutoff), and the settlements of Cadiz, Archer, Fishel, Milligan, Saltmarsh, Sablon, and Freda are shown on the 1943 U.S. Army 15' Milligan and 1944 U.S. Army 15' Rice quadrangles, as well as the 1956 USGS 15' quadrangles (Cadiz; Cadiz Lake; Iron Mountain; and Milligan). The 1954 USGS 15' Rice quadrangle map shows rail sidings at Archer, Fishel, Milligan, Sablon, and Saltmarsh.

Historical information was available for Siam, Cadiz, Archer, Chubbuck, Milligan, and Sablon and these six locations are discussed in more detail below. No information could be obtained for McCoy, Kilbeck, Fishel, or Saltmarsh and these locations are not covered below.

Siam

Very little is known about Siam, other than that it was a railroad siding established in 1897 on the ATSF main line between Old Danby and Cadiz. No settlement is known to have been established at Siam and it may never have been more than a watering stop. It is unknown when Siam was abandoned and no structural remains or foundations are extant at Siam.[46]

---

44 Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert*, Canoga Park, Living West Press, 1981, pages 127-132.
45 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 96.
46 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 83.

Cadiz

Cadiz was first named by an engineer for the Atlantic and Pacific Railroad in 1883.[47] Originally, Cadiz was a siding with four section houses built by the Southern Pacific railroad.[48] Cadiz rose in prominence when the ATSF Parker Cutoff was connected to the main track at Cadiz on July 1, 1910. Prior to that time, water was imported from Newberry Spring. In August 1910, a well was drilled at Cadiz. Tamarisk trees, planted on either side of the tracks, served as a windbreak and helped control drifting sand.[49]

The population of Cadiz was never large, but at one point included 50 residents.[50] Residents consisted of railroad workers and their families.

In the 1940s and 1950s, Frank McConnell served as the ATSF railroad telegrapher and depot agent at Cadiz. Trains passing through would have a three hour layover in Cadiz. No tourist facilities were available, so Mr. McConnell sold candy bars and bottled soda from an ice chest at the depot.[51]

The depot at Cadiz was an important stop for the Santa Fe railroad until the 1950s. Almost all trains stopped to refuel or take on water, and all freight trains were inspected at Cadiz. It was closed in 1967.[52]

Archer

Archer was a small siding located about 10 miles southeast of Cadiz on the ATSF Parker Cutoff. The site served as a watering station for steam locomotives on the line and was probably first occupied when the water well was drilled in 1910.[53] When the railroad switched to diesel locomotives in the 1950s, the site was abandoned.[54] The community was comprised primarily of Mexican laborers and their families, but never included more than about 20 people at any given point in time.[55]

Chubbuck

Chubbuck was established in the early to mid 1920s as a mining settlement, about one mile south of the Kilbeck siding, though it was initially used as a railroad siding as early as 1911.[56] However, Chubbuck was not a railroad settlement and was unique among settlements along the ATSF Parker Cutoff in that it primarily housed mine workers and their families.[57] Charles Inglis Chubbuck, manufacturer of products used in cement and masonry, purchased a 1600-acre mining claim from Marcus Pluth and Tom Schofield in 1922. The claim contained a white limestone

47 Gudde, Erwin Gustav, *California Place Names*, University of California Press, Berkeley, CA, 1969, page 45.
48 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 44.
49 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 51.
50 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 45.
51 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, pages 49-51.
52 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 44.
53 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 98.
54 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 96.
55 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, pages 96-97.
56 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, page 43.
57 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 109.

outcrop, perfect for cement manufacture. The claim was located about one-half mile west of the ATSF Parker Cutoff, facilitating shipment to market. Mr. Chubbuck built the primary crusher at the limestone quarry and kilns adjacent to the railroad tracks. The crushed ore was transported to the kilns via a narrow gauge railroad. Ore carts were pushed back and forth by hand.[58] Lime from Chubbuck was used in the construction of the CRA circa 1937 to 1938.[59]

Over 40 buildings were located at Chubbuck, including a company store, school (1932), post office (1938), and residential structures. The company store reportedly sold great quantities of Eastside Beer, manufactured and distributed by the Los Angeles Brewing Company.[60] Occupants at Chubbuck were primarily Mexican laborers and their families. The mill ceased operation in 1951 and the railroad siding at Chubbuck was removed in 1975 to 1976 when the ATSF Parker Cutoff was re-laid.[61]

Milligan

Like the other sidings, Milligan was established in 1910 when the ATSF Parker Cutoff was constructed. A well was drilled in 1910, with water being pumped up to a tank located 16 feet above ground. Milligan included several section houses, a foreman's house, a bunkhouse for workers, and a cemetery. A line of tamarisk trees was planted adjacent to the tracks as a windbreak and for shade. The trees were surrounded by concrete and cobble water catchments. Milligan was abandoned around 1955.[62]

Sablon

Sablon was established on the ATSF Parker Cutoff in 1909. At that time, the station was called Randolph. The name was changed to Sablon, which means 'gravel' in Spanish, in 1912.[63]

Colorado River Aqueduct

The CRA was constructed in the 1930s by the Metropolitan Water District of Southern Californiain order to transport water from the Colorado River to the Los Angeles metropolitan area. The aqueduct stretches from Lake Havasu on the Colorado River to Lake Matthews, south of Riverside.[64] Construction of the aqueduct began in 1933 and the first delivery of water occurred in 1941. Approximately 3,500 men and women were employed constructing the CRA during the Depression era. The completed aqueduct crosses 242 miles of desert and delivers approximately one billion gallons of water a day. Related projects included roads and electrical power transmission lines. Most project-related work was conducted out of temporary camps;

58 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, pages 111-115.
59 Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert* , Canoga Park, Living West Press, 1981.
60 Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert* , Canoga Park, Living West Press, 1981; Rustycans.com, *Can of the Month: Eastside Beer*, http://www.rustycans.com/COM/month0305.html accessed December 2010.
61 Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert* , Canoga Park, Living West Press, 1981.
62 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, pages 175-176.
63 Gudde, Erwin Gustav, *California Place Names*, University of California Press, Berkeley, CA, 1969, page 275.
64 Neves, J., and J. Goodman, Site *Record for CA-SBR-10521*, on file at SBAIC, San Bernardino County Museum, Redlands, 2000.

however, permanent structures, such as the Iron Mountain pumping station, supported a higher number of longer-lasting settlements. The CRA is still in use.

Desert Training Center – California-Arizona Maneuver Area (DTC-CAMA)

In 1942, General George S. Patton, Jr., and the U.S. Army created the Desert Training Center, later called the California-Arizona Maneuver Area (DTC-CAMA) (which encompassed over 30,000 square miles of California, Arizona, and Nevada) as a training ground for military personnel who would be fighting overseas. Originally intended as a training ground that would simulate the harsh conditions of the North African deserts, the training center was operational for two years. At the height of its two-year period of operation in July 1943, over 190,000 armed forces personnel were stationed within the DTC-CAMA.[65] Fourteen divisional camps, along with airfields, bivouacs, hospitals, and numerous other supporting facilities were constructed during the DTC-CAMA's two-year period of operation. Much of the land outside of the camps was used as maneuver areas for training exercises; evidence of these exercises, such as foxholes, tank tracks, debris scatters, and aircraft landing strips, can still be found. In April, 1944, the Desert Training Center was closed and the land was returned to private use. The area was again used for military training in the 1960s for "Operation Desert Strike."

Because of certain logistical considerations, such as the need for electricity, water, and transportation routes, the operation of the DTC-CAMA resulted in some improvements in infrastructure in the remote desert. The need for a route leading from Twentynine Palms to Parker Dam resulted in the creation of what is now Highway 62, although the road was not completely paved until 1959.[66]

Camp Iron Mountain was located at a CRA pumping station and was the closest base camp to the Project area. The ATSF, including the ATSF Parker Cutoff, were instrumental in supplying goods and equipment for the training center.[67]

Indian Trust Assets

Indian Trust Assets (ITAs) are legal interests in property held in trust by the United States for Indian Tribes or individuals. The Secretary of the Interior, acting as the trustee, holds many assets in trust. Examples of potential trust assets are lands, minerals, hunting and fishing rights, and water rights. While most ITAs are on reservations, they may also be found off reservations. The United States has a responsibility to protect and maintain rights reserved by or granted to Indian Tribes or Indian individuals by treaties, statutes, and executive orders. These are sometimes further interpreted through court decisions and regulations. As part of this trust responsibility, federal agencies must take all actions reasonably necessary to protect ITAs.

---

65 Bischoff, Matthew C., *The Desert Training Center/ California-Arizona Maneuver Area, 1942-1944: Historical and Archaeological Contexts, Tucson, Arizona, Statistical Research, Incorporated, Technical Series 75*, 2000, page 30.

66 Bischoff, Matthew C., *The Desert Training Center/ California-Arizona Maneuver Area, 1942-1944: Historical and Archaeological Contexts, Tucson, Arizona, Statistical Research, Incorporated, Technical Series 75*, 2000, page 22.

67 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, page 55.

4.5.2 Research Methods and Results

Archaeological and Historic Resources Identification

Archival Research and Field Investigation

Archival Research

A Project-specific cultural resources literature and records search was conducted at the California Historical Resources Information System (CHRIS) San Bernardino Archaeological Information Center (SBAIC) on September 22, 2010. The records search study area included the wellfield and pipeline portions of the proposed Project plus a half-mile buffer. The records search provided a summary of previous cultural resources surveys and reports and known cultural resources in the Project area and half-mile buffer. Other sources reviewed include the California Points of Historical Interest (PHI), the California Historical Landmarks (CHL), the California Register of Historical Resources (CRHR), the National Register of Historic Places (NRHP), the California State Historic Resources Inventory (HRI), and historic maps.

Previous Cultural Resources Investigations

The records search revealed that a total of 22 cultural resources investigations were previously conducted within the records search study area. Of these 22 previous investigations, 14 involved surveys covering approximately 10 to 20 percent of the wellfield portion of the Project area and less than 10 percent of the pipeline portion of the Project area. The remaining 8 investigations were identified by the SBAIC as pertaining to the Project area, but did not involve surveys of any portion of the Project area.

Previously Recorded Resources

The records search indicated that 50 cultural resources have been previously recorded within the records search study area (**Table 4.5-2**). The table includes a description of the resources and the known status (eligibility) of resources at that time. It documents the existing conditions prior to the Project surveys and evaluation. The 50 resources include 8 prehistoric archaeological sites, 26 historic-era archaeological sites, one archaeological site with both prehistoric and historic-era components, nine historic-era built architectural/engineering resources, and six isolated artifacts.

Of the 50 previously recorded cultural resources, 16 are located within the wellfield portion of the Project area (CA-SBR-3243, -3281H, -693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-20149, -60315, -60319, -60922, and -64132).

Fifteen (15) previously recorded cultural resources are located within the pipeline portion of the Project area (CA-SBR-3233H, -3235H, -3282H, -3283H, -5606/H, -5819H, -9849H, -9850H, -9851H, -9853H, -9856H, -9858H, -10521H, -10646H, and -11583H). Three previously recorded cultural resources are located immediately adjacent to the pipeline portion of the Project area (CA-SBR-9852, -10525H, and -10645H).

Portions of resources CA-SBR-9853H and CA-SBR-11583H overlap both the wellfield and pipeline portions of the Project area.

TABLE 4.5-2
PREVIOUSLY RECORDED CULTURAL RESOURCES WITHIN 0.5 MILE OF THE PROJECT AREA

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
3233	**3233H	TU-219(11)	"Milligan" RR section camp remains. Historic materials recorded include twelve tamarisk and palo verde trees, planted and surrounded by cemented stone rings; the remains of a low rock wall; and broken fragments of concrete. The foundation of a railroad station and a section house were noted, as well as assorted glass and metal debris. The camp is believed to have been settled in approximately 1910. A concrete loading dock and a more recent stucco/concrete loading bin (c. 1960s) were noted on the north side of the tracks.	9-20-78	No	Pipeline
3235	**3235H	TU-222(14)	"Saltmarsh"- The remains of at least 13 structures were identified, along with "great quantities" of metal, glass, ceramic, brick, wood, and other debris. Structures identified included a probable railroad station or freight house, storage buildings, loading docks, water tower foundations, possible residences, and underground storage rooms. The settlement dates from at least the 1930s.	9-21-78	No	Pipeline
3243	**3243	BC-6	Lithic scatter- primarily chert and chalcedony cores. The artifact assemblage is described as numerous cores of chert and chalcedony, some expended, with one associated piece of debitage. These materials are sparsely scattered over a large area of deflated dunes, and show heavy patination.	8-10-78	No	Wellfield
3254	3254	BC-17	Lithic scatter- small workshop area; chert debitage	9-19-78	No	Pipeline
3280	3280H	BC-219(7)	"Cadiz" RR section camp- east portion including modern buildings and 1920s-era stucco row houses	9-20-78	No	Wellfield
3281	**3281H	BC-220(8)	"Cadiz" RR section camp- west portion includes several wood-framed buildings, a well and water tower, an electrical distribution station, and a spur of railroad track used for storage of "maintenance of way" cars. Debris was also present at the time of recordation, but the material type(s) are listed as "unknown." The camp of Cadiz was supposedly founded as early as 1883; however, site recorders noted	9-20-78	No	Wellfield

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
			that none of the buildings or structures appeared to pre-date the 1920s.			
3282	**3282H	BC-221(9)	"Archer" RR section camp remains. A single building foundation was identified, along with a well/water tank, scattered debris, and a small cemetery with seven wooden crosses and one stone grave marker. The inscriptions on two of the grave markers were transcribed on the site record form; both are in Spanish and mark the graves of young children who died prior to 1925.	9-20-78	Yes - Eligible for NRHP	Pipeline
3283	**3283H	BC-222(10)	"Chubbuck" mill and settlement. The recorded resources include the ruins and structures of the settlement of Chubbuck; the industrial buildings and structures of the mill southeast of Chubbuck; two railroad spurs; the main line of the ATSF Railroad; and an unimproved road leading to the Desert Butte Mine. Nine activity loci were recorded, as well as at least 37 discrete trash dump areas. The district dates from the 1930s-1940s, and theoretically includes the site of the Desert Butte Mine; however, this locus of the district was not recorded.	9-20-78; updated 4-22-99 and 2-27-2001	Yes-Eligible for NRHP under Criteria A and D	Pipeline
5472	5472H	Navajo #1	Dugout depression with wooden timbers, fire-cracked rock in arroyo; described as remnant Navajo sweathouse	11-27-85	No	Wellfield
5606	**5606/H	-	Lithic (flaked- and ground-stone tools; debitage) and historic (metal can) scatter. Prehistoric artifacts included flaked-stone tools and debitage made from locally available chert, jasper, chalcedony, basalt, and quartz. Milling tools (manos, metates) were also recorded. Ration cans from historic military maneuvers were also found on the site, as well as one oil can. The site was revisited in 2001, and the recorders at that time only located a single chert flake. The site is crossed by the Inactive Line A, and is thought to have been largely destroyed in that area.	3-16-77 thru 4-19-77; updated 3-5-01	No	Pipeline
5815	5815	AAP 039-001/IO-AAP 039-002	Rock ring with flaked- and ground-stone artifacts; not relocated during update	11-21-85; updated 2-28-01	No	Wellfield
5816	5816	AAP 043-001	Lithic scatter with flaked-stone tools and debitage; groundstone tools & fragments	10-30-85; updated 2-28-01	No	Pipeline
5817	5817H	AAP 043-002/IO-AAp 043-002	Historic debris scatter; 100% collected in Inactive Line A ROQ; no cultural materials found during update	11-20-85; updated 2-28-01	No	Pipeline

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
5819	**5819H	AAP 045-001/IO-AAP 045-003	Historic debris scatter. Recorders noted glass, metal, and porcelain fragments near the ATSF Parker Cutoff Railroad tracks. All visible artifacts were collected at the time of recording.	11-20-85	No	Pipeline
6693	**6693H	-	ATSF RR- railroad line (Mojave to Needles branch) originally constructed in 1883 for the Atlantic & Pacific Railroad Company by Southern Pacific. The first track line was purchased by the ATSF Railroad, who has operated it since 1890. A second parallel track was added in 1923. This linear historic resource was recorded in 1990 and has been updated several times.	5-30-90; numerous updates	Yes - Eligible for NRHP under Criterion A	Wellfield
6694	**6694H	HS-10 (ML-12)	Historic unpaved road and telephone pole line. It was recorded as the “Old Road to Cadiz,” the original automobile route through the area dating from at least as early as 1914. The telephone poles along the line provided service to the eastern Mojave Desert until 1989. No wires remained on the poles at the time of recordation.	5-30-90	Yes - Not eligible for NRHP	Wellfield
9848	**9848	AE-CAD-1	Lithic scatter- small workshop area; agate chert debitage	4-8-99	Yes - Not significant	Wellfield
9849	**9849H	AE-CAD-2H	Historic debris scatter. Ceramic fragments, a variety of metal cans, and a few other assorted metal and glass items were found in close proximity to the ATSF Railroad tracks.	4-14-99	Yes - Not significant	Pipeline
9850	**9850H	AE-CAD-3H	Historic debris scatter. Glass fragments, metal cans and can lids, a bullet casing, kerosene lamp fragments, metal buttons, crockery fragments, burned faunal bone, and assorted other artifacts were recorded.	4-14-99	Yes - Not significant	Pipeline
9851	**9851H	AE-CAD-4H	Historic debris scatter. Artifacts include whiteware plate fragments, sun-colored amethyst and brown glass fragments, cans and can lids, wire, wire nails, and staples.	4-15-99	Yes - Not significant	Pipeline
9852	*9852	AE-CAD-5	Lithic scatter- debitage and tools of obsidian, chert, chalcedony	4-27-99	Yes - Not significant	Pipeline

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
9853	**9853H	AE-CAD-6H	ATSF RR – Parker Cutoff. This resource extends from the wellfield Project area along the same alignment as the pipeline Project area. The ATSF Parker Cutoff was constructed in 1910, although trestles along the alignment bear later dates indicating that modifications have occurred. The tracks were still in use when the line was recorded in 1999.	5-7-99	Yes- Eligible for NRHP under Criteria A and possibly C	Wellfield and Pipeline
9855	**9855H	AE-CAD-8H	Rectangular rock alignment outlining an area approximately 185 centimeters by 65 centimeters. It is believed to represent a historic grave; however, this has never been confirmed. No artifacts were found in association with the alignment. The rectangle lies parallel to the ATSF Railroad tracks, suggesting it may be associated with the railroad.	5-12-99	No	Wellfield
9856	**9856H	AE-CAD-11H	Historic debris scatter. Artifacts include household items (cans, ceramics, bottles) as well as iron machinery parts, tools, and hardware. A series of four narrow, short wooden posts may represent the remains of an animal pen or small corral. This site was subjected to archaeological testing and evaluation in 1999.	4-13-99	No	Pipeline
9857	9857H	AE-CAD-12H	Two small mine prospects with wooden posts and tailings	4-27-99; updated 3-1-01	No	Pipeline
9858	**9858H	AE-CAD-13H	WWII Tank Corps desert training site-historic camp and debris scatter. One component represents the remains of an encampment or supply center associated with WWII-era military training exercises. This area was probably part of General George Patton's Desert Training Center (DTC). Linear rock features and alignments designating roadways and other use area were recorded, along with several discrete scatters of debris (food, beverage, and tobacco cans, concertina wire, glass fragments, and assorted hardware). The second component is sparse scatter of older debris and is likely a small railroad camp related to the ATSF Parker Cutoff railroad's construction and/or use.	4-28 and 5-3, 1999	Yes- eligible for NRHP under Criteria A, C and D	Pipeline
10521	**10521H	FS 51a, b, c, d	Colorado River Aqueduct. This canal was constructed in the 1930s by the Metropolitan Water District of Southern California. As recorded in 2000, the concrete-lined canal measures 50 feet wide at the top and is fenced on both sides.	4-13-00	Yes - Eligible for NRHP under Criteria A, B, and C	Pipeline

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
10525	*10525H	-	Historic road – State Route 62	9-15-00	Yes - Not eligible for NRHP	Pipeline
10644	10644H	DB-S-JD-7	Historic debris scatter, possible WWII training camp	2-28-01	Yes – Not eligible for NRHP	Wellfield
10645	*10645H	DB-S-JD-8	Historic debris scatter, possible WWII training camp	3-1-01	Yes – Not eligible for NRHP	Pipeline
10646	**10646H	DB-S-JD-9	"Sablon," RR siding and debris scatter. Site constituents included a wide scatter (over 300 m^2) and several concentrations of debris, as well as the railroad siding itself. Various cans, bottles and other glass fragments, railroad hardware, wire, glazed ceramic water pipe fragments, milled lumber, battery cores, and a single steel spoon were specifically noted. Artifact types suggested an occupation from 1910 into the 1960s. Portions of the site were located on both sides of the ATSF Railroad tracks.	3-6-01	No	Pipeline
10647	10647H	DB-S-JD-10	Historic can scatter	3-6-01	No	Pipeline
10653	10653H	DB-S-SR-6	Historic road segments	2-27-01	No	Wellfield
10654	10654H	DB-S-SR-7	Historic can scatter	2-27-01	No	Wellfield
10655	10655H	DB-S-SR-8	Historic can scatter	3-1-01	No	Pipeline
10656	10656H	DB-S-SR-9	Historic debris scatter (metal, glass, ceramics, buttons)	3-1-01	No	Pipeline
10657	10657H	DB-S-SR-10	Historic debris scatter (metal, glass, window screen)	3-7-10	No	Pipeline
11582	**11582H	Camp Cadiz	Military camp associated with the Joint Exercise Desert Strike training scenario conducted in 1964. Features include 22 rock alignments (including roads identified as Tent Rows 1-5), rock clusters, mounds, and pits, as well as a single remaining 7-foot-tall communications pole. Eight can scatters and one glass scatter were recorded in various locations around the camp, with the glass scatter containing fragments that pre-date the Desert Strike training exercise. Machine guns cartridges (blanks), wire, automobile fragments, various hardware and personal grooming implements, and modern intrusive camp hearths were also noted.	1-22-04; updated 11-2-04	Yes - Potentially eligible for NRHP	Wellfield

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
11583	**11583H	AAPL-Cadiz 2	Cadiz-Parker Road. The recorded section of the formerly graded road extends between the two railroad siding camps of Cadiz and Rice. A road following approximately the same alignment is shown on the 1896 “Parris Miners Map of the Desert Region of Southern California;” however, this road could also be associated with construction of the ATSF Parker Cutoff, completed in 1910.	1-22-04	No	Wellfield and Pipeline
11584	**11584H	AAPL-Cadiz 3	Cadiz-Cadiz Pass Road. The road connects the railroad siding camp of Cadiz with Cadiz Summit, which lies to the northeast on Route 66, across the Marble Mountains.	1-22-04	No	Wellfield
11586	**11586H	AAPL-Cadiz 5	Unnamed dirt road. Extends in a general southwest-northeast direction from Amboy Road, along the southern shore of Bristol Lake, across the Cadiz Valley, and south of the Marble Mountains to intersect with Route 66 in the vicinity of Danby Road.	1-22-04	No	Wellfield
19895	13232	ASM-MDR-22-01	Lithic scatter- small workshop area; rhyolite core and debitage	1-3-09	No	Wellfield
19896	13233	ASM-MDR-22-02	Lithic scatter- small workshop area; rhyolite debitage	1-3-09	No	Wellfield
**20149	-	AAPL-Cadiz Iso 1	Historic isolate- half a mule shoe	1-22-04	Yes - Not significant	Wellfield
21094	13618H	JB-47	Phone line remnants and associated access road	5-6-09	No	Wellfield
**60315	-	BC-7	Prehistoric isolate- bifacial chopper	8-10-78	Yes - Not significant	Wellfield
**60319	-	Isolated Artifact #4	Prehistoric isolate- scraper	n.d.	Yes - Not significant	Wellfield
**60922	-	SBCM #358	Prehistoric isolate- scoop-style metate	1-12-63	Yes - Not significant	Wellfield
**64132	-	AE-CAD-ISO-2	Prehistoric isolate- pointed unifacial tool	5-11-99	Yes - Not significant	Wellfield
64414	-	DB-I-JD-4	Prehistoric isolate- single waste flake	2-28-01	Yes - Not significant	Wellfield

**Indicates cultural resource recorded within Project area
*Indicates cultural resource recorded adjacent to the Project area

SOURCE: San Bernardino Archaeological Information Center, California Historical Resources Information System, records search for the Cadiz Groundwater Project, September 28, 2010.

Native American Contact

A Sacred Lands File search with the Native American Heritage Commission (NAHC) was requested on November 8, 2010. Sacred Lands File search results prepared by the NAHC on November 12, 2010, indicated the presence of Native American cultural resources within one-half mile of the Project area in the Arica Mountains, and also noted that there were Native American resources in close proximity to the Project area in other locations.

Contact letters to the eighteen individuals, groups, and tribes indicated by the NAHC as having affiliation with the Project area were prepared and mailed on November 17, 2010. The letters described the Project and included a map indicating the location of the Project area. Recipients were requested to reply with any information they are able to share about Native American resources that might be affected by the Project. All correspondence is attached in Appendix G1. To date, two responses have been received expressing interest in the Project based on concerns for Native American resources in the region.

One response was received via email on December 15, 2010, from Bridget R. Nash-Chrabascz, Quechan Tribe Historic Preservation Officer, and was followed by a phone conversation with ESA archaeologist Monica Strauss. Ms. Nash-Chrabascz expressed the Quechan Cultural Committee's concern over the proposed Project's proximity to Old Woman Mountain. Ms. Nash-Chrabascz explained that the Quechan tribe is concerned that there may be prehistoric archaeological sites, pictographs, and petroglyphs in the vicinity of the Project. The tribe requested an archaeological survey be conducted and the opportunity to review the resulting report. Ms. Strauss explained that the pipeline portion of the Project area has been surveyed and that no prehistoric sites or isolated artifacts were observed, and that the pipeline would be installed within the ARZC ROW. Ms. Nash-Chrabascz expressed that she was more concerned about the wellfield portion of the Project area and the scale of the Project on the landscape.

A second response was received via email on January 13, 2011 from Joseph Benitez, tribal elder of the Chemehuevi Tribe, and followed by a phone conversation with ESA archaeologist Monica Strauss. Mr. Benitez expressed his concern about the impact to sacred sites, such as the Old [Woman] Mountain. He indicated that the general Project area was likely used prehistorically by the Chemehuevi to traverse to and from the Lake Havasu area.

Field Survey

Field surveys were conducted between October 18 and 26, 2010. The survey crew was led by ESA archaeologists Madeleine Bray, M.A. and Candace Ehringer, M.A.

The survey area for the proposed pipeline portion of the Project area included 43.5 miles of the 200-foot-wide ARZC ROW (100 feet on either side of the center line), from the proposed wellfield in the north to the CRA tie-in in the south; and an area from the ARZC ROW east to the Freda Siphon, including the CRA tie-in Option 1. (CRA tie-in Options 2a and 2b and the wellfield portion of the proposed Project area were not surveyed since the precise location of the wells, forebays, and access roads were not yet finalized.) Areas that were not developed or otherwise disturbed were subject to intensive pedestrian survey. Survey was conducted in

transects of no greater than 15 meters (50 feet). To conduct the survey, two surveyors walked on either side of the railroad tracks.

Any cultural resources encountered during the survey were documented and recorded on the appropriate Department of Parks and Recreation (DPR) 523 forms. An attempt was made to relocate all previously recorded archaeological sites within or immediately adjacent to the Project area. Relocated sites were updated on DPR forms where appropriate. Each newly recorded resource was given a temporary field designation, then documented, photographed, and recorded. Isolated historic artifacts and modern (post-1965) features were not recorded.

Ground cover within the proposed pipeline portion of the Project area consisted of disturbed creosote scrub. The Project area evidenced general surface disturbances of varying degree, particularly on the south and southwest side of the railroad, where the railroad access road, typically 20-25 feet wide, paralleled the railroad. Evidence of earth-moving activities near the railroad tracks, primarily on the north side, was frequently encountered. Aside from the obvious surface disturbances, depths of such disturbances, in general, could not be ascertained.

Identified Cultural Resources

A total of 43 cultural resources were recorded or updated during the field surveys of the proposed pipeline portion of the Project area, including 15 previously recorded resources and 28 newly recorded resources (Appendix G1, Table 4). Two of the 15 resources that were previously recorded within the proposed pipeline portion of the Project area (CA-SBR-5606/H and -5819H) could not be located and are presumed to have been destroyed within the Project area; therefore a total of 41 resources are currently known to exist within the proposed pipeline portion of the Project area. Thirty-eight of the resources consist of historic-era archaeological sites, and three are historic architectural/engineering resources. All resources were documented on DPR 523 forms, which will be filed at the SBAIC. No prehistoric resources or artifacts were observed during the survey and no isolated artifacts were recorded.

Significance Evaluation of Cultural Resources

A total of 43 cultural resources were recorded or updated during the survey of the pipeline portion of the Project area, including three historic architectural/engineering resources, 39 historic-era archaeological resources, and one multi-component archaeological resource. Two of the archaeological resources (CA-SBR-5606/H and -5819H) were not located within the Project area and are presumed to have been destroyed within the Project area; these two resources are not addressed further in this document. Of the 41 resources located within the pipeline portion of the Project area, ten appear to be eligible for listing in the NRHP and/or CRHR (**Table 4.5-3**) and should be considered significant resources under CEQA. The remaining 31 resources do not appear to be eligible for listing in the CRHR and are therefore not considered significant resources under CEQA (*CEQA Guidelines*, §15064.5). The significance determinations are described in more detail in Appendix G.

TABLE 4.5-3
SIGNIFICANT CULTURAL RESOURCES

Primary Number (P-36-)	Field Designation	Description	Eligibility	Comments
3233	-	"Milligan" RR settlement remnants and cemetery	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
3235	-	"Saltmarsh" RR settlement remnants	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
3282	-	"Archer" RR settlement remnants and cemetery	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
3283	-	"Chubbuck" mill and settlement remnants	Previously recommended eligible for NRHP under Criteria A and D (therefore eligible for CRHR under Criteria 1 and 4)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
9853	-	ATSF RR – Parker Cutoff	Previously recommended eligible for NRHP under Criteria A and C (therefore eligible for CRHR under Criteria 1 and 3)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
9858	-	1) WWII Tank Corps desert training site and 2) earlier railroad-related components	1) Previously recommended eligible for NRHP under Criteria A, C and D (therefore eligible for CRHR under Criteria 1, 2, and 4) 2) Previously recommended eligible for NRHP under Criteria A and D (therefore eligible for CRHR under Criteria 1 and 4)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff and/or DTC district
10521	-	Colorado River Aqueduct	Previously recommended eligible for NRHP under Criteria A, B, and C (therefore eligible for CRHR under Criteria 1, 2, and 3)	-
10646	-	"Sablon" RR settlement remnants	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff and/or DTC district
11583	-	Cadiz-Parker Road	Recommended eligible for CRHR under Criterion 1	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
-	ESA-C-4	Extensive historic debris scatter	Recommended eligible for CRHR under Criterion 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district

SOURCE: ESA, 2011.

Pipeline Portion of the Project Area

Historic Architectural/Engineering Resources

Three of the 41 resources encountered during the survey of the pipeline portion of the Project area are categorized as historic-era architectural/engineering resources (CA-SBR-9853H, CA-SBR-10521H, and CA-SBR-11583H). All three of these resources are recommended eligible for listing in the CRHR and should be considered significant resources under CEQA.

CA-SBR-9853H (ATSF Railroad, Parker Cutoff): This resource extends from the wellfield portion of the Project area along the same alignment as the pipeline portion of the Project area. The ATSF Parker Cutoff was constructed in 1910, although trestles along the alignment bear later dates indicating that modifications have occurred. This resource was previously recorded by Applied Earthworks, Inc. in 1999, and consists of railroad tracks set on a raised grade on rock ballast. The resource was previously recommended eligible for listing in the NRHP under Criteria A and possibly C.[68]

The railroad was observed during the 2010 ESA survey and found to be as previously described. Dates noted on the tracks themselves span from 1916 to the 1950s and the railroad is still in use. The resource appears to have changed little from the time of its original recording and appears to maintain integrity and its eligibility for listing in the NRHP; therefore it is considered eligible for listing in the CRHR under Criteria 1 and possibly 3. Resource CA-SBR-9853H should be considered a significant resource under CEQA.

CA-SBR-10521H (CRA): The CRA was constructed in the 1930s by the Metropolitan Water District of Southern California and is still in use. As recorded in 2000, the concrete-lined canal measures 50 feet wide at the top and is fenced on both sides. The CRA was previously recommended eligible for listing in the NRHP under Criteria A, B, and C[69] and is therefore eligible for listing in the CRHR. Resource CA-SBR-10521H should be considered a significant resource under CEQA.

CA-SBR-11583H (Cadiz-Parker Road): The recorded section of this dirt road extends between the historic railroad settlement sites of Cadiz and Rice, and generally follows the route of the ARZC railroad (Historic ATSF Parker Cutoff). The road may be associated with construction of the ATSF Parker Cutoff, completed in 1910. The roadway has not been formally evaluated for its eligibility to the NRHP or the CRHR, but appears eligible for its association with the ATSF Parker Cutoff (CRHR Criterion 1). There is no evidence available at the present time to suggest that the resource is eligible for its association with important persons (CRHR Criterion 2) or that the resource represents a distinctive type, style, or manufacture technology (CRHR Criterion 3). Given the nature of this resource, it does not have the potential to yield information important in history (CRHR Criterion 4). Since resource CA-SBR-11583H is recommended eligible for the CRHR under Criterion 1, it should be considered a significant resource under CEQA.

---

68 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, page 55.

69 Neves, J., and J. Goodman, *Site Record for CA-SBR-10521*, on file at SBAIC, San Bernardino County Museum, Redlands, 2000, page 3.

Archaeological Resources

Thirty-one of the 38 recorded historic-era archaeological resources are not recommended eligible for listing in the CRHR and do not otherwise meet CEQA's definitions for historical resources and unique archaeological resources (*CEQA Guidelines* §15064.5) (CA-SBR-9849H, -9850H, -9851H, -9856H, ESA-C-1, -C-2, -C-3, -C-5, -C-6, -C-7, -C-8, -C-9, -C-10, -C-11, -C-12, -C-13, -C-14, -C-15, -C-16, -C-17, -C-18, -C-19, -C-20, -C-21, -C-22, -C-23, -C-24, -C-25, -C-26, -C-27, and -C-28). These resources consist primarily of either surface scatters of historic trash, primarily containing non-diagnostic metal can and glass elements with no features, or are isolated non-diagnostic features. The underrepresentation of diagnostic materials from which to identify artifacts and date the resources limits their potential to yield information important in history (CRHR Criterion 4). While all resources can be broadly dated to the first half of the 20th century and are likely associated with human activity related to railroad construction and/or maintenance, none can be tied to specific historically-significant events or persons (CRHR Criteria 1 and 2). Likewise, the resources do not contain features or artifacts that represent a distinctive type, style, or manufacture technology (CRHR Criterion 3). These 31 resources are therefore not recommended eligible and have been exhausted of their limited data potential simply through the process of their recording on DPR 523 forms. No further work is recommended for these resources.

The remaining seven historic-era archaeological resources are recommended eligible for listing in the CRHR (CA-SBR-3223H, -3235H, -3282H, -3283H, -9858H, -10646H, and ESA-C-4). Five of these are associated with the historic settlements or railroad sidings of Milligan, Saltmarsh, Archer, Chubbuck, and Sablon respectively (-3233H, -3235H, -3282H, -3283H, and -10646H). The remaining two resources recommended eligible are CA-SBR-9858H, a WW-II military encampment or supply depot with an earlier railroad component, and ESA-C-4, a large historic artifact scatter. These resources are discussed in detail below.

Historic Settlements

CA-SBR-3233H (Milligan): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Milligan, which appears on maps as early as 1917-1918. The site is over 600,000 square feet (14 acres) in size and contains numerous structural remains, historic trees, a cemetery, and rather dense concentrations of historic artifacts, many with diagnostic qualities. This resource was evaluated as part of this study and is recommended eligible for listing in the CRHR.

CA-SBR-3235H (Saltmarsh): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Saltmarsh, which appears on maps as early as 1917-1918. The site is over 1.1 million square feet (26 acres) in size and contains numerous structural remains, a well, a loading platform, and concentrations of historic artifacts, many with diagnostic qualities. This resource was evaluated as part of this study and is recommended eligible for listing in the CRHR.

CA-SBR-3282H (Archer): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Archer, which appears on maps as early as 1917-1918.

The site is over 2 million square feet (46 acres) in size and contains a well, structural remains, a cemetery, and concentrations of historic artifacts, many with diagnostic qualities. Archer served as a watering station for steam locomotives along the line and was probably first occupied when the water well was drilled in 1910.[70] When the railroad switched to diesel locomotives in the 1950s, the site was abandoned.[71] The small community was comprised primarily of Mexican laborers and their families.[72] Applied Earthworks, Inc. (1999: Table 1) recommended that site CA-SBR-3282H is eligible for listing in the NRHP; it is therefore also recommended eligible for listing in the CRHR.

CA-SBR-3283H (Chubbuck): This historic-era archaeological site represents the remnants of the early to mid-20th century mining settlement/railroad siding of Chubbuck. Chubbuck was established in the early to mid-1920s as a mining settlement/railroad siding, but is not depicted in available historic maps. The site is over 1.1 miles long and contains numerous structural remains, including the remains of a mill, and extensive concentrations of historic artifacts. Charles Inglis Chubbuck, manufacturer of products used in cement and masonry, purchased a 1600-acre mining claim from Marcus Pluth and Tom Schofield in 1922. The claim contained a white limestone outcrop, perfect for cement manufacture, and was located about one-half mile west of the ATSF Parker Cutoff, facilitating shipment to market. Mr. Chubbuck built the primary crusher at the limestone quarry and kilns adjacent to the railroad tracks. Over 40 buildings were located at Chubbuck, including a company store, school (1932), post office (1938), and residential structures. Occupants were primarily Mexican laborers and their families.[73] The mill ceased operation in 1951. Site CA-SBR-3283H was previously recommended eligible for listing in the NRHP by Applied Earthworks, Inc. (1999: 58) under Criteria A and D for its association with the history of the railroad and early mining in the area. Since the site has been recommended as eligible for the NRHP, it is also considered eligible for the CRHR.

CA-SBR-10646H (Sablon): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement/railroad siding of Sablon, which appears on maps as early as 1917-1918. The site currently measures 820,395 square feet (18.8 acres) and contains several features, including dense artifact concentrations and structural features. Site CA-SBR-10646H was not evaluated for NRHP or CRHR eligibility at the time of its original recordation,[74] however, it was evaluated as part of this study and is recommended eligible for listing in the CRHR.

The five historic settlement sites (CA-SBR-3233H, -3235H, -3282H, -3283H, and -10646H) appear to be eligible for listing in the CRHR under Criteria 1 and 4. While the sites do appear to have been partially pothunted (as evidenced by shallow depressions), they appear to maintain a fair amount of integrity based on surface evidence observed during the course of the survey. Therefore, these five sites contain sufficient archaeological data to yield information significant

70 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 98.
71 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, page 96.
72 de Kehoe, Joe, *The Silence and the Sun*, Trails End Publishing Company, Bakersfield, CA, 2007, pages 96-97.
73 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, page 43.
74 Tierra Environmental Services, *Cultural Resources Survey Report for the All American Pipeline Replacement Project, Daggett to Blythe, San Bernardino and Riverside Counties, California*, 2001.

to the history of the area (CRHR Criterion 4). The settlements of Milligan, Saltmarsh, Archer, Chubbuck and Sablon are five of a number of settlements that began as small railroad siding or mining camps along the ATSF Parker Cutoff railroad. These settlements sprung up early in the 20th century primarily to support the railroad and local mining and continued to be used for movement of goods and materials through the area during WWII and the mid 20th century. For this reason, the sites are also recommended eligible for events (CRHR Criterion 1) for their association with themes relating to transportation, mining, and possibly military activity. There is no evidence available at the present time to suggest the sites are eligible for their association with important persons (CRHR Criterion 2) or that the sites or their constituents represent a distinctive type, style, or manufacture technology (CRHR Criterion 3). Furthermore, the sites appear to be inextricably tied to the railroad and consideration of them as contributing elements to an as yet undefined ATSF Parker Cutoff railroad district, related to the themes mentioned, may deserve consideration.

WW-II Military Site

CA-SBR-9858H: This site appears to represent the remnants of an encampment or supply depot associated with WWII-era military training exercises and contains linear rock features and alignments designating roadways and other use areas along with several discrete scatters of refuse. The site also contains an earlier component related to the use of the site during the ATSF Parker Cutoff railroad's construction and/or use. The WWII-era military component of the site was recommended eligible for listing in the NRHP by Applied Earthworks, Inc.[75] in 1999 under Criteria A, C and D. The earlier railroad component was recommended as eligible for listing in the NRHP under Criteria A and D for its association with the history of the railroad. Since the site has been recommended as eligible for the NRHP, it is also considered eligible for the CRHR and should be considered a significant resource under CEQA.

Historic Debris Scatter

ESA-C-4: This is a large (approximately 249,000 square foot) historic artifact scatter with three can concentrations, two glass concentrations, four concentrations of burnt bone, three rock cairns, and a general historic scatter of hundreds of cans and glass fragments, many of which contain diagnostic characteristics. The site likely dates to the early and possibly mid 20th century and may be associated with the early use of the railroad. The site does not contain structural remains, nor does it appear to coincide with any mapped historic settlement sites.

The size of the site and density of artifacts present suggests that this site contains sufficient archaeological data to yield information important to the local and regional history (CRHR Criterion 4). Based on surface evidence, it does not however appear to be associated with important events (CRHR Criterion 1) or persons (CRHR Criterion 2), nor does the site or any of the identified surface constituents appear to represent a distinctive type, style, or manufacture technology (CRHR Criterion 3).

75 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, pages 57-58.

Wellfield Portion of the Project Area

Less than 10 percent of the wellfield portion of the Project area has been previously surveyed. Sixteen cultural resources were identified during the records search as being located within or immediately adjacent to the wellfield portion of the Project area (CA-SBR-3243, -3281H, -6693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-20149, P-36-60315, P-36-60319, P-36-60922, and P-36-64132). Of these 16 resources, one (CA-SBR-6693H), the historic Atchison, Topeka, & Santa Fe Railroad, is known to have been evaluated and recommended eligible for listing in the NRHP by Applied Earthworks, Inc. (1999) and another (CA-SBR-9855H), possibly containing a grave, is believed to be eligible, although sufficient study to determine this was never conducted. No archaeological survey of the wellfield portion of the Project area was conducted as part of this study effort since the precise location of wells pads and access roads were not finalized. Therefore, the condition of the previously identified eligible resource (-6693H) and the potentially eligible resource (-9855H) have not been confirmed, nor has it been determined the number and types of any other cultural resources that might be present in the wellfield portion of the Project area.

Paleontological Resources Identification

Resource Assessment Criteria

This paleontological resources analysis utilizes the Potential Fossil Yield Classification System (PFYC). This system is widely utilized by professional paleontologists for the purpose of paleontological resource management:[76]

> ***Class 1*** – **Very Low**. Geologic units that are not likely to contain recognizable fossil remains, such as igneous rock units.
>
> ***Class 2*** – **Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils, such as recent or very young (younger than 10,000 years) units.
>
> ***Class 3*** – **Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.
>
> ***Class 3a*** – **Moderate Potential.** Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered.
>
> ***Class 3b*** – **Unknown Potential.** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds.

[76] Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, pages 8-12.

Class 4 – **High**. Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability.

Class 4a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres.

Class 4b – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances.

Class 5 – **Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a – Unit is exposed with little or no soil or vegetative cover.

Class 5b – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances.

Review of Previously Recorded Fossil Localities

A Project-specific review of previously recorded fossil localities at the Natural History Museum of Los Angeles County (LACM) and the San Bernardino County Museum (SBCM) was conducted.[77] The purpose of the record search was to determine whether any previously recorded fossil localities occur within the Project area, or have been found in the same geologic units that occur within the Project area. The paleontological archival research and field studies conducted as part of the prior paleontological analysis in 1999 were also reviewed.[78]

No previously recorded fossil localities within the Project area exist at the LACM. However, three LACM fossil localities are located in the vicinity of the Project area.[79] Locality LACM 5977, found within Quaternary deposits located to the south-southwest of the Project area, produced a fossil specimen of the pocket mouse *Perognathus*. Localities LACM (CIT) 208 and LACM 3414, found in Quaternary deposits to the west-southwest of the Project area between the Eagle Mountains and the Coxcomb Mountains, yielded specimens of tortoise (*Gopherus*), horse (*Equus*), and camel (*Camelops* and *Tanupolama stevensi*).[80]

77 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 24.
78 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume I*, September 2001.
79 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 24.
80 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 24.

The SBCM has four previously recorded fossil localities along the proposed pipeline alignment and in other localities in the general vicinity. Locality SBCM 141.2, located at Danby Dry Lake, produced fossil horse (*Equus* sp.), camel (*Camelops* sp.), jack rabbit (*Lepus* sp. Cf. *L. californicus*), kangaroo rat (*Dipodomys*), fox (*Vulpes*), and badger (*Taxidea taxus*). Localities SBCM 141.8 and SBCM 142.8 produced unspecified fossil types of Rancholabrean North American Land Mammal "Age" from Danby Dry Lake and Cadiz Dry Lake, respectively. Locality SBCM 142.2, located on Cadiz Dry Lake, produced plant remains (Tracheophtyta) and kangaroo rat (*Dipodomys*). The SBCM also reports that the Danby and Cadiz areas have produced fossils of extinct horse (*Equus* sp.), large camel (cf. *Camelops* sp.), and pronghorn (?*Tetrameryx*), as well as mollusks, toads, tortoises (including the giant tortoise *Hesperotestudo*), lizards, snakes, birds, rabbits, and rodents.[81]

Geologic Map Review

Geologic maps with the highest resolution possible were examined. These include the geologic map of the Amboy 30' x 60' Quadrangle,[82] and the geologic map of the Sheep Hole Mountains 30' x 60' Quadrangle.[83] The geologic map of the Needles 1 x 2 Degree Quadrangle[84] was used for portions of the Project area that are not covered by the 30' x 60' maps.

The geologic map search revealed that surficially, the Project occurs mostly on alluvium and lake deposits of Quaternary (Holocene and Pleistocene) age. Igneous and metamorphic bedrock units of Precambrian to Mesozoic age also occur.[85]

The Project area contains 19 mapped geologic units (**Table 4.5-4**). In terms of geographic extent, most of the Project area includes surficial sedimentary deposits that are of both Pleistocene and Holocene age.

Four of the geologic units within the Project area (Jurassic Diorite and Quartz Diorite; Buckskin Formation; Kilbeck Gneiss; and granitic rocks) have very low paleontological sensitivity (PFYC Class 1) because they consist of igneous or metamorphic rocks that were formed at extremely high temperatures or high pressures, and do not typically contain recognizable fossil remains.[86] Six of the geologic units (Youngest alluvium; Younger alluvium; playa deposit; Quaternary alluvium; Quaternary lake deposits; and Dune sand) have low paleontological sensitivity (PFYC Class 2) because they consist of surficial sedimentary deposits that were formed during the

81 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 25.
82 Bedford, D.R., Miller, D.M., and Phelps, G.A., *Surficial geologic map data and physical properties for the Amboy 30 x 60 minute Quadrangle, California*, U.S. Geological Survey Open-File Report 2006-1165, 33 p., scale 1:100,000, http://pubs.usgs.gov/of/2006/1165, 2010.
83 Howard, K.A., *Geologic Map of the Sheep Hole Mountains 30'x 60' quadrangle, San Bernardino and Riverside Counties, California*, U.S. Geological Survey Miscellaneous Field Investigations Map, MF-2344, scale 1:100,000, 2002.
84 Bishop, C.C., *Geologic Map of California: Needles Sheet*, California Division of Mines and Geology, scale 1:250,000, 1963.
85 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 12.
86 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 16.

Holocene (less than 10,000 years ago), and as such, are too young to contain in-situ fossil remains. It should be noted that although PFYC Class 2 units have low paleontological sensitivity at the surface, they are often underlain at varying depths by older Pleistocene surficial deposits that may contain scientifically significant fossil remains, and these deposits and contained fossils can be adversely impacted by ground disturbing projects that penetrate through the overlying low sensitivity Holocene age deposits. Because of their low potential to produce scientifically significant fossil remains, neither the PFYC Class 1 nor the PFYC Class 2 geologic units are discussed further in this Section.

TABLE 4.5-4
SURFICIAL MAPPED GEOLOGIC UNITS WITHIN THE PALEONTOLOGICAL RESOURCES STUDY AREA

Map Abbreviation	Geologic Unit	Age	PFYC Class (potential for fossils)
Bedford et al., 2010, Amboy 30' x 60'Quadrangle			
Qya	Young alluvial fan deposit	Holocene and latest Pleistocene	4* (high)
Qyaf	Young alluvial fan composed of fine-grained deposits	Holocene and latest Pleistocene	4* (high)
Qyv	Young valley-axis deposit	Holocene and latest Pleistocene	4* (high)
Qia	Intermediate alluvial fan deposit	Late to middle Pleistocene	4* (high)
Qha/ca	Abundant hillslope deposits and "carbonate rocks"	Holocene and Pleistocene	3* (moderate)
Qha/mi	Abundant hillslope deposits and "metamorphic rocks"	Holocene and Pleistocene	3* (moderate)
Howard, 2002, Sheep Hole Mountains 30' x 60' Quadrangle			
Qy	Youngest alluvium	Holocene	2** (low)
Qya	Younger alluvium	Holocene	2** (low)
Qps	Playa deposit, silt and clay	Holocene	2** (low)
Qwo	Older windblown sand, stabilized (fossil) dunes	Holocene and Pleistocene	3* (moderate)
Jd	Diorite and Quartz diorite	Jurassic	1 (very low)
TrRb	Buckskin Formation, schist and gneiss	Triassic	1 (very low)
Xk	Kilbeck Gneiss	Early Proterozoic	1 (very low)
Bishop, 1963, Needles 1 x 2 Degree Quadrangle			
Qal	Quaternary alluvium	Recent/Holocene	2 (low)
Ql	Quaternary lake deposits	Recent/Holocene	2 (low)
Qs	Dune sand	Recent/Holocene	2 (low)
pC	Undivided metamorphic rocks	Precambrian	1 (very low)
pC-gr	Undivided granitic rocks	Precambrian	1
gr	Granitic rocks	Mesozoic	1

*Holocene age deposits are too young to contain fossils, although Pleistocene deposits have high paleontological sensitivity. Highest PFYC ranking is applied to entire map unit for units mapped as containing both Holocene and Pleistocene age sediments.
**Holocene age deposits are considered to have low paleontological sensitivity, but may be underlain at depth by Pleistocene age deposits with moderate or high paleontological sensitivity.

SOURCE: Paleo Solutions, Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA, November 2010, page 16.

Three geologic units (Holocene and Pleistocene abundant hillslope deposits and carbonate rocks; abundant hillslope deposits and metamorphic rocks; and older windblown sand and stabilized dunes) are considered to have moderate paleontological sensitivity (PFYC Class 3) because they consist of Holocene and Pleistocene age sedimentary deposits (and other lithologies, see **Table 4.5-1**) that were deposited on hillslopes or consist of older stabilized sand dunes and thus have lower sensitivity than other sedimentary deposits of Pleistocene age, such as alluvium. Note that for geologic units that are mapped as being both Pleistocene and Holocene age, the PFYC Class for the higher sensitivity Pleistocene deposits is applied to the entire unit. Four geologic units (Holocene and Late Pleistocene Young alluvial fan deposits; Young alluvial fan composed of fine grained deposits; Young valley-axis deposit; and late to middle Pleistocene Intermediate alluvial fan deposits) have high paleontological sensitivity (PFYC Class 4) because they consist of Pleistocene age sedimentary deposits including alluvial deposits that regularly produce scientifically significant fossil remains in the general vicinity of the Project area and elsewhere in Southern California.

The sensitivity rankings for the mapped geologic units within the Project area apply only to surface geologic units, and units with higher (or lower) sensitivity may be encountered at a shallow depth beneath the surface. In terms of geographic extent, most of the Project area includes surficial sedimentary deposits that are of both Pleistocene and Holocene age. It is critical to note that although deposits of Holocene age that are too young to produce in-situ fossils, these deposits are known to be underlain at a shallow depth at many locations in the Mojave Desert by Pleistocene age deposits that do contain scientifically significant fossils and that document the paleoenvironments and paleoecology of this area during the Pleistocene "ice age." Thus, in areas mapped as Holocene in age, Project excavations that are at or close to existing grade are unlikely to impact paleontological resources. However, deeper excavations may disturb older (Pleistocene), especially in alluvium and lake deposits, and less likely in hillslope, alluvial fan, and sand dune deposits. Specifically, older lake deposits underlie and encompass a larger geographic area than the current extent of Danby Dry Lake and Cadiz Dry Lake.

Field Survey

A paleontological field survey was conducted between October 18 and 26, 2010.[87] Survey was conducted for the 43.5-mile long linear pipeline portion of the Project area only, between the CRA on the south and the intersection of the wellfield and water conveyance pipeline portion of the Project areas on the north. Survey occurred within the 200-foot wide ARZC ROW, which centered on the ARZC railroad tracks. The wellfield portion of the Project area was not surveyed since the precise locations of the well pads and access roads were not yet finalized.

The goal of the field surveys was to determine the presence of paleontological resources within the disturbance limits of the Project area. The surveys consisted of walking transects along bedrock outcrops and visually examining bedrock outcrops for exposed fossil remains.

The pedestrian field survey did not result in the identification of any fossils.

87 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 25.

4.5.3 Regulatory Framework

Numerous laws and regulations require federal, state, and local agencies to consider the effects a project may have on cultural resources. These laws and regulations stipulate a process for compliance, define the responsibilities of the various agencies proposing the action, and prescribe the relationship among other involved agencies (e.g., State Historic Preservation Office and the Advisory Council on Historic Preservation). The National Historic Preservation Act (NHPA) of 1966, as amended; CEQA; and the CRHR, Public Resources Code (PRC) 5024, are the primary federal and State laws governing and affecting preservation of cultural resources of national, state, regional, and local significance.

Federal

Section 106 of the NHPA

Archaeological resources are protected through the NHPA of 1966, as amended (16 USC 470f), and its implementing regulation, Protection of Historic Properties (Code of Federal Regulations [CFR] 36 Part 800), the Archaeological and Historic Preservation Act of 1974, and the Archaeological Resources Protection Act of 1979. Prior to implementing an "undertaking" (e.g., issuing a federal permit), Section 106 of the NHPA requires federal agencies to consider the effects of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation and the State Historic Preservation Officer a reasonable opportunity to comment on any undertaking that would adversely affect properties eligible for listing in the NRHP. As indicated in Section 101(d)(6)(A) of the NHPA, properties of traditional religious and cultural importance to a tribe are eligible for inclusion in the NRHP. Under the NHPA, a resource is considered significant if it meets the NRHP listing criteria at 36 CFR 60.4 (see below).

National Register of Historic Places

The NRHP was established by the NHPA of 1966 as "an authoritative guide to be used by federal, state, and local governments, private groups and citizens to identify the Nation's historic resources and to indicate what properties should be considered for protection from destruction or impairment" (36 CFR Section 60.2). The NRHP recognizes both historical-period and prehistoric archaeological properties that are significant at the national, state, and local levels. In the context of the Project, which does not involve any historical-period structures, the following NRHP criteria are given as the basis for evaluating archaeological resources.

To be eligible for listing in the NRHP, a resource must be significant in American history, architecture, archaeology, engineering, or culture. Districts, sites, buildings, structures, and objects of potential significance must meet one or more of the following four established criteria:[88]

A. Are associated with events that have made a significant contribution to the broad patterns of our history;

[88] U.S. Department of the Interior, National Park Service, *National Register Bulletin: How to Apply the National Register Criteria for Evaluation*, Washington, D.C., 1995.

B. Are associated with the lives of persons significant in our past;

C. Embody the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. Have yielded, or may be likely to yield, information important in prehistory or history.

Unless the property possesses exceptional significance, it must be at least fifty years old to be eligible for NRHP listing.[89]

In addition to meeting the criteria of significance, a property must have integrity. Integrity is defined as "the ability of a property to convey its significance".[90] The NRHP recognizes seven qualities that, in various combinations, define integrity. To retain historic integrity a property must possess several, and usually most, of these seven aspects. Thus, the retention of the specific aspects of integrity is paramount for a property to convey its significance. The seven factors that define integrity are location, design, setting, materials, workmanship, feeling, and association.

State

The State implements the NHPA through its statewide comprehensive cultural resources surveys and preservation programs. The California Office of Historic Preservation (OHP), as an office of the California Department of Parks and Recreation, implements the policies of the NHPA on a statewide level. The OHP also maintains the California Historic Resources Inventory. The State Historic Preservation Officer (SHPO) is an appointed official who implements historic preservation programs within the State's jurisdictions.

California Register of Historical Resources

The CRHR is "an authoritative listing and guide to be used by State and local agencies, private groups, and citizens in identifying the existing historical resources of the State and to indicate which resources deserve to be protected, to the extent prudent and feasible, from substantial adverse change" (PRC § 5024.1[a]). The criteria for eligibility for the CRHR are based upon NRHP criteria (PRC § 5024.1[b]). Certain resources are determined by the statute to be automatically included in the CRHR, including California properties formally determined eligible for, or listed in, the NRHP.

To be eligible for the CRHR, a prehistoric- or historical-period property must be significant at the local, State, and/or federal level under one or more of the following criteria:

1. Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;

2. Is associated with the lives of persons important in our past;

89 U.S. Department of the Interior, National Park Service, *National Register Bulletin: How to Apply the National Register Criteria for Evaluation*, Washington, D.C., 1995.

90 U.S. Department of the Interior, National Park Service, *National Register Bulletin: How to Apply the National Register Criteria for Evaluation*, Washington, D.C., 1995.

3. Embodies the distinctive characteristics of a type, period, region, or method of construction or represents the work of an important creative individual, or possesses high artistic values; or
4. Has yielded, or may be likely to yield, information important in prehistory or history.

A resource eligible for the CRHR must meet one of the criteria of significance described above, retain enough of its historic character or appearance (integrity) to be recognizable as a historical resource, and convey the reason for its significance. It is possible that an historic resource may not retain sufficient integrity to meet the criteria for listing in the NRHP, but it may still be eligible for listing in the CRHR.

Additionally, the CRHR consists of resources that are listed automatically and those that must be nominated through an application and public hearing process. The CRHR automatically includes the following:

- California properties listed on the NRHP and those formally Determined Eligible for the NRHP;
- California Registered Historical Landmarks from No. 770 onward; and,
- Those California Points of Historical Interest that have been evaluated by the OHP and have been recommended to the State Historical Commission for inclusion in the CRHR.

Other resources that may be nominated to the CRHR include:

- Historical resources with a significance rating of Category 3 through 5 (those properties identified as eligible for listing in the NRHP, the CRHR, and/or a local jurisdiction register);
- Individual historical resources;
- Historical resources contributing to historic districts; and,
- Historical resources designated or listed as local landmarks or designated under any local ordinance, such as an historic preservation overlay zone.

California Environmental Quality Act

CEQA is the principal statue governing environmental review of development projects in the State. CEQA requires lead agencies to determine if a proposed project would have a significant effect on archaeological resources. CEQA is codified at PRC Section 21000 et seq. As defined in Section 21083.2 of CEQA, a “unique” archaeological resource is an archaeological artifact, object, or site, about which it can be clearly demonstrated that without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

- Contains information needed to answer important scientific research questions and there is a demonstrable public interest in that information;
- Has a special and particular quality such as being the oldest of its type or the best available example of its type;

- Is directly associated with a scientifically recognized important prehistoric or historic event or person.

CEQA provides that a project may cause a significant environmental effect where the project could result in a substantial adverse change in the significance of a historical resource (Public Resources Code, Section 21084.1). *CEQA Guidelines* Section 15064.5 defines a "substantial adverse change" in the significance of a historical resource to mean physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of a historical resource would be "materially impaired" (*CEQA Guidelines*, Section 15064.5[b][1]).

CEQA Guidelines, Section 15064.5(b)(2), defines "materially impaired" for purposes of the definition of "substantial adverse change" as follows:

The significance of an historical resource is materially impaired when a project:

- Demolishes or materially alters in an adverse manner those physical characteristics of an historical resource that convey its historical significance and that justify its inclusion in, or eligibility for, inclusion in the California Register of Historical Resources; or
- Demolishes or materially alters in an adverse manner those physical characteristics that account for its inclusion in a local register of historical resources pursuant to Section 5020.1(k) of the Public Resources Code or its identification in an historical resources survey meeting the requirements of Section 5024.1(g) of the Public Resources Code, unless the public agency reviewing the effects of the project establishes by a preponderance of evidence that the resource is not historically or culturally significant; or
- Demolishes or materially alters in an adverse manner those physical characteristics of an historical resource that convey its historical significance and that justify its eligibility for inclusion in the California Register of Historical Resources as determined by a lead agency for purposes of CEQA.

In accordance with *CEQA Guidelines* Section 15064.5(b)(3), *generally a project that follows the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings* or *Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings* is considered to have mitigated impacts to historic resources to a less-than-significant level.

Historic resources are usually 50 years old or older and must meet at least one of the criteria for listing in the CRHR (such as association with historical events, important people, or architectural significance), in addition to maintaining a sufficient level of physical integrity (*CEQA Guidelines* Section 15064.5[a][3]).

Local

San Bernardino County General Plan

The Conservation Element of the recently adopted San Bernardino County General Plan (2007a) identifies goals and policies regarding the cultural resources of the County. The General Plan policies strive to identify and protect important cultural resources in the County. The County General Plan stresses avoidance of cultural resources as the preferred mitigation method. For discussion of the applicability of the County General Plan and Development Code policies to the Project, please see Section 4.10.3 (*Consistency with Land Use Plans*) of the Land Use and Planning Chapter.

Paleontological Resources

Federal

A variety of federal statutes specifically address paleontological resources. They are generally applicable to a project if that project includes federally owned or federally managed lands or involves a federal agency license, permit, approval, or funding. Federal legislative protection for paleontological resources stems from the Antiquities Act of 1906 (PL 59-209; 16 United States Code 431 et. seq.; 34 Stat. 225), which calls for protection of historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on federal lands.

State

Paleontological resources are also afforded protection by CEQA. Appendix G (Part V) of the *CEQA Guidelines* provides guidance relative to significant impacts on paleontological resources, stating that a project will normally result in a significant impact on the environment if it will "…disrupt or adversely affect a paleontologic resource or site or unique geologic feature, except as part of a scientific study." Section 5097.5 of the Public Resources Code specifies that any unauthorized removal of paleontological remains is a misdemeanor. Further, the California Penal Code Section 622.5 sets the penalties for the damage or removal of paleontological resources.

Professional Standards

The Society for Vertebrate Paleontology (SVP) has established standard guidelines for acceptable professional practices in the conduct of paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, and specimen preparation, identification, analysis, and curation. Most practicing professional paleontologists in the nation adhere closely to the SVP's assessment, mitigation, and monitoring requirements as specifically provided in its standard guidelines. Most California State regulatory agencies accept the SVP standard guidelines as a measure of professional practice.

4.5.4 Impact and Mitigation Analysis

Construction of the proposed Project may result in direct impacts to cultural resources through ground disturbing activities. Potential impact mechanisms can include both surface disturbance by vegetation removal and by the movement of large construction vehicles and equipment, and subsurface disturbance through excavation or grading. Indirect impacts to cultural resources could result during construction and/or operations from elevated noise or vibration levels or changes to the visual setting of resources. Indirect impacts may also result from increased traffic and public access to the area as a result of road improvements or other factors.

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to cultural resources if it would:

- Cause a substantial adverse change in the significance of a historical resource pursuant to *CEQA Guidelines* Section 15064.5;
- Cause a substantial adverse change in the significance of a unique archaeological resource pursuant to *CEQA Guidelines* Section 15064.5;
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature; or
- Disturb any human remains, including those interred outside of formal cemeteries.

Indian Trust Assets

For purposes of this Draft EIR, a project is considered to have a significant impact on the environment in relation to Indian Trust Assets if it would:

- Directly involve the use of land or sites of religious or cultural importance to Native Americans; or
- Affect the use of reservation lands or sites of religious or cultural importance to Native Americans.

Methodology and Assumptions

Cultural Resources

Impacts to cultural resources are assessed based upon archival research and site surveys with the intent to locate any historic, archaeological, or paleontological resources or human remains within the Project area.[91]

[91] Environmental Science Associates, *Phase 1 Cultural Resources Assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County (CA),* January 2011.

Indian Trust Assets

No ITAs were identified in the Project Area when federal environmental review was completed on a previously proposed Cadiz Groundwater Storage and Dry-Year Supply Program[92] in 2001.

Groundwater Conservation and Recovery Component

Historical Resources

Significance Threshold

Would the proposed Project cause a substantial adverse change in the significance of a historical resource as defined in *CEQA Guidelines* Section 15064.5?

Impact Analysis

Construction

Construction of the wellfield and pipeline would disturb surface soils that may contain historic resources that are eligible for listing in the NRHP or CRHR. With respect to the pipeline, a total of 10 significant historical resources considered eligible for the CRHR and/or NRHP are located within the pipeline portion of the Project area surveyed for cultural resources as part of this study. Three of these resources (CA-SBR-9853H, CA-SBR-11583H, and CA-SBR-10521H) are historic/architectural/engineering resources and are not anticipated to be subject to Project-related impacts that would result in a substantial adverse change in the significance of these resources.

Resource CA-SBR-9853H, the ATSF Railroad, Parker Cutoff, is considered eligible for listing in the CRHR under Criteria 1 and possibly 3. However, the proposed pipeline would be constructed at least 50 feet from the railroad. In some areas the pipeline may need to cross under the railroad; however, this would be accomplished via jack and bore or directional drilling construction methods, which would not impact the resource's eligibility for listing in the CRHR. Therefore, no significant impacts to CA-SBR-9853H as a result of the Project are anticipated because construction methods would ensure that the resources would not be disturbed.

Resource CA-SBR-11583H, Cadiz-Parker Road, may be associated with the construction of the ATSF Parker Cutoff and the early settlement of the region, and thus is recommended eligible for listing in the CRHR. However, the road would be used only for transportation of materials during Project construction, which would not impact the resource's eligibility for listing in the CRHR. Therefore, no significant impacts to CA-SBR-11583H as a result of the Project are anticipated.

Resource CA-SBR-10521H, the CRA, was recommended eligible for the NRHP and CRHR. The Project would connect the proposed water conveyance pipeline to the CRA's sidewall; however, Project construction would only impact a very small section of the CRA. Considering the length of the resource in relation to the size of the area to be impacted by the Project, an overall change to the resource's character or construction style is not anticipated. The Project is not anticipated to

92 Metropolitan Water District of Southern California and Bureau of Land Management,*Cadiz Groundwater Storage and Dry-Year Supply Program and Final Environmental Impact Report and Final Environmental Impact Statement Volume I*, September 2001.

affect the resource's eligibility for listing in the NRHP or CRHR. Therefore, no significant impacts to CA-SBR-10521H as a result of the Project are anticipated.

The remaining seven of the significant historical resources considered eligible for the CRHR are archaeological sites located within the pipeline portion of the Project area (CA-SBR-3233H, CA-SBR-3235H, CA-SBR-3282H, CA-SBR-3283H, CA-SBR-9858H, CA-SBR-10646H, and ESA-C-4**).** These seven sites may be impacted by the Project. Avoidance is the preferred means of mitigating impacts to cultural resources. While mitigation through data recovery excavations would be a means to capture and preserve important data contained in the resources, excavation could lead to the ultimate destruction of the resources. Thus, an attempt should be made to avoid impacts to these resources before data recovery is considered as a viable means of mitigating impacts.

Sixteen cultural resources within the wellfield area are located within or immediately adjacent to this part of the Project. (CA-SBR-3243, -3281H, -6693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-20149, P-36-60315, P-36-60319, P-36-60922, and P-36-64132). Of these 16 resources, only one (CA-SBR-6693H, the historic Atchison, Topeka, & Santa Fe Railroad) has been determined eligible for listing in the NRHP and another (CA-SBR-9855H), possibly containing a grave, was identified as being potentially eligible.[93]

Potential impacts to significant historical resources can include both surface disturbance by vegetation removal and by the movement of large construction vehicles and equipment and subsurface disturbance through excavation or grading. Damage or destruction of significant historical resources would be a significant impact. Prior to installation of the wellfield, site-specific surveys would be conducted within all impact areas as required by Mitigation Measure **CUL-5**. Mitigation Measure **CUL-2** would require modification of the well pad and pipeline locations to avoid identified cultural resources where feasible. Since the exact location of the well pads is flexible within several hundred feet, it is anticipated that these two mitigation measures would effectively avoid impacts to cultural resources in the wellfield area. Implementation of Mitigation Measures **CUL-1 through CUL-6** would result in a less than significant impact for all Project-related construction and operational activities.

Operation

The Project would not introduce substantially more visitors to the region and therefore would not increase the risk of vandalism or damage to historical resources. Although no ground disturbance would occur, operation and maintenance of the Project, particularly the operation of maintenance vehicles, could impact historical resources in the Project area. However, Mitigation Measure CUL-3, which would require the preparation of a long-term management for significant historical resources, would mitigate impacts from Project operation to less than significant.

93 Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999.

Mitigation Measures

CUL-1: A qualified archaeologist, defined as an archaeologist meeting the Secretary of the Interior's Standards for professional archaeology,[94] shall be retained to carry out all mitigation measures related to archaeological resources.

CUL-2: The construction zone shall be narrowed or otherwise altered to avoid all significant historical resources where feasible. Significant or unevaluated cultural resources within 50 feet of the construction zone shall be marked with exclusion markers to ensure avoidance. In the case of resources CA-SBR-3282H and CA-SBR-3233H, a 50-foot buffer shall be established outside of recorded site boundaries as an added protective measure to protect historic cemeteries. Protective fencing shall not identify the protected areas as cultural resource areas in order to discourage unauthorized disturbance or collection of artifacts.

CUL-3: A long-term management plan shall be developed for those significant historical resources or portion(s) of resources that can be avoided during Project construction, in order to minimize future impacts during Project operation and maintenance.

CUL-4: If avoidance of significant historical resources is not feasible, prior to any Project-related ground disturbing activities, a detailed treatment plan shall be prepared and implemented by a qualified archaeologist. The treatment plan shall include a research design and a scope of work for data recovery of the portion(s) of the significant resource(s) to be impacted by the Project. Treatment for most resources shall consist of (but would not be not limited to) sample excavation, surface artifact collection, site documentation, and historical research, with the aim to target the recovery of important scientific data contained in the portion of the significant resource to be impacted by the Project. The treatment plan shall include provisions for analysis of data in a regional context, reporting of results within a timely manner, and curation of artifacts and data at an approved facility.

CUL-5: Prior to construction, a qualified archaeologist shall be retained to carry out a Phase 1 cultural resources survey in those portions of the Project area (including but not limited to: the wellfield, CRA tie-in Options 2a and 2b, and any access roads, staging areas, borrow areas, and any other proposed areas of potential ground disturbance) not previously surveyed within the past 5 years. The Phase 1 survey shall identify and evaluate the significance of any potentially eligible resources that may be directly or indirectly impacted by the proposed Project, and shall take Native American comments concerning viewshed impacts into consideration. The Phase 1 Survey effort shall be documented in a Phase 1 Cultural Resources Survey report. Resources determined eligible for listing shall be subject to Mitigation Measures **CUL-1 through CUL-4** and **CUL-6**. All significant cultural resources identified in the wellfield area during surveys shall be avoided.

CUL-6: Prior to construction, an archaeological monitor shall be retained to monitor all ground-disturbing activities, including brush clearance and grubbing, within 100 feet of all significant historical resources. The monitor shall work under the supervision of the qualified archaeologist. The duration and timing of monitoring shall be determined by the qualified archaeologist in consultation with the lead agency and based on the grading plans. In the event that cultural resources are unearthed during ground-disturbing.

94 Department of the Interior, *Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (As Amended and Annotated): Professional Qualification Standards,* http://www.nps.gov/history/local-law/arch_stnds_9.htm, accessed November 2010.

activities, the archaeological monitor shall be empowered to halt or redirect ground-disturbing activities away from the vicinity of the find so that the find can be evaluated and appropriate treatment determined.

Significance Conclusion

Less than significant with mitigation.

Archaeological Resources

Significance Threshold

Would the proposed Project cause a substantial adverse change in the significance of a unique archaeological resource pursuant to *CEQA Guidelines* Section 15064.5?

Impact Analysis

The proposed Project has the potential to impact previously unknown archaeological resources. A portion of the Project area (including the wellfield) has not yet been surveyed and would require survey and identification of cultural resources prior to issuance of a grading permit.

No archaeological survey of the wellfield portion of the Project area was conducted as part of this study effort since the exact locations for well pads and access roads has not been determined precisely. Prior to installation of the wellfield, site-specific surveys would be conducted within all impact areas as required by Mitigation Measure **CUL-5**. Mitigation Measure **CUL-2** would require modification of the well pad and pipeline locations to avoid identified cultural resources where feasible. Since the exact locations of the well pads are flexible within several hundred feet, it is anticipated that these two mitigation measures would effectively avoid impacts to cultural resources in the wellfield area. Implementation of Mitigation Measures **CUL-1 through CUL-6** would result in a less than significant impact for all Project-related construction and operational activities.

In addition, there exists the possibility of uncovering previously unknown buried archaeological resources during Project construction. The high number of recorded prehistoric and historic-era archaeological sites within and adjacent to the Project indicate a potential for archaeological resources discoveries during Project implementation. In the event that archaeological resources are discovered during Project construction, the following mitigation measures would be implemented.

Mitigation Measures

CUL-7: If archaeological resources are encountered, all activity in the vicinity of the find shall cease until it can be evaluated by a qualified archaeologist. If the qualified archaeologist determines that the resources may be significant, he or she will develop an appropriate treatment plan for the resources. Appropriate Native American representatives shall be consulted in determining appropriate treatment for unearthed cultural resources if the resources are prehistoric or Native American in nature.

In considering any suggested mitigation proposed by the archaeologist in order to mitigate impacts to archaeological resources, avoidance will be determined necessary and feasible in light of factors such as the nature of the find, Project design, costs, and other considerations. If avoidance is infeasible, other appropriate measures (e.g., data recovery) will be instituted. Work may proceed on other parts of the Project site while mitigation for cultural resources is being carried out.

Implement Mitigation Measures **CUL-1 through CUL-6**.

Significance Conclusion

Less than significant with mitigation.

Paleontological Resources

Significance Threshold

Would the proposed Project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Impact Analysis

The Project occurs mostly on alluvium and Holocene and Pleistocene lake deposits. Igneous and metamorphic bedrock units of Precambrian to Mesozoic age also occur.[95]

Based on the geologic map review completed for this analysis, the Project area contains 19 mapped geologic units. Four of the geologic units within the Project area (Jurassic Diorite and Quartz Diorite; Buckskin Formation; Kilbeck Gneiss; and granitic rocks) have very low paleontological sensitivity (PFYC Class 1).[96] Six of the geologic units (Youngest alluvium; Younger alluvium; playa deposit; Quaternary alluvium; Quaternary lake deposits; and Dune sand) have low paleontological sensitivity (PFYC Class 2).

Three geologic units (Holocene and Pleistocene abundant hillslope deposits and carbonate rocks; abundant hillslope deposits and metamorphic rocks; and older windblown sand and stabilized dunes) are considered to have moderate paleontological sensitivity (PFYC Class 3). Four geologic units (Holocene and Late Pleistocene Young alluvial fan deposits; Young alluvial fan composed of fine grained deposits; Young valley-axis deposit; and late to middle Pleistocene Intermediate alluvial fan deposits) have high paleontological sensitivity (PFYC Class 4).

Although deposits of Holocene age are too young to produce in-situ fossils, these deposits are known to be underlain at a shallow depth at many locations in the Mojave Desert by Pleistocene age deposits that do contain scientifically significant fossils and that document the

95 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 12.
96 Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010, page 16.

paleoenvironments and paleoecology of this area during the Pleistocene "ice age." Older lake deposits underlie and encompass a larger geographic area than the current extent of Danby Dry Lake and Cadiz Dry Lake. Thus, in areas mapped as Holocene in age, Project excavations that are at or close to existing grade are unlikely to impact paleontological resources. However, deeper excavations may disturb older (Pleistocene) deposits, especially in the alluvium and lake deposits areas, less likely in hillslope, alluvial fan, and sand dune deposits.

There is a high likelihood that paleontological resources would be encountered in Project excavations in certain areas. Implementation of Mitigation Measure **CUL-8 through CUL-10** during Project construction would ensure potential impacts to paleontological resources are reduced to less than significant levels.

Mitigation Measures

CUL-8: Prior to construction, those portions of the Project area (including the wellfield, CRA tie-in Options 2a and 2b, access roads, staging areas, and borrow areas) not previously surveyed within the past 5 years, shall be surveyed by a qualified vertebrate paleontologist, defined as one holding an advanced degree in paleontology, biology, or a related discipline, and having at least five years of professional experience. If paleontological resources are encountered, they shall be documented or recovered, and curated, as appropriate, prior to the start of construction. The evaluation will be documented in a report to be submitted for review and approval by the lead agency prior to the start of construction. The report shall also be submitted to the San Bernardino County Museum.

CUL-9: Prior to the start of any earth moving activity, a qualified vertebrate paleontologist shall be retained. The paleontologist shall prepare a Paleontological Mitigation and Monitoring Plan (PMMP) that shall be based on prior paleontological evaluations, including the results of the paleontological survey as described in Mitigation Measure **CUL-8**, and shall address pre-construction salvage and reporting; pre-construction contractor sensitivity training; procedures for paleontological resources monitoring including the identification of specific paleontological monitoring locations as defined by areas where Pleistocene age sediments may be impacted during construction; microscopic examination of samples where applicable; the evaluation, recovery, identification, and curation of fossils; and the preparation of a final mitigation report.

CUL-10: All earth-moving activities within those formations identified as sensitive within the PMMP shall be monitored on a full-time basis, unless the paleontologist determines that sediments are previously disturbed or there is no reason to continue monitoring in a particular area due to other depositional factors which would make fossil preservation unlikely or deemed scientifically insignificant. In the event fossils are exposed during earth moving, construction activities shall be redirected to other work areas until the procedures outlined in the PMMP have been implemented or the paleontologist determines work can resume in the vicinity of the find.

When fossils are discovered, they and associated data shall be collected quickly and professionally. Fossil salvage procedures shall include the collection of bulk matrix samples if scientifically significant microfossils are believed to be present based on field evidence. All fossils collected during monitoring shall be transferred to a secure facility for

laboratory preparation and identification. Laboratory preparation shall include stabilization, matrix removal, and conservation of individual fossil specimens, as well as screenwashing and picking of bulk matrix samples. Fossils shall be prepared to the point of curation and identified by technical specialists, as needed, to the lowest possible taxonomic level. At the end of the Project, the paleontologist shall prepare a report that includes a description and inventory list of recovered fossil materials; a map showing the location of paleontological resources found in the field; determinations of sensitivity and significance; and a statement that Project impacts to paleontological resources have been mitigated. The results of the paleontological surveys, construction monitoring, and subsequent laboratory work shall be compiled in a final paleontological mitigation report authored by the qualified paleontologist for the Project. The final report shall include all Project data and a copy of the receipt of specimens from the paleontological repository.

Following preparation, the fossils and associated data and a copy of the final paleontological mitigation report shall be transferred to a public museum (paleontological repository) where they will be available for the benefit of current and future generations.

Significance Conclusion

Less than significant with mitigation.

Human Remains

Significance Threshold

Would the proposed Project disturb any human remains, including those interred outside of formal cemeteries?

Impact Analysis

Two historic-era cemeteries have been identified adjacent to the Project area. The cemetery at the historic railroad settlement of Archer (CA-SBR-3282H), which dates to the early 20th century, is located less than 10 feet outside of the Project area. The cemetery at the historic railroad settlement of Milligan (CA-SBR-3233H) is located less than 100 feet outside of the Project area. Neither of these cemeteries are located within the Project area and neither would be impacted. However, both cemeteries are located very close to the Project area. There remains a possibility that unmarked graves may exist near these cemeteries but outside of their marked boundaries.

In addition, a possible historic gravesite, documented as resource CA-SBR-9855H, was recorded in the wellfield portion of the Project area. The existence of historic burial sites within the Project area indicates that there is a potential for the discovery of human remains during Project implementation.

However, Mitigation Measure **CUL-2** would require avoidance of significant historical resources and establish a 50-foot buffer area around the cemeteries at CA-SBR-3282H and CA-SBR-3233H. Mitigation Measure **CUL-3** would establish a long-term management plan for these sites. In addition, Mitigation Measure **CUL-6** would require archaeological monitoring within 100 feet

of significant resources. The risk of inadvertently damaging human remains causing a significant impact to occur would be minimized by implementation of Mitigation Measure **CUL-11**, in conjunction with Mitigation Measures **CUL-2, CUL-3,** and **CUL-6**.

Mitigation Measures

CUL-11: If human remains are uncovered during Project construction, all work in the vicinity of the find shall be halted and the County Coroner will be contacted to evaluate the remains and follow the procedures and protocols set forth in Section 15064.5 (e)(1) of the *CEQA Guidelines*. If the County Coroner determines that the remains are Native American, the NAHC shall be contacted, in accordance with Health and Safety Code Section 7050.5, subdivision (c) and Public Resources Code 5097.98 (as amended by AB 2641). Per Public Resources Code 5097.98, the landowner shall ensure that the immediate vicinity, according to generally accepted cultural or archaeological standards or practices, where the Native American human remains are located, is not damaged or disturbed by further development activity until the landowner has discussed and conferred, as prescribed in this Section (PRC 5097.98) with the most likely descendents taking into consideration their recommendations, and developing a treatment plan, taking into account the possibility of multiple human remains.

Implement Mitigation Measures **CUL-2, CUL-3,** and **CUL-6**.

Significance Conclusion

Less than significant with mitigation.

Indian Trust Assets

Significance Threshold

Would the proposed Project directly involve the use of land or sites of religious or cultural importance to Native Americans?

Would the proposed Project affect the use of reservation lands or sites of religious or cultural importance to Native Americans?

Impact Analysis

No Indian Trust Assets have been identified within the Project area. Therefore, there will be no impact on ITAs and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Historical Resources

Significance Threshold

Would the proposed Project cause a substantial adverse change in the significance of a historical resource as defined in *CEQA Guidelines* Section 15064.5?

Impact Analysis

As described above with the Groundwater Conservation and Recovery Component, a total of 41 archaeological and built historic resources were recorded during archaeological survey of the pipeline portion of the Project area. Ten of these are considered significant resources eligible for the CRHR and are located within the pipeline portion of the Project area surveyed for cultural resources as part of this study effort. Three of these resources (CA-SBR-9853H, CA-SBR-11583H, and CA-SBR-10521H) are historic/architectural/engineering resources and seven (CA-SBR-3233H, CA-SBR-3235H, CA-SBR-3282H, CA-SBR-3283H, CA-SBR-9858H, CA-SBR-10646H, and ESA-C-4**)** are archaeological sites located within the pipeline portion of the Project area.

Less than 10 percent of the wellfield portion of the Project area has been previously surveyed. Sixteen cultural resources (CA-SBR-3243, -3281H, -6693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-20149, P-36-60315, P-36-60319, P-36-60922, and P-36-64132) are located within or immediately adjacent to this part of the Project. Of these 16 resources, one (CA-SBR-6693H, the historic Atchison, Topeka, & Santa Fe Railroad) has been determined eligible for listing in the NRHP and another, (CA-SBR-9855H) possibly containing a grave, was identified as being potentially eligible.[97]

Project-related construction may present the possibility of impacts to these and other yet-undiscovered cultural resources. Cultural resources survey to identify and evaluate any cultural resources that may be subject to impacts should be conducted once the specific construction footprint of the Imported Water Storage Component has been further delineated.

Potential impact mechanisms can include both surface disturbance, by vegetation removal and by the movement of large construction vehicles and equipment, and subsurface disturbance through excavation or grading. Damage or destruction of known significant historical resources or unique archaeological resources would be a significant impact. Implementation of Mitigation Measures **CUL-1 through CUL-6** would ensure that most impacts are avoided and that the remaining impacts are appropriately analyzed and recorded to reduce impacts to a less than significant level.

Furthermore, along the existing natural gas pipeline alignment, a number of archaeological resources have been identified during a surveys in 2000-2002.Potential impacts could occur to

[97] Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999.

existing cultural resources and other undiscovered cultural resources during construction and operation. Because ten years have passed since the previous archaeological surveys of the existing natural gas pipeline corridor, new archaeological surveys would be required. However, implementation of Mitigation Measures **CUL-1 through CUL-6** would ensure that most impacts are avoided and that the remaining impacts are reduced to less than significant levels. Thus, impacts would be less than significant with mitigation measures.

Mitigation Measures

Implement Mitigation Measures **CUL-1 through CUL-6**.

Significance Conclusion

Less than significant with mitigation.

Archaeological Resources

Significance Threshold

Would the proposed Project cause a substantial adverse change in the significance of an archaeological resource pursuant to *CEQA Guidelines* Section 15064.5?

Impact Analysis

The Imported Water Storage Component of the proposed Project has the potential to impact previously unknown archaeological resource. A portion of the Project area (including the wellfield) has not yet been surveyed and would require Phase 1 Cultural Survey efforts prior to issuance of a grading permit. In addition, if new areas are incorporated into the Project area, they must also be surveyed for cultural resources prior to the issuance of a grading permit. The Phase 1 effort shall take into consideration previously recorded and new cultural resources as well as comments provided by the Native American community concerning view shed impacts; it shall also formally evaluate any cultural resources that would be directly or indirectly impacted by the Project. Implementation of Mitigation Measures **CUL-1 through CUL-6** would reduce impacts to archaeological resources to a less than significant level.

In addition, there exists the possibility of uncovering previously unknown buried archaeological resources during Project construction. The high number of recorded prehistoric and historic-era archaeological sites within and adjacent to the Project indicate a moderate archaeological sensitivity in the Project area. In the event that archaeological resources are discovered during Project construction, implementation of Mitigation Measure **CUL-7** would reduce impacts to a less than significant level.

As previously discussed, a number of archaeological resources have been identified along the existing natural gas pipeline corridor during archaeological surveys in 2000-2002. Because ten years have passed since the previous archaeological surveys of the existing natural gas pipeline corridor, new archaeological surveys would be required. Potential significant impacts could occur

to existing archeological resources and other undiscovered archeological resources during construction and operation. However, implementation of Mitigation Measures **CUL-1 through CUL-7** would ensure that most impacts are avoided and that the remaining impacts are reduced to less than significant levels. Thus, impacts to archeological resources would be less than significant with mitigation.

Mitigation Measures

Implement Mitigation Measures **CUL-1 through CUL-7**.

Significance Conclusion

Less than significant with mitigation.

Paleontological Resources

Significance Threshold

Would the proposed Project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Impact Analysis

As discussed above with the Groundwater Conservation and Recovery Component, it is possible that significant fossils may be uncovered within the Project area. The Project occurs mostly on Quaternary alluvium and lake deposits (Holocene and Pleistocene age). Igneous and metamorphic bedrock units of Precambrian to Mesozoic age also occur.[98] Based on the geologic map review completed for this analysis, the Project area contains 19 mapped geologic units, of which seven are assigned a moderate to high paleontological sensitivity.

Fossils and their associated contextual data are nonrenewable scientific resources; the loss of these resources resulting from a project, for example due to construction-related excavation and ground disturbance, would be a significant adverse impact. Earthmoving operations can result in the destruction of fossils and rock units within the construction disturbance limits. Implementation of Mitigation Measure **CUL-8 through CUL-10** during Project construction would ensure potential impacts to paleontological resources are reduced to less than significant levels.

The existing natural gas pipeline alignment is an existing pipeline and is in an area currently disturbed. Potential significant impacts could occur to existing paleontological resources and other undiscovered paleontological resources during construction and operation. However, implementation of Mitigation Measures **CUL-8 through CUL-10** would ensure potential impacts to paleontological resources are reduced to less than significant levels. Thus, impacts would be less than significant with mitigation measures.

---

98 *Applied Earthworks, Inc., Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources*, 1999, page 12.

Mitigation Measures

Implement Mitigation Measures **CUL-8 through CUL-10**.

Significance Conclusion

Less than significant with mitigation.

Human Remains

Significance Threshold

Would the proposed Project disturb any human remains, including those interred outside of formal cemeteries?

Impact Analysis

As discussed above with the Groundwater Conservation and Recovery Component, it is possible that previously undocumented human remains could be uncovered within the Project area. In the event that human remains are discovered during Project construction activities, the human remains could be inadvertently damaged, which could be a significant impact. However, the risk of this impact occurring would be minimized by implementation of Mitigation Measure **CUL-11**.

The existing natural gas pipeline alignment area is currently disturbed. However, potential significant impacts could occur to previously undocumented human remains. However, the risk of this impact occurring would be minimized by implementation of Mitigation Measure **CUL-11**. Thus, impacts to human remains would be less than significant with mitigation measures.

Mitigation Measures

Implement Mitigation Measure **CUL-11**.

Significance Conclusion

Less than significant with mitigation.

Indian Trust Assets

Significance Threshold

Would the proposed Project directly involve the use of land or sites of religious or cultural importance to Native Americans?

Would the proposed Project affect the use of reservation lands or sites of religious or cultural importance to Native Americans?

Impact Analysis

No Indian Trust Assets have been identified within the Project area. Therefore, there will be no impact on ITAs and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.5-5 presents the impacts and mitigation summary for Cultural Resources.

TABLE 4.5-5
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Historical Resources	**CUL-1 through CUL-6**	Less than significant with mitigation
Archaeological Resources	**CUL-1 through CUL-7**	Less than significant with mitigation
Paleontological Resources	**CUL-8 through CUL-10**	Less than significant with mitigation
Human Remains	**CUL-2, CUL-3, CUL-6,** and **CUL-11**	Less than significant with mitigation
Indian Trust Assets	None required	No impact
Imported Water Storage Component		
Historical Resources	**CUL-1 through CUL-6**	Less than significant with mitigation
Archaeological Resources	**CUL-1 through CUL-7**	Less than significant with mitigation
Paleontological Resources	**CUL-8 through CUL-10**	Less than significant with mitigation
Human Remains	**CUL-11**	Less than significant with mitigation
Indian Trust Assets	None required	No impact

4.6 Geology and Soils

The purpose of this Section is to identify existing topography, geology, soils, and seismicity within the Project area, analyze potential impacts to those conditions associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. The primary information sources include Project-specific investigations, available resources from the USGS and the California Geological Survey (CGS), as well as other sources cited in the References Section. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

In addition to the *CEQA Guidelines*, the operation of the Project will be managed under a GMMMP which incorporates additional safeguards and action criteria when adverse conditions occur attributable to the Project.

4.6.1 Environmental Setting

A number of field investigations have been performed over the years to describe the geologic setting of the general area of the proposed Project site. Until recently, geologic mapping conducted by the California Division of Mines and Geology (CDMG) published in 1964 had served as the basis for understanding local geologic conditions in the Fenner Gap. Prior to the CDMG investigation, detailed geologic mapping of the Project area had not been published. New geologic mapping of the southeastern portion of the Marble Mountains, the Fenner Gap, and the northwestern portion of the Ship Mountains was conducted for this CEQA investigation by Dr. Miles Kenney, Kenney GeoScience report, and is included within Appendix H of the Draft EIR. The Kenney GeoScience study consolidated the previous geologic and geophysical studies, and then updated and augmented the consolidated geologic information with a 21-day field investigation of the geology of the Fenner Gap area and discussions with previous investigators.[1] This detailed mapping was conducted to allow interpretation of the geologic structure in the Fenner Gap in order to determine potential groundwater flow paths. The Kenney GeoScience report formed the basis for construction of the groundwater flow model and impacts analysis developed by GEOSCIENCE Support Services, Inc., (Geoscience) and is also included within Appendix H of the Draft EIR) for the Project.[2] The environmental setting information below largely draws from the geologic setting information provided in both the Kenney GeoScience study and Geoscience's modeling and impact analysis.

Regional Physiographic and Geologic Setting

Regionally, the Project is located within the Eastern Mojave Desert portion of San Bernardino County, California, which is a part of the Mojave Desert Geomorphic Province, also cited as part of the Basin and Range Geomorphic Province.[3, 4] The Province is characterized by a series of

1 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011.
2 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011.
3 Norris, Robert M. and Robert W. Webb, *Geology of California*, Second Edition, 1990, pages 220- 225.
4 California Geological Survey, *California Geomorphic Provinces, Note 36*, 2002, page 3.

structural and topographic basins bounded by relatively linear mountain ranges. The alternating mountain and valley topography primarily (**Figure 4.6-1**) resulted from extensional (pulling apart) tectonics that occurred during the Miocene (5 to 23 million years ago).[5] Most valleys within the region are truly basins in that sediments eroding from the local mountain ranges deposit locally as alluvial fan sediment aprons (bajadas) draped on the mountains and extend out into the immediate valley. This also means that streams remain trapped within the basins and do not flow outside of the basins to the Pacific Ocean or Gulf of California (Sea of Cortez) or the Colorado River. In addition, groundwater remains trapped in alluvial valley sediments and upper bedrock units within the basins and also does not flow to the Colorado River. In other words, all flow within basin drainages remains within the hydraulically-closed basins, eventually flowing to playas at the lowest elevations, creating dry lakes where flows gather, become saline, and evaporate.

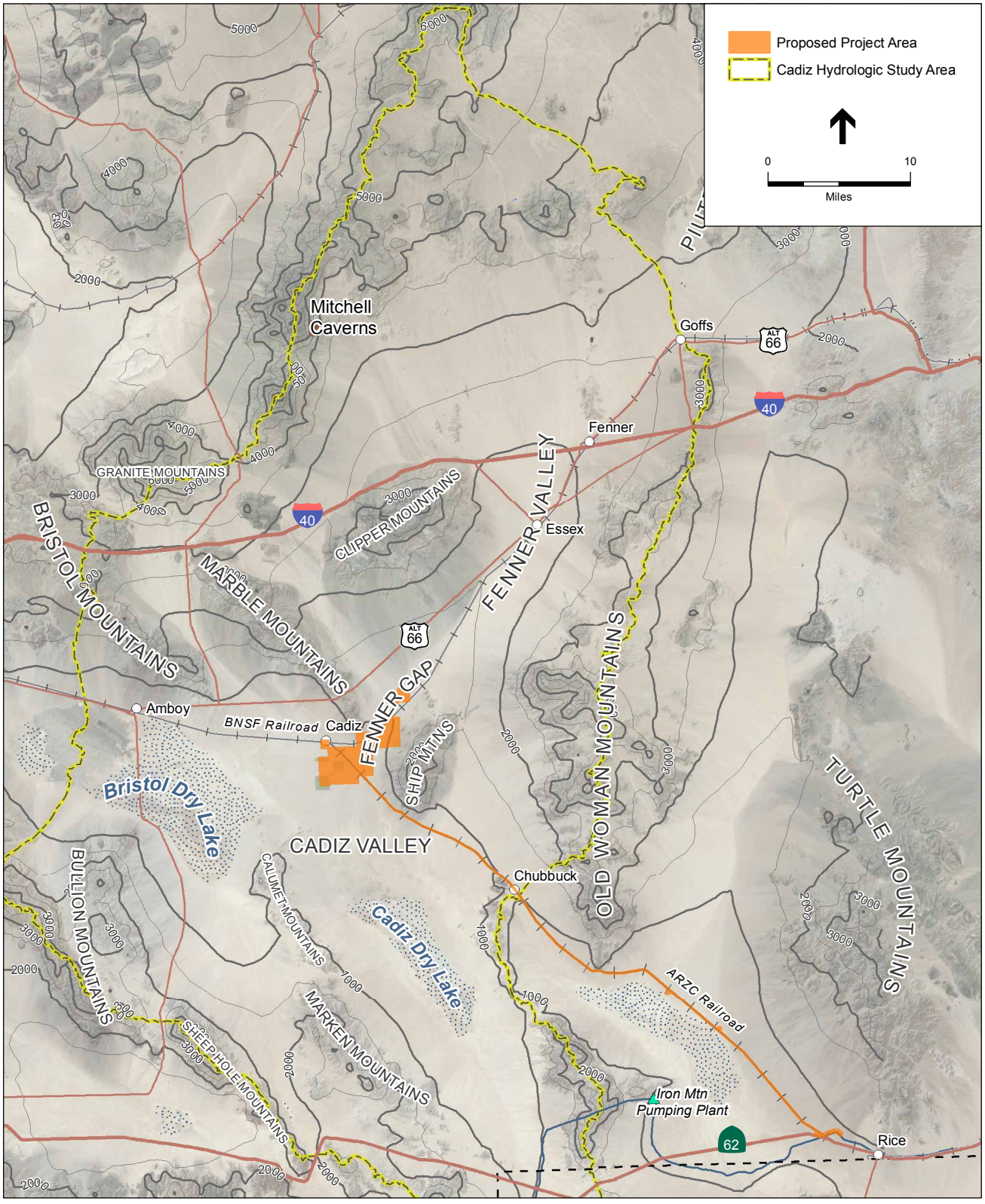
Topography and Geomorphology

The Project site is located at the confluence of the Fenner and Orange Blossom Wash Watersheds, as shown on Figure 4.9-1. This area is within a drainage basin consisting of the Watersheds, as discussed in Section 4.9, Hydrology and Water Quality. These combined Watersheds are considered one hydraulically-closed drainage system because all surface water and groundwater drain to Bristol and Cadiz Dry Lakes at the interior of the overall drainage basin. This drainage basin system is separated from surrounding drainage basins by topographic divides, generally mountain ranges.

The Fenner Watershed is located in the northern portion of the Project area. The New York Mountains, located at the northernmost end of the Project area at the head of the Fenner Valley and Fenner Watershed, are the highest mountains in the Project area, rising to an elevation of approximately 7,532 feet National Geodetic Vertical Datum of 1988 (NGVD).[6] The mountains bounding the east and west sides of the Fenner Valley range in height from 4,165 to 7,178 feet NGVD.[7] Generally, the Fenner Valley slopes south to southwest toward the Fenner Gap at an elevation of about 900 feet NGVD. The Fenner Gap occurs at the southern end of the Watershed between the Marble and Ship Mountains at 3,842 and 3,239 feet NGVD, respectively. At this location, surface water drainage and groundwater flow from the Fenner Watershed enter the Bristol and Cadiz Watersheds to the south. This area comprises the Fenner Watershed and encompasses approximately 1,090 square miles.

The Project wellfield and spreading basin facilities will be located within the Fenner Gap area on Cadiz Inc. owned property, as shown on Figure 3-14. As stated above, the axis of the Fenner Gap is located at an elevation of approximately 900 feet NGVD and is the location of constant groundwater and intermittent surface water outflow from the Fenner Valley to the Bristol and Cadiz Dry Lakes. The ground surface within the Fenner Gap trends gently toward the south at a slope of less than 50 feet per mile to the Cadiz and Bristol Dry Lakes. With minor local

5 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 3.
6 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-1.
7 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.



SOURCE: Bing Maps, 2011; ESRI, 2010
Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-1
Topography

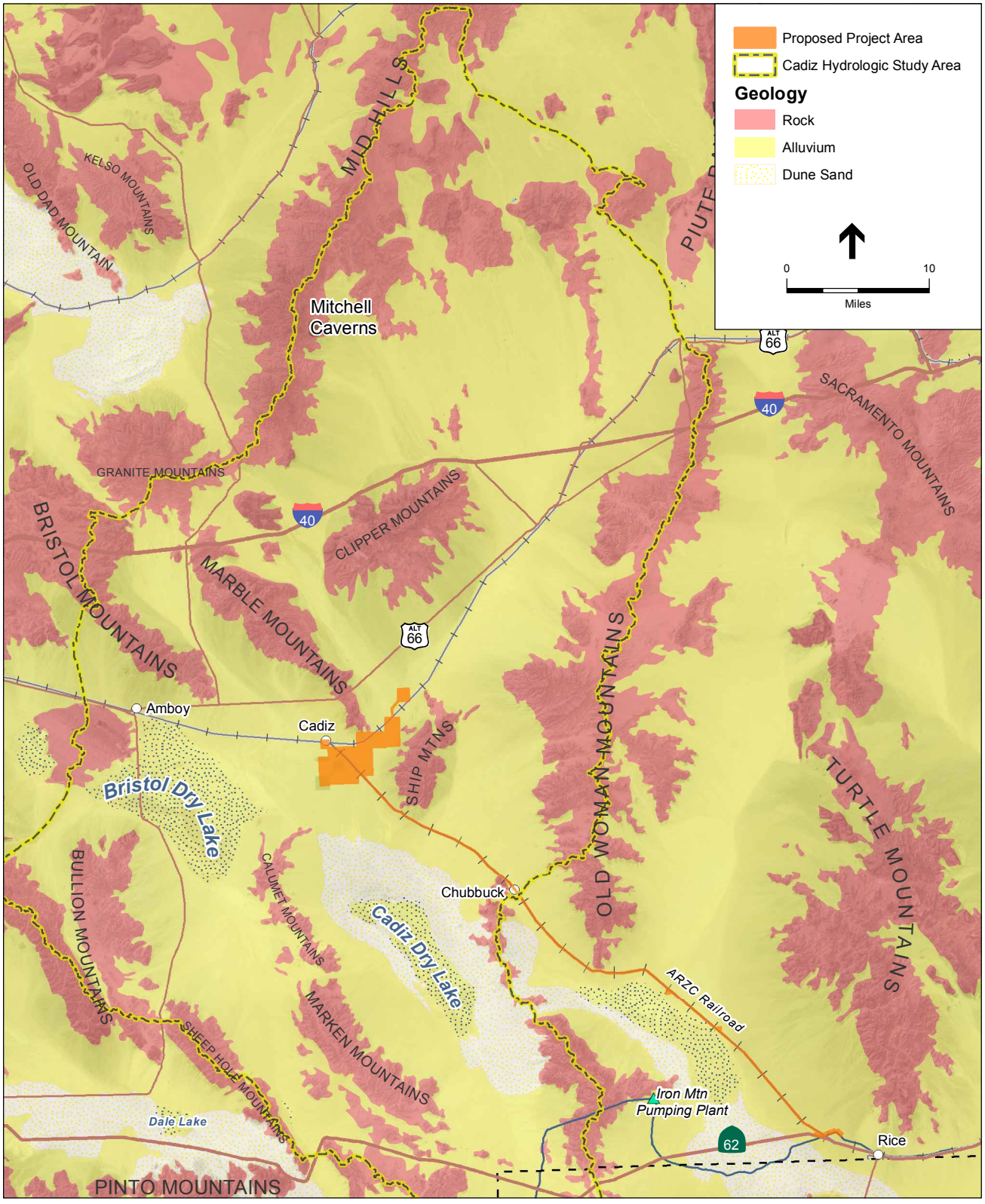
exceptions, the slope of the ground surface ranges from approximately one to six percent (approximately 50 to 300 feet per mile).

Elevations across the Fenner Gap from northwest to southeast vary from about 1,600 feet NGVD in the southern Marble Mountains to about 930 feet NGVD at the base of the Marble Mountains to about 900 feet in the gap axis to about 1,100 feet NGVD at the base of the Ship Mountains to about 3,200 feet NGVD along the crest of the Ship Mountains.[8] Bajadas that range in age from late Pleistocene to present surround the deeply incised Marble and Ship Mountains. Numerous alluvial fan surfaces near the mountain fronts are latest Pleistocene in age (less than 25,000 years old). The fan surfaces do not exhibit any identified fault scarps or lineaments suggesting that faulting has not occurred locally since their deposition.[9] In addition, no lineaments associated with the now inactive normal faults that were active during the Miocene extensional tectonic phase of deformation were identified.

Relatively large bedrock inselbergs[10] exist along the northern flanks of the Ship Mountains (see **Figure 4.6-2**). The inselbergs provide critical information regarding the subsurface structure and lithology in the area.[11] The existence of inselbergs along mountain ranges is typical of Basin and Range extensional tectonic regions where they represent elevated bedrock highlands associated with normal faulting that subsequently received alluvial sediments around them once normal faulting ceased. The presence of the alluvial sediments provides strong evidence that normal faulting is no longer active in the Project area.

The Bristol and Cadiz Watersheds in the southern portion of the Project area form a broad depression that is referred to as the Bristol Trough (also referred to as the Barstow-Bristol or Bristol-Danby Trough).[12,13,14] This depression is thought to be six to ten million years old[15] and to have been formed as a result of regional movement along faults. The Bristol and Cadiz Watersheds are surrounded by the Bristol, Iron, Bullion, Sheep Hole, Calumet, and Coxcomb Mountains, ranging in elevations from 1,751 to 4,685 feet NGVD. The surface water drainage and groundwater flow from the Four Watersheds drain into the Bristol and Cadiz Dry Lakes with surface elevations of approximately 595 and 545 feet NGVD, respectively. The Bristol and Cadiz Dry Lakes are separated by a low topographic and surface drainage divide. The Cadiz Watershed encompasses approximately 590 square miles. The Bristol Watershed encompasses

8 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, page 2.
9 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 2.
10 Isolated bedrock exposures surrounded by young alluvium.
11 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, page 2.
12 Thompson, D.G., *The Mojave Desert Region, California: A Geographic, Geologic, and Hydrologic Reconnaissance,* U.S. Geological Survey Water Supply Paper 578, 1929 page 652.
13 Bassett, A.M. and D.H. Kupfer, *A Geologic Reconnaissance in the Southeastern Mojave Desert, California,* California Division of Mines and Geology Special Report 83, 1964, page 41.
14 Jachens, R.C., and Howard, K.A, "Bristol Lake Basin – A Deep Sedimentary Basin Along the Bristol-Danby Trough, Mojave Desert" In *Old Routes to the Colorado,* San Bernardino County Museums Special Publication 92-2, Redlands, CA, 2002, pages 57-59.
15 Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): Model for Playa Development and Implications for Paleoclimate*, 1989, page 23.



SOURCE: Bing Maps, 2011; ESRI, 2010
Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-2
Simplified Geology

approximately 640 square miles, which is considered to include the 160 square mile Orange Blossom Wash Watershed, discussed below.

The Orange Blossom Wash Watershed is located along the western portion of the Project area between the Marble and Bristol Mountains and below the Granite Mountains. It begins at the Granite Mountains, which are located along the western border of the Project area and rise to 6,786 feet NGVD. The Orange Blossom Wash Watershed comprises approximately 160 square miles and drains to the southeast into the Bristol Watershed, which is to the south and southwest.

Geologic Units

The Kenney GeoScience study provides a complete description of the geologic units present within the Project area including numerous subdivisions of the units, along with a detailed geologic map and eight detailed geologic cross sections.[16] Figure 4.6-2 provides a simplified geologic map of the larger study area showing the distribution of bedrock and alluvial deposits. The bedrock includes igneous, metamorphic, and consolidated sedimentary rocks. The alluvial and playa deposits are unconsolidated sediments deposited by streams, wind, or dry lakes. In general, bedrock forms the perimeter of the Four Watersheds.

Using all of the available geologic information, including the results of aquifer testing conducted by Geoscience and the recent mapping and interpretations in the Kenney GeoScience study, Geoscience grouped the geologic formations found in the Project area into the four broad categories listed below[17] with a focus on the generally differing hydraulic properties (i.e., the characteristics of groundwater movement through geologic materials).

- Holocene Playa Deposits
- Pleistocene to Holocene Alluvium
- Tertiary volcanic and fanglomerate units
- Archean to Jurrassic granitic and metamorphic rock units

A brief description of the grouped geologic units in the overall Project area is presented below, mostly drawing from the Kenney GeoScience study but also from others studies as cited. The units are presented from youngest to oldest.

Playa Deposits

The playa sediments underlying the Bristol and Cadiz Dry Lakes consist of brine-saturated clay, silt, fine-grained sand, and evaporite deposits. The clastic sediments were deposited when stream flow and sheet flow from the surrounding alluvial fans spread onto the playas during major storm

16 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011.

17 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 6-7.

events.[18] The evaporite deposits formed from evaporation of both surface water and groundwater that seeped into the playa sediments from the adjacent alluvial fans.

The Dry Lake surfaces are devoid of vegetation due to the saline conditions and are usually dry. However, runoff from winter storms and late summer thunderstorms can result in occasional standing water.[19, 20, 21, 22, 23] The playas are made up of a variety of surface types, varying from the interior of the playas, where the Dry Lakes are located, towards the outer perimeter, to the edge where vegetation begins.[24] The sediments in the innermost area are generally composed of clay and silt with smaller amounts of sand. Because the playas have been closed drainages for thousands of years, these playas have acquired economically valuable deposits of evaporite salt minerals that are currently being produced (see Section 4.11, Mineral Resources). The salts bind the sediments of the playa surface in the innermost areas into a relatively hard, porous crust that is devoid of vegetation.[25] Czarnecki [26] proposed that the puffy surfaces are formed from surficial capillary water movement causing salts to precipitate and clays to swell on the surface, resulting in a network of polygons and hummocky relief. With the accumulation of salts in the central playa area over the past several thousand years, the annual rainfall and associated surface water runon from the surrounding areas appears to be sufficient to maintain the salt crust surface, as discussed in Section 4.9, Hydrology and Water Quality.

Cadiz Dry Lake is locally bordered by active dunes formed by fine to medium-grained windblown sand.[27] These Holocene[28] deposits overlie older playa deposits of differentiated Quaternary age.[29] In addition, Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lava field that is believed to be as young as 6,000 years.[30, 31]

18 Gale, H.S., *Geology of the Saline Deposits, Bristol Dry Lake, San Bernardino County, California,* California Division of Mines and Geology Special Report 13, pages 4-5, 1951.
19 Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California,* U.S. Geological Survey Bulletin, 1045-D, 1959, pages 97-138.
20 Koehler, J.H, *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California: USGS Water Resources Investigations Report 83-4053,* 1983, page 2.
21 County of San Bernardino, *Draft Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development,* 1993, page 4-5.
22 Cadiz Inc., *Communication with ESA,* December 9, 2010.
23 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 2, Report No. 1163,* November 1999, page 29.
24 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, page 2-2.
25 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* January 2011, page 9.
26 Czarnecki, J.B., *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California*: USGS Water Supply Paper 2377, 1997, page 5.
27 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* January 2011, page 13.
28 Within the last 11,000 years.
29 Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): Model for Playa Development and Implications for Paleoclimate,* 1989, page 10.
30 Parker, R.B., *Recent Volcanism at Amboy Crater San Bernardino County,* California Division of Mines and Geology Special Report 76, *1963,* page 22.
31 Hazlett, R.W., "Some Thoughts on the Development of Amboy Crater" In *Old Routes to the Colorado, San Bernardino County Museum Association Special Publication 92-2,* page 71.

Alluvium

Sediments eroding from the bedrock are deposited as alluvium on the flanks of the hills and mountains, and over time, have largely filled the valleys (basins) between the mountain ranges.[32] Geophysical evidence indicates that the depth of alluvium locally exceeds 3,500 feet bgs in the area between Bristol Dry Lake and the Fenner Gap in the vicinity of the irrigation wellfield.[33] Based on recent drilling, the depth of alluvial sediments in the Fenner Gap is known to reach 1,500 feet.[34] Groundwater in the Bristol, Cadiz, and Fenner Watershed area is stored within these alluvial sediments. In addition, Geoscience reports that drilling conducted by CH2M Hill has revealed that permeable bedrock lying beneath the alluvium also contains an appreciable amount of groundwater within fractures and secondary porosity features.[35]

The alluvial sediments are primarily composed of layers of gravel, sand, silt, and clay in varying proportions.[36] The grain size of the alluvium is generally coarse on the upper parts of the alluvial slopes with more fine-grained deposits down slope. However, significant layers of coarse-grained material (including cobbles and boulders) have been noted in the Fenner Gap and as far down slope as Bristol Dry Lake. Most of the exposed alluvial sediments were deposited from 11,000 years ago to the present. However, deposits older than 11,000 years have been noted in some areas.

Volcanics and Fanglomerates

Tertiary volcanic rocks are found primarily on the northeast side of the Marble Mountains, the north side of the Ship Mountains, and in the Clipper Mountains. The volcanic rocks consist of tuffs, ashes, basalt, and pyroclastic deposits deposited about 14 to 19 million years ago.[37]

Tertiary fanglomerates[38] are exposed in the northeastern Ship Mountains.[39] The fanglomerate unit may be at least 1,000 feet thick and consists of sediments deposited into the basins prior to and during local Miocene extension. The basal members of the fanglomerate contain exotic and well-rounded clasts (conglomerates), very well sorted sedimentary members, and few volcanic deposits or clasts. The Fanglomerate unit was penetrated by a number of the borings within

---

32 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, pages 21-22.

33 Maas, J., *Depth to Basement Calculated from Gravity Data,* Proprietary report to Cadiz Land Company, Inc., In CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 19.

34 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 19.

35 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 25-26.

36 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, pages 21-22.

37 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, page 20.

38 Fanglomerates are a series of conglomerates accumulated into an alluvial fan, in rapidly eroding (e.g. desert) environments. A conglomerate is a rock consisting of individual clasts within a finer-grained matrix that have become cemented together.

39 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, page 19.

Fenner Valley during the Geoscience and CH2M Hill investigations and was found to consist of consolidated sediments of sand, gravel, and cobbles.[40]

Igneous, Metamorphic and Consolidated Sedimentary Bedrock

The bedrock exposed in the mountain ranges surrounding these regional watersheds consists of Archaen (up to 1.4 billion years old), and in some areas, Mesozoic (167 to 151 million years old) granitic and metamorphic rocks.[41] Paleozoic (570 to 240 million years old) meta-sedimentary rocks consisting of quartzite, shale, and the carbonates limestone and dolomite are present in the Marble Mountains and on the northwestern and northern flanks of the Ship Mountains, located on either side of the Fenner Gap. This bedrock also contains an appreciable amount of groundwater within fractures and secondary porosity features.

Geologic Structure

The following section provides a brief overview of the structure of the overall area and the Project area. For a complete description of the geologic history and structure in the study area, please refer to the Kenney GeoScience study.

Overview of Geologic History and Structure

The geologic structure in the Project area, as well as the Mojave Desert and Basin and Range Geomorphic Provinces in general, is the result of two main geologic events. Initially, Paleozoic sediments were deposited on Archaen cratonal crust during a relatively quiet geologic time period. During the Jurrassic, intrusive rocks were emplaced at depth resulting in folding and metamorphism of some of the older rocks into which they intruded. As an example within the Project area, Paleozoic Rocks in the Marble Mountains are unmetamorphosed but are moderately folded and faulted. Recent geologic mapping indicates that only a few granitic sills are present in the southern Marble Mountains area. In this area, the Paleozoic rocks are uplifted, metamorphosed, eroded away, and folded by the Jurassic igneous intrusions.

The second and most dominating event is the Miocene crustal extension (5 to 23 million years ago). The Miocene crustal extension occurred when detachment faults developed as a basal slip surface to accommodate the movement of the upper portions of the crust with respect to the lower portions.[42] An imbricated series of listric faults[43] developed above the detachment faults as the area was pulled apart. Highland and adjacent lowland areas (i.e., horsts and grabens[44]) formed from the movement of the listric faults.

---

40 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 20-21.

41 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, pages 16-19.

42 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011, pages 24-25.

43 Listric faults are curved fault planes with the dip of the fault plane becoming shallower with increased depth.

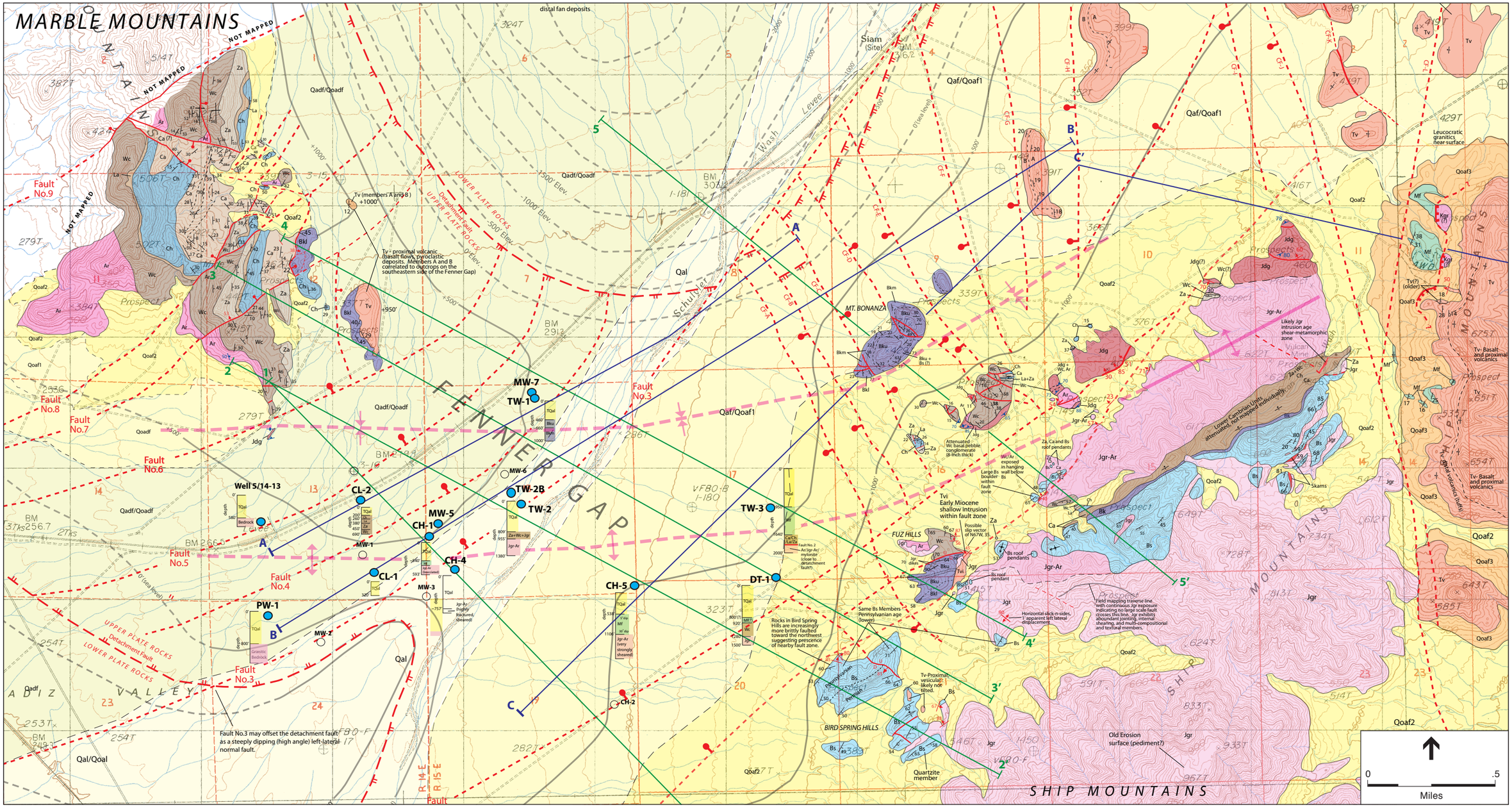
44 Horsts and grabens are raised or lowered fault blocks, respectively, bounded by normal faults, typically caused by crustal extension.

The development of high-angle normal faults[45] occurred subsequent to the extension, and in places extends through and offsets the detachment faulting. The results of these processes, are highly faulted, tilted, and rotated blocks of Paleozoic sediments and Mesozoic granitic rocks. Movement along faults created highland areas (mountains) from which sediments were eroded, and basins (valleys) into which sediments were deposited, forming the fanglomerate and alluvium units described previously. Volcanic rocks, which are typically associated with the Miocene extensional period, were deposited following the deposition of the fanglomerate units. From the Miocene period of extension and continuing to the present, the basin areas were filled with sediments which continued to erode from the adjacent highland areas creating thick sequences of basin fill.

Geologic Structure in the Fenner Gap

In general, the geologic structure in the Fenner Gap is characterized by highly faulted and folded bedrock overlain by Tertiary fanglomerates and Pleistocene to Holocene alluvial units. **Figures 4.6-3a** and **4.6-3b** present a portion of the Kenney GeoScience geologic map[46] that focuses on the Fenner Gap. The geologic map shows numerous faults, identified by the dashed red lines; the down-dropped sides of the faults are indicated with the attached red ball. The geologic cross sections show even more detail about the development of the geologic structure in the Fenner Gap area by identifying the dominance of normal faults as well as the Jurassic intrusives.[47] In general, the southern portion of the Fenner Gap is underlain primarily by faulted Archaen and Jurassic intrusive rock on the western side of the Gap and by faulted Paleozoic limestones on the eastern side of the Gap. Due to faulting, an increase in Paleozoic limestone units are interpreted to occur beneath the Fenner Gap further up the valley. Paleozoic units (i.e., limestones and quartzites) are faulted, tilted, and folded. An antiform and synform is shown to be present near the center of the Fenner Gap as a means of explaining the distribution and bedding dip angles of the Paleozoic units. Both the normal faults and the detachment fault are shown to have a zone of fractures on the hanging wall of the faults (above the fault planes) which are approximately 150 to 400 feet thick. In the study area, the existence and zone of faulting is based on the geologic exposures of some of these faults. With respect to the movement of groundwater through the Fenner Gap, the existence of extensive faulting, tilting, and folding of both Paleozoic and Jurassic bedrock units, along with accompanying joint and fracture systems, provide extensive secondary groundwater flow paths within the bedrock.

45 Normal faults occur with extension; reverse faults occur with crustal shortening.
46 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, Plate 2.
47 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, Plates 3, 4.

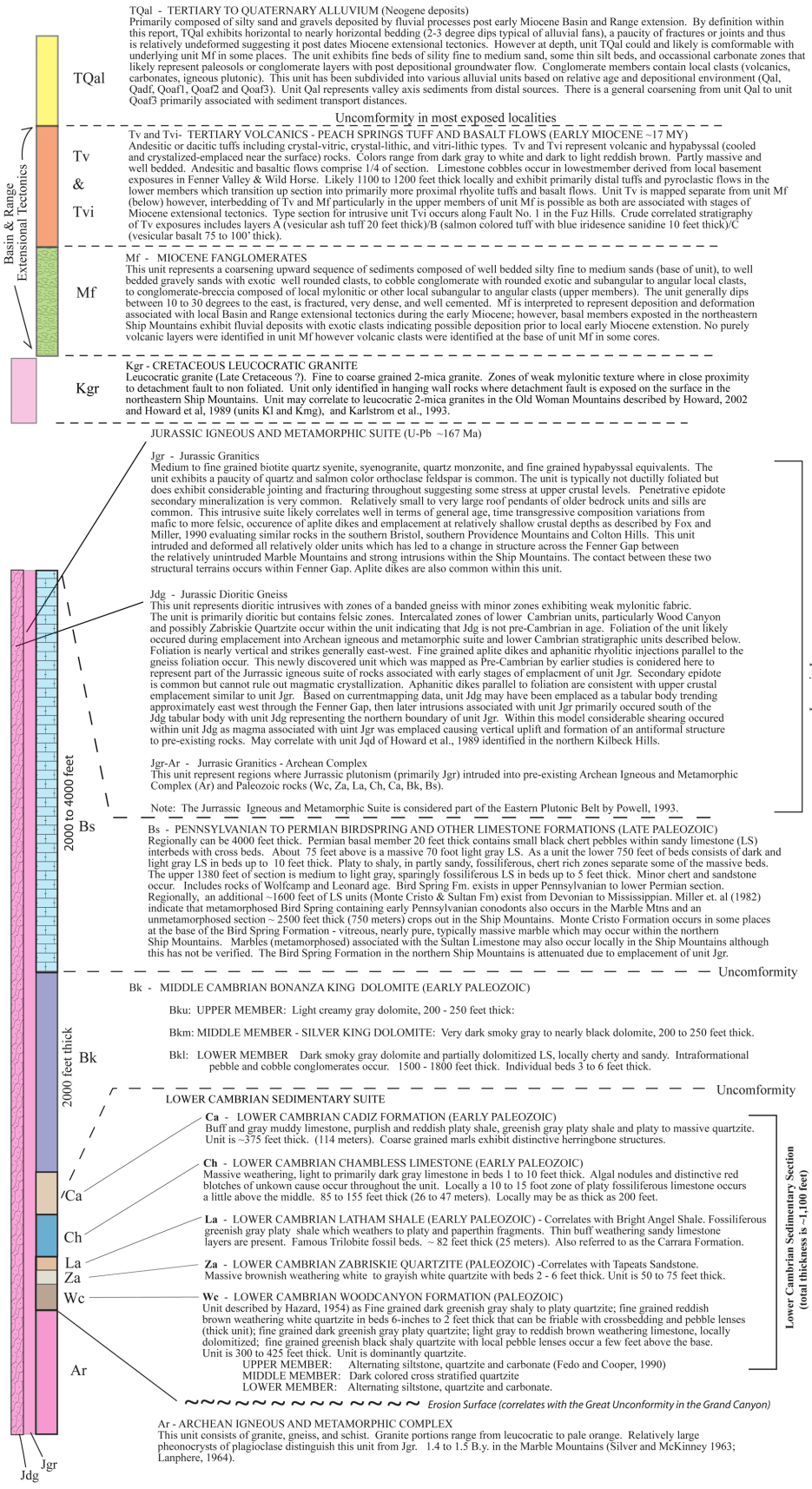


SOURCE: Kenney GeoScience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-3a

Geology of Fenner Gap Area



SOURCE: Kenney GeoScience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-3b

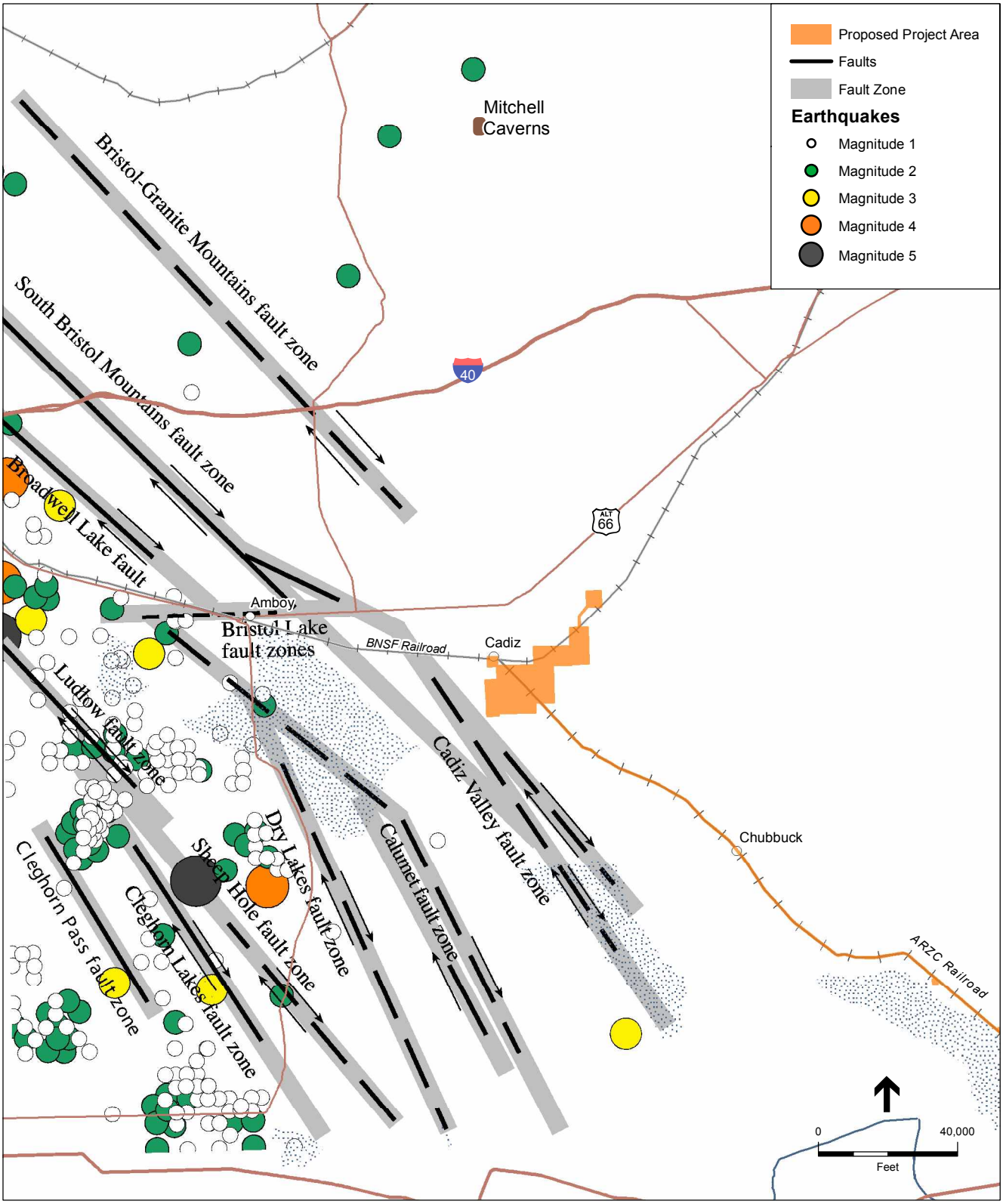
Map Key - Geology of Fenner Gap Area

Regional Faults and Seismicity

The Project area is located at the eastern margin of the Eastern California Shear Zone, a broad seismically-active region dominated by northwest trending right-lateral strike-slip faulting.[48] Eleven named fault zones showing evidence of Quaternary movement[49] have been identified in and adjacent to Bristol, Cadiz, and Fenner Valleys and are illustrated on the generalized fault map on **Figure 4.6-4.**[50] Superposed on this map are recorded earthquake epicenters recorded by the USGS between 1900 and March 12, 1997.[51]

Cadiz Valley is underlain by two major northwest trending inactive faults, inferred on the basis of gravity and magnetic data.[52] These fault zones have strike lengths of at least 25 miles and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones.[53,54] Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated on the basis of the correlation of a distinctive Precambrian gneiss unit across the zone.[55] Slickenside surfaces, produced by fault movement, and steeply dipping sediments recovered from cored drill holes beneath Cadiz Dry Lake, suggest that the fault zone displaces sediments of Pleistocene but not Holocene age.[56,57]

48 Dokka, R.K, and C.J. Travis, *Late Cenozoic Strike Slip Faulting in the Mojave Desert, California*, Tectonics, Vol. 9, 1990, page 336.
49 Potentially active faults are defined as having activity during Quaternary time or within the last 1.6 million years.
50 Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992, page 39.
51 Advanced Geologic Exploration, *Map of Recorded Earthquake Epicenters in Proximity to Bristol Dry Lake, San Bernardino County, CA*, Report to Cadiz, 1997, page 2.
52 Simpson, R.W., R.C. Bracken and D.J. Stierman, *Aeromagnetic, Bouguer Gravity, and Interpretation Maps, Sheep Hole-Cadiz Wildness Study Area, California*: USGS MF 1615-B, 4 sheets, scale 1:62,500 (ID163), 1984.
53 Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992, page 42.
54 Lease, Richard Oliver, Nadine McQuarrie, Michael Oskin, and Andrew Leier, *Quantifying Dextral Shear on the Bristol-Granite Mountains Fault Zone: Successful Geologic Prediction from Kinematic Compatibility of the Eastern California Shear Zone*, Journal of Geology, Vol. 117, 2009, Figure 10.
55 Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992, page 42.
56 Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*, U.S. Geological Survey Bulletin, 1045-D, 1959, page 106.
57 Active faults are those defined as having activity during Holocene time or within the last 11,000 years.



SOURCE: Metropolitan, 2001; AGE,1997; ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-4

Quaternary Fault Zones and Earthquake Epicenters

Bristol Dry Lake is bordered by possible extensions of the Cadiz Valley and South Bristol Mountains fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west.[58] Geophysical data indicate this structural depression may exceed 6,000 feet in depth.[59,60] Drill cores recovered from depths of over 1,000 feet beneath Bristol Dry Lake suggest that subsidence of this basin began by Pliocene time and continues to the present,[61] and therefore it may be tectonically active.

Figures 4.6-3a and 4.6-3b present the Kenney GeoScience geologic map of the Fenner Gap area showing the system of northeast-trending, northwest-dipping normal faults, some of which are exposed in outcrops of the bedrock that flank the Fenner Gap. The presence of these northeast-trending faults beneath the alluvial deposits that underlay the Fenner Gap were mapped using the gravity and magnetic surveys as well as a seismic reflection survey that was conducted across the Fenner Gap by NORCAL Geophysical Consultants.[62]

Very few earthquake epicenters have been recorded in the immediate region within and surrounding the Project area. One relatively minor earthquake of magnitude 3.0 was recorded approximately 20 miles west of the water conveyance system.[63] Although a relatively large amount of seismic events have been recorded in the western portion of the area shown in Figure 4.6-4, none of the faults in this area are presently classified as active or Holocene. The Kenney GeoScience study concluded that since the end of the Miocene extension 10 million years ago, the area has been relatively tectonically stable allowing for the deposition of the subsequent Tertiary and Holocene deposits.[64] The Kenney GeoScience study furthered noted that the alluvial fans in the Fenner Gap area do not show any fault scarps or lineaments, suggesting that faulting has not occurred since their deposition.[65]

The principal seismic hazard in the Project area is the potential for ground shaking associated with large earthquakes on distant faults. Of these, the most important is the San Andreas Fault Zone, an active fault of regional significance located 65 miles southwest of the Project area. The

58 Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992, pages 39, 42.

59 Advanced Geologic Exploration, 1997. *Map of Recorded Earthquake Epicenters in Proximity to Bristol Dry Lake, San Bernardino County, CA.* Report to Cadiz, page 2.

60 Maas, J., *Depth to Basement Calculated from Gravity Data,* Proprietary Report Prepared for Cadiz Land Company, Inc, 1994, In CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010.

61 Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental,Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, Ph.D. Dissertation: Austin, University of Texas, 1989, pages 145-149.

62 NORCAL Geophysical Consultants, Inc., *Seismic Reflection Survey Cadiz Valley, Cadiz, California,* Proprietary Report to Cadiz, 1997, page 16.

63 Advanced Geologic Exploration, *Map of Recorded Earthquake Epicenters in Proximity to Bristol Dry Lake, San Bernardino County, CA.* Report to Cadiz, 1997, page 2.

64 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 15.

65 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 2.

Ludlow fault zone is located approximately 25 miles west of the Project area.[66] The Ludlow fault zone has displaced alluvium as young as late Pleistocene but not Holocene. As shown in Figure 4.6-4, the Ludlow, Sheephole and Cleghorn Lakes and Cleghorn Pass fault zones appear to be associated with a relatively high amount of micro-seismic activity, however, none of these fault zones are classified as active, and none trend toward the Project area.

In addition to the San Andreas Fault Zone, other regional fault zones that have been active in Holocene time include the Bullion and Mesquite Lake fault zones. These faults are located 35 and 40 miles west of the Project area, respectively. The maximum probable earthquake magnitudes on these faults are estimated to be similar to those on the San Andreas Fault Zone (Magnitude 7.1).[67] However, the recurrence interval of large earthquakes in the Eastern California Shear Zone is considered to be in the order of thousands of years.[68, 69] Therefore, the potential for a seismic event along these faults during the design life of the Project is considered to be very low.

The Hector Mine Earthquake

The magnitude 7.1 Hector Mine earthquake of October 16, 1999 occurred on the Lavic Lake fault, a northwest-southeast trending zone located approximately 13 miles west of the Ludlow fault zone.[70] The epicenter of the Hector Mine earthquake was located approximately 45 miles west of the Project area, and the closest surface rupture was located approximately 35 miles southwest of the Project area. Although the Project area is preliminarily estimated by the USGS to have been within the zone of 10 percent g (gravity) peak acceleration, no damage of any kind was observed to any existing facilities in the Project area. These facilities include at least seven irrigation wells (several of which were operating at the time of the earthquake), production well PW-1, and the pilot spreading basin (one cell of which was in operation). This earthquake is considered one of the four largest to have occurred in Southern California this century.

66 Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992, pages 37-47.

67 Petersen, Mark D., William A. Bryant, Chris H. Cramer, Tianqing Cao, and Michael Reichle, *Probabilistic Seismic Hazard Assessment for the State of California,* California Department of Conservation, Division of Mines and Geology, Open-File Report 96-08, and U.S. U.S. Geological Survey Open-File Report 96-706, 1996.

68 Robert J. Mellors, Lydie Sichoix, and David T. Sandwell, *Lack of Precursory Slip to the Hector Mine Earthquake as Constrained by INSAR*, Bulletin Seismological Society of America, Vol.92(4), 2002, page 1443.

69 Price, Evelyn J. and Roland Bürgmann, *Interactions between the Landers and Hector Mine, California, Earthquakes from Space Geodesy, Boundary Element Modeling, and Time-Dependent Friction*, Bulletin of the Seismological Society of America, V. 92, No. 4, May 2002, page 1450-1451.

70 U.S. Geological Survey, *Special Report: The Hector Mine Earthquake, 10/16/1999*, http://pasadena.wr.usgs.gov/hector/report.html, accessed April 2010.

Soil Resources

Areas of low topographic relief consist of the Carrizo-Rositas-Gunsight soil series and are typically described as light colored, red, desert alluvial, sandy soils.[71] The majority of the Project footprint, including the proposed pipeline to the CRA, consists of the Carrizo-Rositas-Gunsight soil units. The Carrizo soils include floodplains, alluvial fans, and associated formations formed in mixed alluvium, with slopes ranging from 0 to 15 percent. Typical profiles range from extremely gravelly sand to very gravelly coarse sand, with low shrink-swell capacity, rapid to very rapid drainage, and negligible to low runoff potential. The Rositas soils consist of sand sheets to dunes formed of eolian material, with slopes ranging up to 30 percent in dune areas. Typical profiles include sand depths of about 60 inches, with less than 15 percent coarse to very coarse sand. These soils have rapid permeability, low shrink-swell capacity, and negligible to low runoff potential. Areas along the mountain slopes adjacent to the proposed water conveyance facilities consist of the Gunsight-Rillito-Chuckwalla soil series and are typically described as consisting of alluvium, colluvium, and residuum from granite, gneiss, quartzite, and limestone formations. The Gunsight and Rillito soils consist of mixed alluvium with mostly moderate slopes, though up to 60 percent slope in isolated areas; gravelly sandy loam to extremely gravelly sandy loam; somewhat excessively drained, with low shrink-swell capacity; and runoff potential from very low to high.

Other associations that could be intersected in proportionally small amounts include Tecopa Rock Outcrop-Lithic Torriorthents. The Tecopa formation comprises very shallow soils of recently weathered material on low hills and low mountain slopes with 15 to 75 percent slope, as well as rock outcrops and torriorthents, along the northwestern edge of the proposed wellfield area and the southern tip of the Old Woman Mountains along the proposed pipeline route. The Rillito-Gunsight association (mixed alluvium with mostly moderate slopes but isolated areas up to 60 percent slope, gravelly sandy loam to extremely gravelly sandy loam, somewhat excessively drained, and runoff potential from very low to high) is present along the proposed pipeline route to the southeast of the wellfield area and where the pipeline approaches the Old Woman Mountains.

All of the soils associations identified within the footprint of the Project contain very low to negligible amounts of clay material. Consequently, they all have a low potential for shrink-swell capacity. All of the soil units have moderate to high corrosion potential, meaning they could corrode uncoated steel due to their relatively high salt content. The corrosion potential for concrete is cited as low to moderate.

[71] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume I*, September 2001, pages 5-34, 5-35.

Geologic and Seismic Hazards

Given the characteristics of the Project area as described above and in the Project Description, the Project area is potentially subject to a range of geologic and seismic hazards, such as slope failure, unstable soils, and seismic-related ground shaking and failure. Potential geologic and seismic hazards that could occur in the Project area are described below.

Geologic Hazards

Mass Wasting and Slope Failure

Slope failures (commonly referred to as landslides) include many phenomena that involve the downslope displacement and movement of material either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. Slope failures are categorized as falls, topples, spreads, slides, or flows. Falls are masses of soil or rock that dislodge from steep slopes and free-fall, bounce, or roll downslope. Topples move by the forward pivoting of a mass around an axis below the displaced mass. Lateral spreads, described in more detail below, are commonly induced by liquefaction of material in an earthquake and move by horizontal extension and shear or tensile fractures. Slides displace masses of material along one or more discrete planes. In rotational sliding, the slide plane is curved and the mass rotates backwards around an axis parallel to the slope; in translational sliding, the failure surface is more or less planar and the mass moves parallel to the ground surface. Flows mobilize as a deforming, viscous mass without a discrete failure plane.[72] Slope stability can depend on a number of complex variables, including the geology, structure, and amount of groundwater, as well as external processes such as climate, topography, slope geometry, and human activity. The factors that contribute to slope movements include those that decrease the resistance in the slope materials and those that increase the stresses on the slope. Facility infrastructure located near and at the foot of mountainous or hilly areas could be subject to damage from slope failure.

Unsuitable Soils

The distribution of soil units is highly variable within the Project area. The NRCS has published individual soil surveys for all counties in California. Information contained in these soil surveys is typically used to help evaluate whether a particular soil type is suited for a specific use and what type of soil management might be required. A general discussion of potentially unsuitable soil conditions including corrosive, expansive, and erodible soils is provided below.

Corrosive Soils

Corrosivity of soils is commonly related to several key parameters: soil resistivity, the presence of chlorides and sulfates; oxygen content; and pH. Typically, the most corrosive soils are those with the lowest pH and highest concentration of chlorides and sulfates. Wet/dry conditions can result in a concentration of chlorides and sulfates as well as movement in the soil that tends to break down protective corrosion films and coatings on the surface of building materials. High-sulfate soils are also corrosive to concrete and may prevent complete curing, reducing its strength

[72] California Geological Survey, *Landslides*,http://www.consrv.ca.gov/cgs/geologic_hazards/landslides/Pages/Index.aspx, accessed May 2010.

considerably. Low pH and/or low-resistivity soils can corrode buried or partially buried metal structures.

Subsidence and Expansive Soils

Land subsidence is the loss of surface elevation due to removal of subsurface support. Subsidence has many causes, including seismically-induced stresses and the extraction of mineral, liquid, and/or gas deposits. Although mineral and gas extraction can and do result in subsidence, it is more common for subsidence to occur as a result of groundwater extraction in excess of groundwater recharge. For example, in areas of the San Joaquin Valley of California, the extensive pumping of groundwater for use in crop production has resulted in much of the valley floor subsiding over several generations.

Expansive soils have a significant amount of clay particles that can give up water (shrink) or take on water (swell). The change in volume exerts stress on buildings and other loads placed on these soils. The occurrence of these soils often is associated with geologic units having marginal stability. Expansive soils can be dispersed widely and found in hillside areas as well as low-lying areas in alluvial basins. Although the soils in the Project area are predominantly composed of sand and gravel grain sizes, some clay has been noted in boring logs. As a result, soils testing to identify expansive characteristics and appropriate remediation procedures are routinely required by current grading and building codes.

Erodible Soils

Erosion is the detachment and movement of soil materials through natural processes or human activities. In general, rates of erosion can vary depending on the soil resource's capacity to drain water, slope angle and length, extent of groundcover, and human influence. Areas with increased susceptibility to soil erosion would depend on the sediment or rock type, its porosity and permeability, the slope or grade of the land, the amount of existing ground cover from vegetation, amount of existing soil disturbance, and land use type. Due to the sandy or loamy nature of the soil and the sparse vegetation in most of the Project area, the soil can be susceptible to wind erosion.[73, 74]

Seismic Hazards

Seismic hazards are generally classified in two categories: primary seismic hazards (surface fault rupture and ground shaking) and secondary seismic hazards (liquefaction and other types of seismically induced ground failure, along with seismically induced landslides).

Surface Fault Rupture

Although future earthquakes could occur anywhere along the length of an active fault, only regional strike-slip earthquakes of magnitude 6.0 or greater are likely to be associated with

[73] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume I*, September 2001, page 5-35.

[74] HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, January 2011, page 5.

surface fault rupture and offset.[75] It is also important to note that earthquake activity and fault rupture due to unmapped subsurface fault traces are a possibility that is not predictable.

As discussed above, no known active faults have been identified within the Project area. Consequently, the Project area does not have any active faults that could cause surface fault rupture as classified by the Alquist-Priolo Earthquake Fault Zoning Act.[76] This classification does not mean that the Project area could not be subject to surface fault rupture, only that there are no known active faults that could cause rupture.

Earthquake Ground shaking

An earthquake is classified by the amount of energy released, which traditionally has been quantified using the Richter scale. Seismologists now use a moment magnitude (Mw) scale because it provides a more accurate measurement of the size of major and great earthquakes. For earthquakes of less than 7.0, the moment and Richter magnitude scales are nearly identical. For earthquake magnitudes greater than 7.0, readings on the moment magnitude scale are slightly greater than a corresponding Richter magnitude.[77]

The intensity of earthquake-induced ground motions can be described using peak ground accelerations (PGAs), represented as a fraction of the acceleration of gravity (g).[78] The CGS provides data and maps to estimate PGAs in California. Taking into consideration the uncertainties regarding the size and location of earthquakes and the resulting ground motions that can affect a particular site, the map depicts PGAs with a 10 percent probability of being exceeded in 50 years, which equals an annual probability of 1 in 475 of being exceeded in any given year.[79] Shaking intensity for the proposed Project area is considered low, with estimated PGAs of 0.132g for firm rock, 0.144g for soft rock, and 0.187g for alluvium.[80] It is important to note that these estimates of PGAs are used primarily for formulating building codes and for designing buildings and are not intended for site-specific hazard analysis. It would be necessary to conduct a site-specific evaluation to estimate peak ground accelerations only at a level suitable for Project design; this Project does not propose any occupied structures.

Another commonly used measure of earthquake intensity is the Modified Mercalli Intensity Scale (MMI), which is a subjective measure of the strength of an earthquake at a particular place as determined by its effects on people, structures, and earth materials. **Table 4.6-1** presents the Modified Mercalli Scale for Earthquake Intensity, along with approximate earthquake magnitudes

75 California Geological Survey, *Probabilistic Seismic Hazard Assessment for the State of California,* from CDMG Open File-Report 96-08, http://www.consrv.ca.gov/CGS/rghm/psha/ofr9608/, accessed April 2010.
76 California Geological Survey, *Alquist-Priolo Earthquake Fault Zones,* http://www.consrv.ca.gov/cgs/rghm/ap/Pages/index.aspx., accessed May 2010.
77 Petersen, Mark D., William A. Bryant, Chris H. Cramer, Tianqing Cao, and Michael Reichle, *Probabilistic Seismic Hazard Assessment for the State of California.* California Department of Conservation, Division of Mines and Geology, Open-File Report 96-08, and U.S. U.S. Geological Survey Open-File Report 96-706, 1996.
78 Acceleration of gravity (g) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.
79 California Geological Survey, *Probabilistic Seismic Hazards Mapping Ground Motion,* http://redirect.conservation.ca.gov/cgs/rghm/ pshamap/pshamain.html, accessed April 2010.
80 California Geological Survey, *Probabilistic Seismic Hazards Mapping Ground Motion,* http://redirect.conservation.ca.gov/cgs/rghm/ pshamap/pshamain.html, accessed April 2010.

TABLE 4.6-1
MODIFIED MERCALLI INTENSITY SCALE FOR EARTHQUAKE INTENSITY

Intensity Value	Intensity Description	Approximate Earthquake Magnitude (Richter)	Average Peak Acceleration
I	Not felt except by a very few persons under especially favorable circumstances.	1.0–3.0	<0.015 g
II	Felt only by a few persons at rest, especially on upper floors on buildings. Delicately suspended objects may swing.	3.0–3.9	
III	Felt noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly, vibration similar to a passing truck. Duration estimated.		
IV	During the day felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	4.0–4.9	0.015–0.03 g
V	Felt by nearly everyone, many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles may be noticed. Pendulum clocks may stop.		0.03–0.08 g
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; and fallen plaster or damaged chimneys. Damage slight.	5.0–5.9	0.08–0.15 g
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.		0.15–0.25 g
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.	6.0–6.9	0.25–0.45 g
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.		0.45–0.60 g
X	Some well-built wooden structures destroyed; most masonry and frame structures with foundations destroyed; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	7.0 and higher	0.60–0.80 g
XI	Few, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.		0.80–0.90 g
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.		>0.90 g

SOURCE: California Geological Survey, *Background Information on the Shake Maps*,http://quake.usgs.gov/research/strongmotion/effects/shake/about.html, accessed April 2010.

and average peak accelerations associated with each intensity value.[81] According to Map Sheet 49, published by the CGS, the Project area has not experienced damaging shaking of earthquakes of MMI VII or greater since data has been recorded between 1800 and 1999.[82]

Liquefaction

Liquefaction is a phenomenon in which saturated granular sediments temporarily lose their shear strength during periods of earthquake-induced, strong ground shaking. The susceptibility of soils to liquefaction is a function of the depth, density, and water content of the granular sediments and the magnitude of earthquakes. Saturated, unconsolidated silts, sands, silty sands, and gravels within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction-related phenomena include vertical settlement from densification, lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects.[83] Holocene-age alluvial sediments are especially prone to liquefaction. Older alluvial sediments deposited during the Pleistocene epoch are generally not liquefiable because they are more consolidated. Artificial fills are also highly prone to liquefaction.

Earthquake-Induced Settlement

Settlement of the ground surface can be accelerated and accentuated by earthquakes. During an earthquake, settlement can occur as a result of the relatively rapid rearrangement, compaction, and settling of subsurface materials (particularly loose, non-compacted, and variable sandy sediments). Settlement can occur both uniformly and differentially (i.e., where adjoining areas settle at different rates). Areas are susceptible to differential settlement if underlain by compressible sediments, such as poorly engineered artificial fill.

Seismic Slope Instability/Ground Cracking

Earthquake motions can also induce substantial stresses in slopes, causing earthquake-induced landslides or ground cracking when the slope fails. Earthquake-induced landslides can occur in areas with steep slopes that are susceptible to strong ground motion during an earthquake.

4.6.2 Regulatory Framework

Federal

Earthquake Hazards Reduction Act

The Earthquake Hazards Reduction Act was enacted in 1997 to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program." To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction

81 California Geological Survey, *Background Information on the Shake Maps*, http://quake.usgs.gov/research/strongmotion/effects/shake/about.html, accessed April 2010.
82 California Geological Survey, *Regional Geologic Mapping Program, Epicenters of and Areas Damaged by M>5California Earthquakes, 1800-1999, Map Sheet 49, 2000.*
83 U.S. Geological Survey, *Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region, California: A Digital Database*, USGS Open File Report 00-444, 2000, page 1.

Program Act (NEHRPA), which refined the description of agency responsibilities, program goals, and objectives.

NEHRP's mission includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improvement of building codes and land use practices; risk reduction through post earthquake investigations and education; development and improvement of design and construction techniques; improvement of mitigation capacity; and accelerated application of research results. The NEHRPA designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns it several planning, coordinating, and reporting responsibilities.

Federal Railroad Administration - Track Safety Standards

The Federal Railroad Administration (FRA) provides track safety standards in 49 CFR Chapter 5, Section 213. These standards developed a system of classification for track quality. The class of a section of track determines the maximum possible running speed limits for freight and passenger trains. The BNSF rail line is a Class 5 line. The ARZC rail line is a Class 4 line. **Table 4.6-2** below summarizes the maximum speeds allowed on these rail lines.

TABLE 4.6-2
MAXIMUM RAIL LINE SPEEDS

Track Type	Rail Line	Freight Train	Passenger Train
Class 4	ARZC	60 mph (97 km/h)	80 mph (129 km/h)
Class 5	BNSF	80 mph (129 km/h)	90 mph (145 km/h)

SOURCE: ESA, 2011.

Table 4.6-3 below from 49 CFR 213 summarizes various tolerance limits for changes to the track surface.

Track surface is the evenness or uniformity of track in short distances measured along the tread of the rails. Under load, the track structure gradually deteriorates due to dynamic and mechanical wear effects of passing trains. Improper drainage, unstable roadbed, inadequate tamping, and deferred maintenance can create surface irregularities. Track surface irregularities can lead to serious consequences, if ignored.

Allowable deviations in track surface include runoff at the end of a raise, deviation from uniform profile, deviation from zero cross level at any point on tangent or reverse cross level elevation on curves, and the difference in cross level between any two points less than 62 feet apart, are specified in the track surface table, Table 4.6-3.

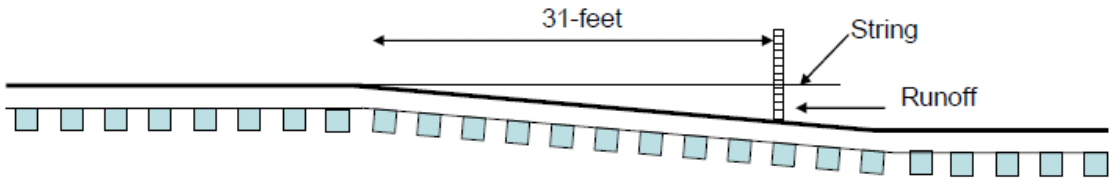
TABLE 4.6-3
TOLERANCE LIMITS

	Class of Track	
Track Surface	**4**	**5**
The runoff in any 31 feet of rail at the end of a raise may not be more than	1½"	1"
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	2"	1¼"
The deviation from zero cross level at any point on tangent or reverse cross level elevation on curves may not be more than	1¼"	1"
The difference in cross level between any two points less than 62 feet apart may not be more than	1¾"	1½"
Where determined by engineering decision prior to the promulgation of this rule, due to physical restrictions on spiral length and operating practices and experience, the variation in cross level on spirals per 31 feet may not be more than	1"	¾"

SOURCE: ESA, 2011.

The Tolerance Limits refer to the runoff (ramp) in any 31 foot segment at the end of a raise where the track is elevated as a result of automatic or manual surfacing or bridge work. Conditions created by track degradation (e.g., settlement or frost heaves) are to be addressed using the uniform profile parameter, under this section. Trains encountering a ramp (up or down) will experience a vertical pitch or bounce if the change in elevation occurs in too short a distance. As in the more general profile parameter, damage to car components, undesirable brake applications or derailments may occur; especially when the vehicle experiences a lateral force such as a buff force.

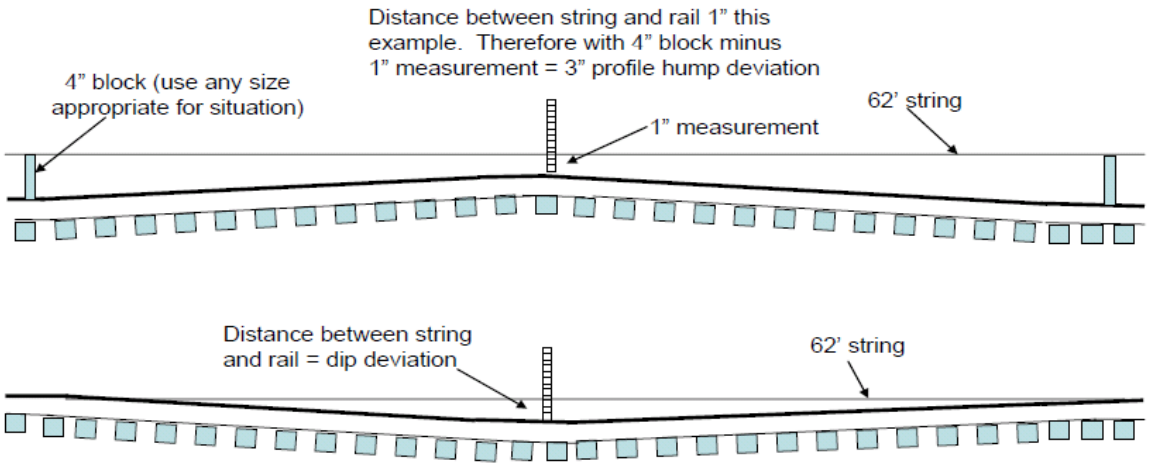
The schematic below illustrates the measurement of the runoff of raised track.



The second parameter (profile), relates to the elevation of either rail along the track. When trains encounter short dips or humps in the track, it can result in vertical separation of couplers and broken springs, bolsters, and truck frames. Dips can result from mud spots or develop at the ends of fixed structures (e.g., bridges, highway rail grade, and track crossings). Profile is determined by placing the mid-point of a 62-foot chord at the point of maximum measurement, irrespective of vertical curves. Profile may also be a track “hump” cause by a frost heave or other occurrence.

The schematic on the following page illustrates the measurement of profile conditions.

As summarized in Table 4.6-3 above, the maximum allowable deviation of the track surface is on the order of 1 to 2 inches over a 62-foot length of track.



State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act[84] was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this Act, the California State Geologist (State Geologist) established regulatory zones, called earthquake fault zones, around the surface traces of active faults and has published maps showing these zones. Within these zones, buildings for human occupancy cannot be constructed across the surface trace of active faults. Each earthquake fault zone extends approximately 200 to 500 feet on either side of the mapped fault trace because many active faults are complex and consist of more than one branch that may experience ground surface rupture. This Act does not apply to the proposed Project because no active faults cross the Project area.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the Project design. To date, the State Geologist has not prepared a map for the area in which the Project is located.

84 California Geological Survey, *Alquist-Priolo Earthquake Fault Zones*,http://www.consrv.ca.gov/cgs/rghm/ap/Pages/index.aspx, accessed May 2010.

California Building Code

The California Building Code (CBC) has been codified in the California Code of Regulations (CCR) as Title 24, Part 2. Title 24 is administered by the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable. The purpose of the CBC is to establish minimum standards to safeguard the public health, safety and general welfare through structural strength, means of egress, and general stability by regulating and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all building and structures within its jurisdiction. The CBC is based on the International Building Code (IBC; previously known as the Uniform Building Code) published by the International Code Conference. In addition, the CBC contains necessary California amendments, which are based on the American Society of Civil Engineers (ASCE) Minimum Design Standards 7-05. ASCE 7-05 provides requirements for general structural design and includes means for determining earthquake loads as well as other loads (flood, snow, wind, etc.) for inclusion into building codes. The provisions of the CBC apply to the construction, alteration, movement, replacement, and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures throughout California.

The earthquake design requirements take into account the occupancy category of the structure, site class, soil classifications, and various seismic coefficients, which are used to determine a Seismic Design Category (SDC) for a project. The SDC is a classification system that combines the occupancy categories with the level of expected ground motions at the site and ranges from SDC A (very small seismic vulnerability) to SDC E/F (very high seismic vulnerability and near a major fault). Design specifications are then determined according to the SDC. All constructed elements of the Project are subject to the CBC.

Local

San Bernardino County Land Use Regulations and Ordinances

The San Bernardino County General Plan Safety Element and building, grading, and erosion control ordinances are intended to ensure safe building construction and control erosion and sedimentation caused by construction activities. Specifically, Public Resources Code Section 2699 directs cities and counties to "take into account the information provided in available seismic hazard maps" when it adopts or revises the safety element of the general plan and any land-use planning or permitting ordinances.[85] A building permit typically requires that new construction be inspected during and after completion to ensure compliance with national, regional, and local building codes. A grading permit is typically required prior to initiating the construction phase of a project. As part of the permit, applicants usually must submit a grading and erosion control plan, vicinity and site maps, and other supplemental information. Standard conditions in the grading permit include a description of Best Management Practices (BMP) similar to those contained in a Stormwater Pollution Prevention Program (SWPPP). The BMPs typically included in a SWPPP are discussed in further detail in Section 4.9, Hydrology and Water Quality. The constructed

[85] California Geographical Survey, *Guidelines for Evaluating and Mitigating Seismic Hazards in Californi*a, Special Publication 117A, 2008.

elements of the Project are subject to the County regulations and ordinances described in this section.

4.6.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to geology and soils if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42):
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides;
- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; or
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Methodology

Site-specific and regional reports and maps were reviewed to evaluate the potential impacts of the Project relative to Geology and Soils. Geologic data from regional and local investigations were evaluated, including site-specific hydrogeologic data collected from 12 wells drilled in the Fenner Gap area. The Conservation and Recovery and Imported Water Storage Components are evaluated separately below.

Recent geologic mapping of the southeastern portion of the Marble Mountains, the Fenner Gap area, and the northwestern portion of the Ship Mountains was conducted for this investigation by Dr. Miles Kenney. The Kenney GeoScience report consolidated numerous previous geologic and geophysical studies and then updated and augmented the consolidated geologic information with a 21-day field investigation of the geology of the Fenner Gap area and discussions with previous

investigators.[86] This detailed mapping was conducted to allow interpretation of the geologic structure in the Fenner Gap in order to determine potential groundwater flow paths and rates. The Kenney GeoScience report formed the basis for construction of the groundwater flow model developed by Geoscience in their report describing the geology and hydrology of the Project area.[87]

Using the available geologic and hydrologic information, including the recent geologic mapping, Geoscience prepared a three-dimensional, density-dependant groundwater flow and transport model to simulate the aquifer system in the Project area, including Fenner Valley, Fenner Gap, and the Cadiz Valley area that includes most of the Bristol Playa and the northern portion of the Cadiz Playa (Appendix H).[88] The groundwater model was used to simulate the potential response of the aquifer system to variations in recharge using two variations of the wellfield configuration and three variations of potential annual recharge volumes over a period of 50 years of groundwater production at 50,000 AFY, followed by 50 years of recovery (no groundwater production). The output of the simulations are the modeled drawdown of groundwater levels, the potential movement of the freshwater-saline water interface, and the amount of potential subsidence (groundwater drawdown and freshwater/saline water interface migration are addressed in Section 4.9, Hydrology).

The modeled scenarios vary by recharge amounts. The Project scenario assumes an annual recharge of approximately 32,000 AFY in the Fenner Watershed and Orange Blossom Wash, based on CH2M Hill's updated evaluation of recharge.[89] This recharge volume estimate is derived from the USGS INFIL3.0 Model, is based on long-term precipitation records, and represents the long-term average recharge within the Fenner Watershed that ultimately migrates to the Bristol and Cadiz Dry Lakes, becomes saline, and evaporates. Because a few earlier evaluations of available recharge predicted a lower potential range for recharge, two sensitivity scenarios also were applied to model conservative, worst-case aquifer responses where the average annual recharge over a 100-year time period is reduced to 16,000 and 5,000 AFY, respectively.[90] As discussed in Section 4.9, Hydrology, the modeling did not include recharge that occurs west, south, and east of the Bristol and Cadiz Dry Lakes. Consequently, the groundwater model provides the most conservative aquifer responses because the inclusion of recharge from other watersheds would reduce the predicted groundwater level drawdown and thus the potential for subsidence. The modeling also considered two different production well configurations: Well Configuration A would use 5 existing Cadiz agricultural wells, 2 new high

86 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California,* August 2011.
87 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011.
88 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 27-48.
89 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, page 4-8.
90 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 35.

capacity wells, and 15 new lower-capacity wells; Configuration B would use 5 existing Cadiz agricultural wells and 29 new lower-capacity wells.[91]

Using the results from the predictive aquifer model discussed above, Geoscience evaluated the model-predicted subsidence results for the three scenarios. The potential land subsidence results for the three scenarios are illustrated on **Figures 4.6-5, 4.6-6,** and **4.6-7.**[92]

The groundwater model simulated the elastic (recoverable) compaction and expansion and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The deformation of interbeds is caused by changes in effective stress as a result of groundwater level changes. If the stress is less than the preconsolidation stress of the sediments, the deformation is elastic (i.e., recoverable). If the stress is greater than the preconsolidation stress, the deformation is inelastic (i.e., permanent). If necessary, this model will be updated and refined during Project operations through active management of groundwater extraction based on data obtained from the monitoring features.

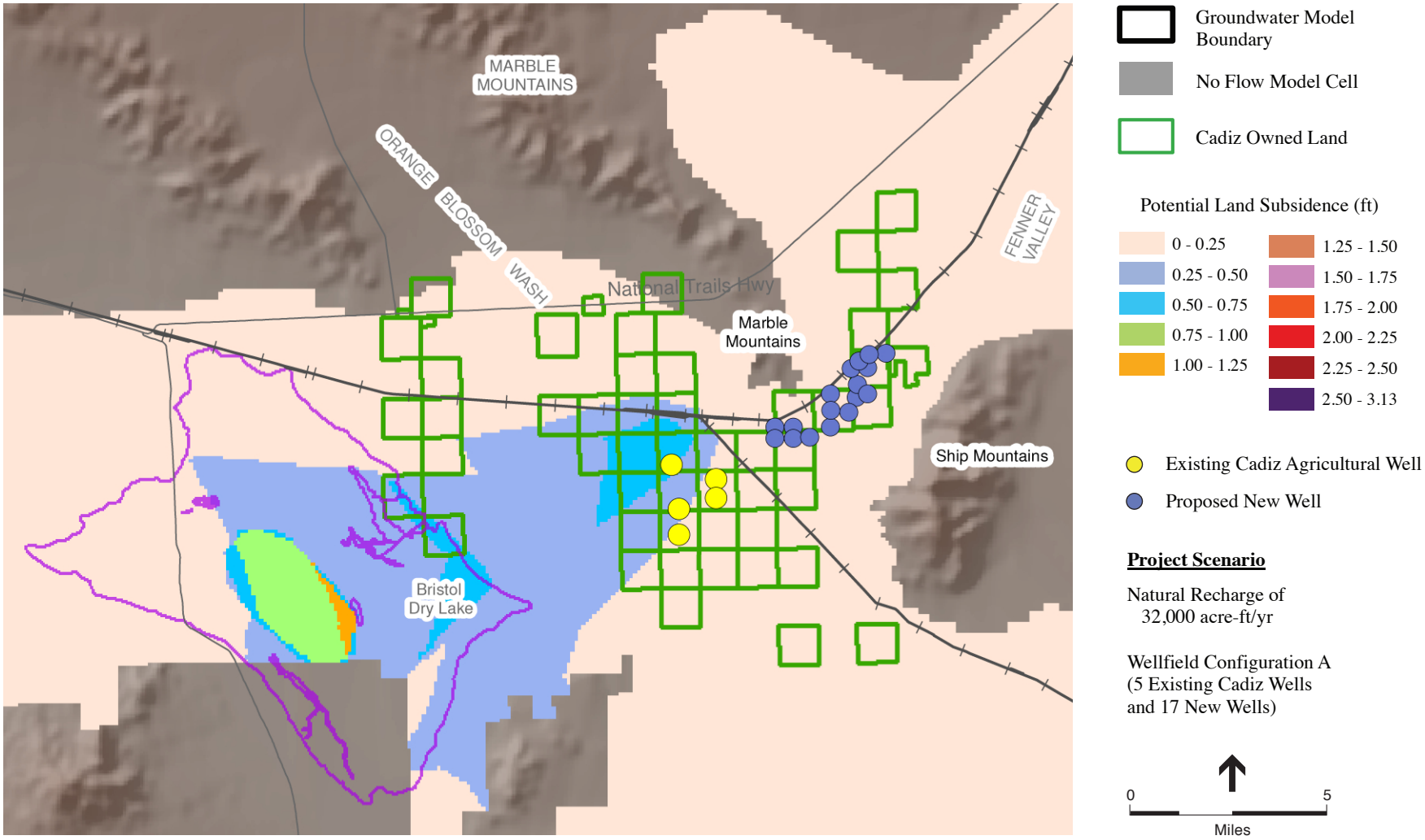
In general, the potential for land subsidence corresponds to the magnitude of groundwater level decline and the thickness of the clay layers in the aquifer. Based on the results of the Geoscience groundwater model, any predicted subsidence would occur gradually and be dispersed laterally over a large area from the Fenner Gap to the Bristol and Cadiz Dry Lakes.

Groundwater Management, Monitoring, and Mitigation Plan

The GMMMP prepared for the Project to provide for the adaptive management of the basin includes measures to monitor Project operations and potential effects on critical resources, and, as necessary, to implement corrective actions to insure protection of such resources (Appendix H).[93] These measures are referred to as Project Design Features (PDF) in this EIR and they are numbered according to the GMMMP Section in which they are described (i.e., Project Design Feature 6.3 – Land Subsidence is Section 6.3 of the GMMMP). These Project Design Features from the GMMMP include a monitoring element, action criteria, and corrective measures to address a potential issue if the action criteria are triggered. The action criteria are set below the trigger or threshold for impact significance as established in accordance with CEQA for each impact area, thus insuring adequate time to implement the corrective actions and avoid significant impact. The monitoring and response measure from the GMMMP for subsidence is listed below.

- GMMMP Project Design Feature 6.3 – Land Subsidence

91 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 47.
92 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 54-55, Figures 77-79.
93 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011.

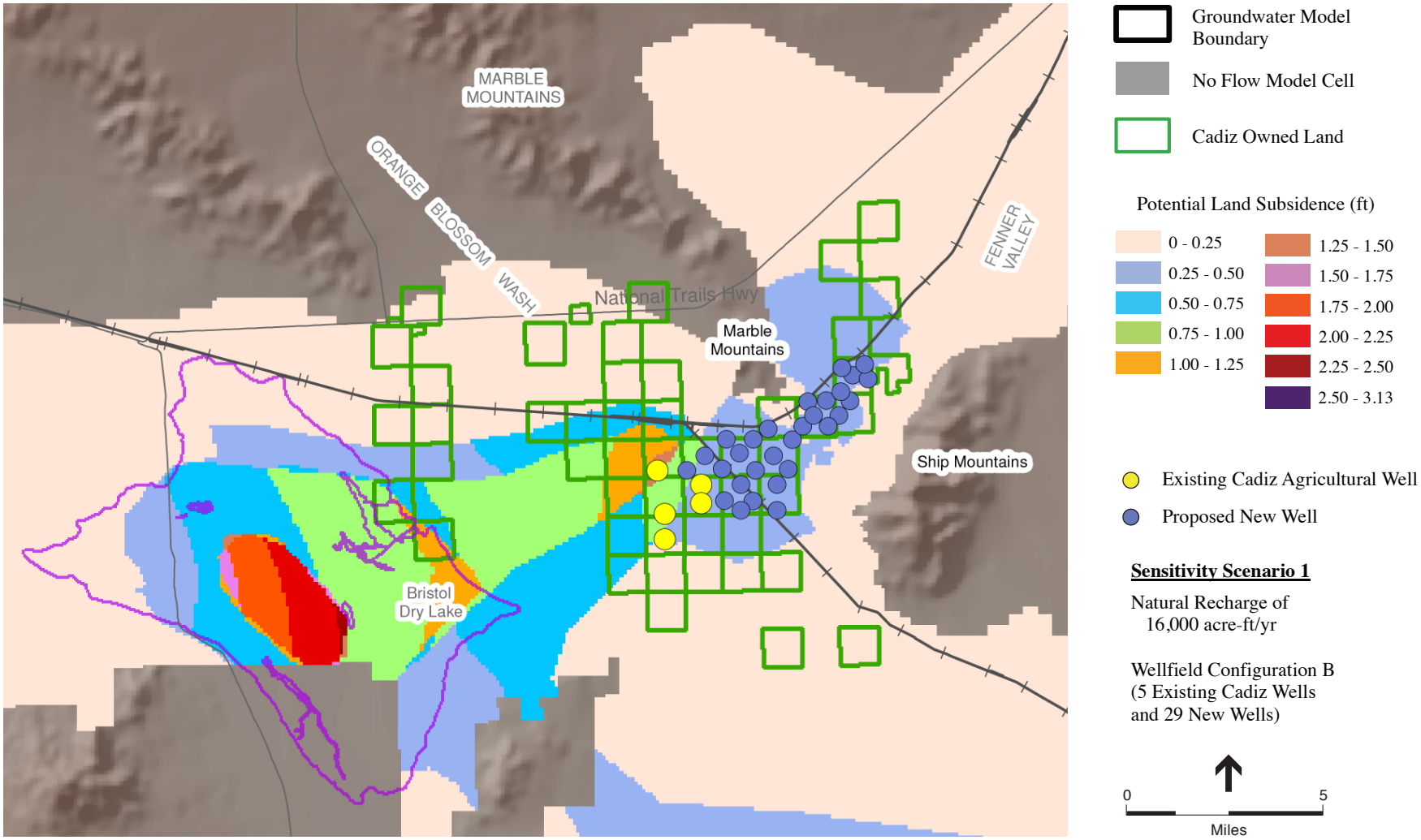


SOURCE: GeoScience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-5

Model-Predicted Land Subsidence - Project Scenario
(Assumes 32,000 AFY Recharge)

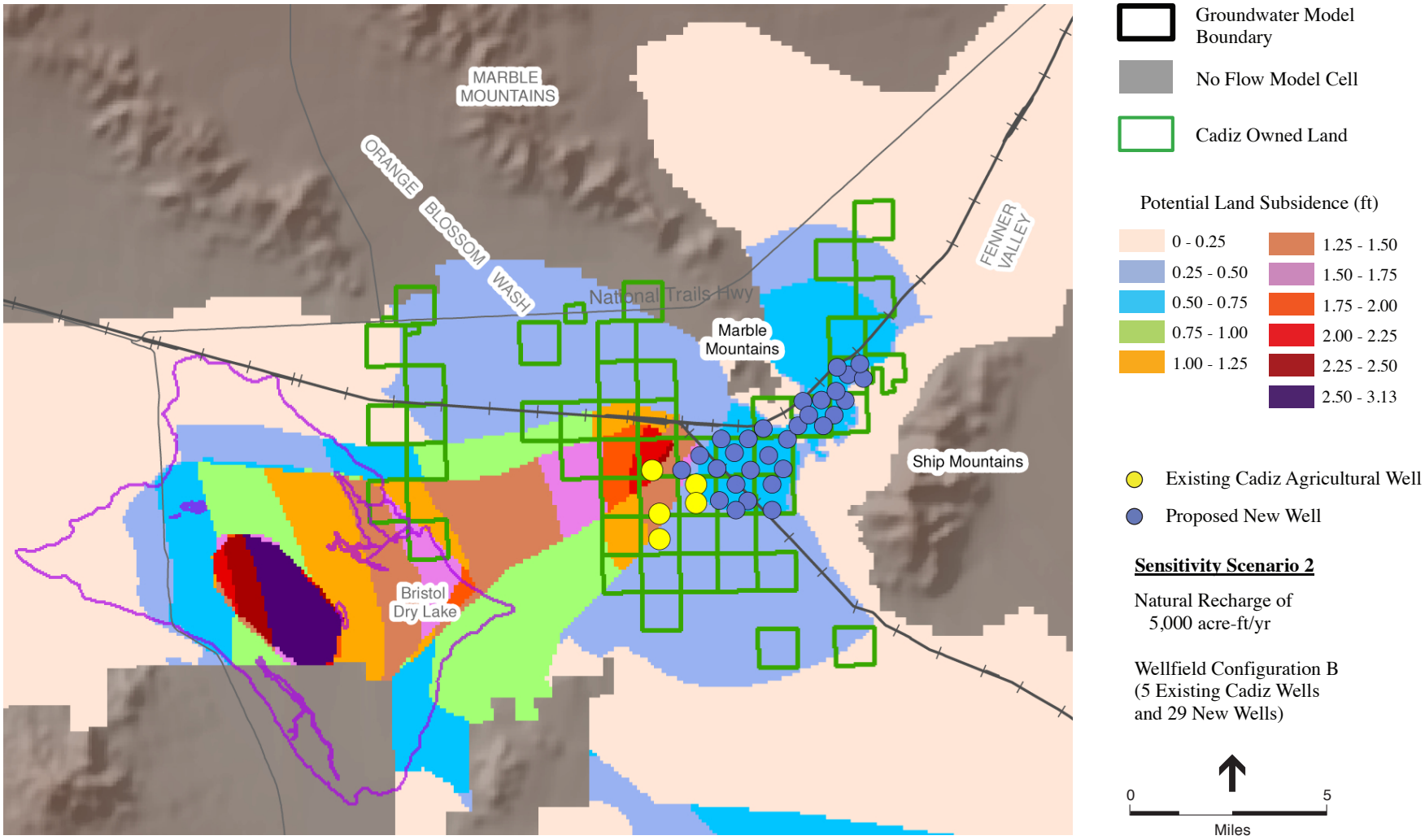


SOURCE: GeoScience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-6

Model-Predicted Land Subsidence - Sensitivity Scenario 1
(Assumes 16,000 AFY Recharge)



SOURCE: GeoScience, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.6-7

Model-Predicted Land Subsidence - Sensitivity Scenario 2
(Assumes 5,000 AFY Recharge)

Groundwater Conservation and Recovery Component

Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction

Significance Threshold

Would the proposed Project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);
- Strong seismic ground shaking;
- Seismic-related ground failure, including liquefaction; or
- Landslides.

Impact Analysis

The Project site is not located along the trace of an active or potentially active fault or fault system. A review of Alquist-Priolo maps provided by the CGS indicates no faulting zones in or adjacent to the Project area, with the nearest mapped active faults being located approximately 45 miles west of the Project site. Additionally, the Kenney GeoScience study, which included both the review of previous studies and a detailed on-site field investigation, indicated that no recent fault movement has been documented in the footprint of any of the Project facilities because the area has been relatively tectonically stable since Miocene time and no deformation or displacement of recent sediments are known within the Project area.[94]

Major seismic activity along the nearby and active San Andreas or Garlock fault systems, or other associated faults, could affect the Project site through strong seismic ground shaking. Strong seismic ground shaking could potentially cause structural damage to the proposed wellfield, water conveyance facilities, or associated infrastructure, possibly resulting in damage to facilities and interruption of service.

In the event that shallow groundwater is present, strong ground shaking could enable liquefaction of sediments. Liquefaction in such areas could cause differential settlement or other damage to pipelines, wells, and other proposed facilities. However, as discussed in Section 4.9, Hydrology and Water Quality, the depth to water along the water conveyance pipeline is generally over 100 feet below ground surface. Therefore, water-saturated soils are not anticipated along the pipeline alignment and liquefaction-prone conditions are not present.

Most of the Project facilities would be located upon relatively flat topography. As shown in Figure 4.6-1, portions of the water pipeline alignment are located along areas adjacent to

94 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, pages 2, 15, and 26.

mountains and hills with higher topographic relief. A review of geologic maps of the area did not reveal any existing landslides within or adjacent to the Project site, and the soils associations identified for sloped areas are not anticipated to have a high propensity for landslides. In addition, the water conveyance pipeline and wellfield manifold system piping would be placed below ground, thus protecting these facilities from potential landslides.

The Project facilities would be designed to withstand strong ground shaking, because the facility design would be required to comply with the CBC to minimize the potential effects of liquefaction, ground shaking, landslides, and other seismic activity within the Project area. This would include installing shut-off valves and blow-off valves in the pipeline to minimize water releases in the event of a pipe break. Well pads and interconnections would be installed on flat terrain with no liquefaction hazards. Due to the remote location, no people would be exposed to increased risk from installation of the facilities. Therefore, impacts related to surface rupture, seismic ground shaking, liquefaction, or seismically induced landslides are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Soil Erosion and Loss of Topsoil

Significance Threshold

Would the proposed Project result in substantial soil erosion or the loss of topsoil?

Impact Analysis

During the construction phase of the proposed Project, the use of heavy machinery for grading, trenching, well drilling, facilities installation, and other proposed activities would disturb surface topsoil layers. Existing desert vegetation in those locations would be removed from the facilities' installation sites, which would also disturb surficial sediments. These factors could expose construction areas to erosive forces including wind and storm-water runoff. Increases in erosion could result in changes to nearby topography, drainage patterns, and vegetation patterns in affected areas.

The Project wells and pipeline would not be subject to the NPDES Construction General Permit for Discharges of Stormwater since there are no Waters of the U.S. affected by the wells or pipeline. Nevertheless, the FVMWC would implement Mitigation Measure **HYDRO-1** to ensure that construction-related Best Management Practices (BMPs) are implemented to prevent soil erosion during construction, as well as to control hazardous materials used during construction from adversely affecting the environment.

Upon completion of pipeline construction activities, a surface restoration crew would follow the appurtenance installation crew to perform re-vegetation and erosion control. (See Section 4.4 Biological Resources regarding restoration efforts.) Excavated topsoil would be returned to the trenches and compacted. Washes and training dikes that are impacted by construction would be returned to their pre-construction condition in coordination with ARZC.

With implementation of Mitigation Measures **HYDRO-1** and **BIO-6**, impacts from potential erosion from construction activities would be less than significant.

Mitigation Measures

Implement **HYDRO-1** and **BIO-6**.

Significance Conclusion

Less than significant with mitigation.

Geologically Unstable Area

Significance Threshold

Would the proposed project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?

Impact Analysis

As discussed above, the Project would not be located in areas subject to unstable soils or landslides, including seismically-induced landslides or liquefaction. The proposed Project would involve the installation of a production wellfield, water conveyance pipeline, natural gas supply line, and various appurtenances. These facilities would be installed primarily along areas with low topographic relief having sandy to rocky unconsolidated structure or along areas with exposed or very shallow bedrock. Installation of the proposed facilities would not interfere with the underlying structure of these formations and therefore would not increase formation instability or result in a subsequent increase in landslides, lateral spreading, collapse, or other surficial hazards.

The Project operations would result in the long-term extraction of groundwater, which would lead to a reduction in groundwater levels in the vicinity of the proposed Project. The long-term extraction of groundwater as part of Project operations could result in some land subsidence or settlement. Using the groundwater flow and transport model discussed above, Geoscience modeled the potential subsidence that could occur as the result of groundwater extraction.

Figures 4.6-5, 4.6-6, and 4.6-7 present the model-predicted amount of subsidence based on 50,000 AFY of groundwater extraction for 50 years using three aquifer recharge scenarios. The Project Scenario assumes the recharge to the Fenner and Orange Blossom Wash Watersheds would be 32,000 AFY and is based on CH2M Hill's evaluation of 60 years of precipitation records (see Section 4.9, Hydrology and Water Quality). To assess worst-case climate scenarios,

Geoscience also ran the predictive model using 16,000 AFY and 5,000 AFY referred to as Sensitivity Scenarios 1 and 2, respectively. **Table 4.6-4** on the following page summarizes the potential model-predicted subsidence under the three recharge scenarios at five different locations.[95]

The model-predicted degree of potential land subsidence would not significantly impact the alluvial aquifer's storage capacity because consolidation of the aquifer will occur in clay and silt intervals, which do not contribute to the useable storage capacity. Subsidence at, or below, the range projected in Table 4.6-4 is therefore not considered to be a significant environmental impact to the aquifer.

The BNSF and ARZC rail lines, improved roads, and natural gas and crude oil pipelines cross parts of the Project area and are the only existing linear structures that could be affected by subsidence. The proposed Project infrastructure would also be within the area that could be affected by subsidence.

TABLE 4.6-4
SUMMARY OF MODEL-PREDICTED SUBSIDENCE AMOUNTS

		Maximum Potential Subsidence (feet)		
Location	**Time**	**Project Scenario (32,000 AFY Natural recharge)**	**Sensitivity Scenario 1 (16,000 AFY Natural Recharge)**	**Sensitivity Scenario 2 (5,000 AFY Natural Recharge)**
Center of Wellfield	End of 50 Years	0.2	0.4	0.7
	End of 100 Years	0.2	0.4	0.7
Existing Cadiz Wells	End of 50 Years	0.6	1.0	1.5
	End of 100 Years	0.6	1.0	1.5
Edge of Bristol Dry Lake	End of 50 Years	0.5	1.0	1.4
	End of 100 Years	0.5	1.0	1.7
Center of Bristol Dry Lake	End of 50 Years	0.9	1.7	1.2
	End of 100 Years	0.9	2.1	2.7
Edge of Cadiz Dry Lake	End of 50 Years	0.1	0.4	0.5
	End of 100 Years	0.1	0.4	0.6

SOURCE: GEOSCIENCE Support Services, Inc., Cadiz Groundwater Modeling and Impact Analysis, September 1, 2011, pages 54-55.

The area with the greatest potential for subsidence would be in the western part of the Project wellfield in the vicinity of the Cadiz agricultural operations and under Bristol and Cadiz Dry Lakes. Under the Project Scenario, the maximum potential subsidence ranges from 0.1 foot at the edge of Cadiz Dry Lake to 0.9 feet in the center of Bristol Dry Lake. Under Sensitivity Scenario 1, the maximum potential subsidence ranges from 0.4 foot at the edge of Cadiz Dry Lake to 2.1 feet in the center of Bristol Dry Lake. Under the Sensitivity Scenario 2, the maximum potential

95 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 54-55.

subsidence ranges from 0.6 foot at the edge of Cadiz Dry Lake to 2.7 feet in the center of Bristol Dry Lake.

The maximum railroad subsidence tolerance levels are 2 inches or less over a 62-foot rail chord length, which equates to a ratio of 0.002688 (2 inches divided by 62 feet). The maximum model-predicted subsidence ratio would occur under the worst-case Sensitivity Scenario 2 with subsidence up to 1.7 feet under the center of Bristol Dry Lake. Measured across the entire area of subsidence, this would equate to 1.7 feet of subsidence across the distance of about 12 miles from Bristol Dry Lake to the center of the wellfield which equates to a ratio of 0.00002683, two orders of magnitude below the maximum tolerance level for railroad lines. Furthermore, the rail lines are not located in the center of Bristol Dry Lake, where the maximum potential subsidence would be expected. Therefore, the maximum model-predicted subsidence would not exceed railroad tolerance levels and is considered a less than significant impact.

Although the maximum potential model-predicted subsidence would be considered a less than significant impact, Cadiz monitors subsidence at the Project area as part of its agricultural development monitoring program. The results of its current subsidence monitoring program are described in annual monitoring reports for the agricultural operations, which are submitted to San Bernardino County.[96] No subsidence has been observed in the area as a result of Cadiz' use of groundwater for irrigation since its agricultural operation began in 1993.

Even though the model-predicted subsidence would not exceed railroad tolerance levels and the degree of potential land subsidence would not significantly impact the alluvial aquifer's useable storage capacity, the GMMMP nonetheless includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design feature relative to subsidence is GMMMP Project Design Feature 6.3 – Land Subsidence.[97] The Action Criteria and Corrective measures are summarized in **Table 4.6-5**.

TABLE 4.6-5
GMMMP PROJECT DESIGN FEATURE 6.3 – LAND SUBSIDENCE

Action Criteria	Corrective Measures
For land subsidence effects, the action criteria shall be: 1. Land subsidence and subsidence rate that are greater than projected by the groundwater flow simulation model for an equivalent elapsed time;, 2. A change in the ground surface elevation of more than 0.5 feet within the Project area; or 3. Land subsidence of more than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks.	Corrective measures that would be implemented would be modification of Project operations to arrest subsidence that would include one or more of the following actions: • Reduction in pumping from Project wells; • Revision of pumping locations within the Project wellfield; • Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or • Repair of any structures damaged as a result of subsidence attributable to Project operations.

SOURCE: CH2M Hill, Groundwater Management, Monitoring, and Mitigation Plan, November 2011, pages 83-84.

96 Cadiz Inc., *13th Annual Groundwater Monitoring Report, January – December 2010, Cadiz Valley Agricultural Development*, June 2011.
97 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, pages 83-84.

Chapter 5 of the GMMMP describes Monitoring Features 5 and 6 to be used to monitor for subsidence.[98]A network of approximately 20 land survey benchmarks and three extensometers would be installed in the area of the highest probability of subsidence to monitor changes in land surface elevation should they occur.

Implementation of the project design features in Chapter 6.3 of the GMMMP would reduce the potential impacts to infrastructure to less than significant. Therefore, for purposes of this CEQA analysis of the Project, the project design features in Chapter 6.3 of the GMMMP are incorporated into this EIR as Mitigation Measure **GEO-1**. Implementation of Mitigation Measure **GEO-1** would ensure that the potential impacts from subsidence are mitigated to less than significant.

Mitigation Measures

GEO-1: The project design features in Chapter 6.3 of the GMMMP shall be implemented to address the potential impact for land subsidence. If land subsidence is observed at rates that are greater than projected by the groundwater flow simulation model for an equivalent elapsed time, or if a change in the ground surface elevation of more than 0.5 feet within the Project area occurs, or if subsidence of more than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks occurs, the following shall occur:

- Implement the corrective measures that involve modification of Project operations to actively arrest subsidence through one or more of the following:
  - Reduction in pumping from Project wells;
  - Revision of pumping locations within the Project wellfield;
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or
  - Repair of any structures damaged as a result of subsidence attributable to Project operations.

Significance Conclusion

Less than significant with mitigation

Expansive or Corrosive Soils

Significance Threshold

Would the proposed Project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

98 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, page 73.

Impact Analysis

The geologic and soils maps have not identified expansive soils within the area of the proposed Project. Expansive soils generally occur in regions with moderate to high clay content. Mapped soil associations within the Project area contain very low to negligible amounts of clay material. Therefore, the issue of expansive soils would have no impact and no mitigation is required.

The Project site is located in areas where the soils are known to have lower pH levels and higher salt contents. The corrosive effects of such soil conditions could reduce the integrity of steel or concrete materials. Failure of the water pipeline would result in damage to the conveyance facilities and the erosion of soil at the break location. A sudden failure of the water or natural gas pipe integrity could cause the release of water or natural gas at pressures that could cause injury to nearby workers.

This impact is considered less than significant because, in compliance with relevant state and local requirements, the facility design of the water pipelines, natural gas supply lines, and associated subsurface infrastructure would be required to meet the minimum standards of the CBC, as required for areas with potential corrosive soils. Buried metal pipes typically have cathodic protection installed that reduces corrosive effects. Compliance with the CBC would ensure that the proposed facilities would be constructed to minimize the potential effects of corrosion. Therefore, impacts related to corrosion are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Soil Suitability for Septic System

Significance Threshold

Would the proposed Project have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of waste water?

Impact Analysis

The development of the proposed Project would not include the addition or removal of septic tanks or alternative wastewater disposal systems. Current worker accommodations in the vicinity are designed to accommodate septic demands for periodic work forces. Therefore, the issue of support for septic or alternate wastewater disposal systems would have no impact and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction

Significance Threshold

Would the proposed Project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the state geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);
- Strong seismic groundshaking;
- Seismic-related ground failure, including liquefaction; or
- Landslides.

Impact Analysis

Similar to the Groundwater Conservation and Recovery Component, the Project area is not within an Alquist-Priolo Earthquake Zone and is not subject to surface rupture or seismically-induced landslides. The spreading basins, pump station, existing natural gas pipeline, and expanded wellfield would be subject to strong ground shaking resulting from nearby seismic activities. The spreading basins would be filled with water periodically. Side-slope failure could result in the release of water into the Schuyler Wash that could significantly impact down-stream infrastructure. Compliance with the existing standards would reduce the potential impact to less than significant. Mitigation Measure **GEO-2** would ensure that spreading basin berms are designed to minimize the potential for catastrophic failure during strong ground shaking events.

Mitigation Measures

> **GEO-2: Imported Water Storage Component.** The spreading basin berms shall be designed so that soil composition, side slopes, and freeboard requirements are approved by a qualified geotechnical engineer.

Significance Conclusion

Less than significant with mitigation.

Soil Erosion and Loss of Topsoil

Significance Threshold

Would the proposed Project result in substantial soil erosion or the loss of topsoil?

Impact Analysis

The expanded wellfield, pump station, and spreading basins would increase the potential for soil erosion during construction similar to the Groundwater Conservation and Recovery Component. In addition, construction activities for air relief valves and the pump stations needed to convert the existing natural gas pipeline would increase the potential for soil erosion during construction. However, the Imported Water Storage Component would not construct facilities within existing drainages. Compliance with construction BMPs to minimize erosion during construction, as included in Mitigation Measures **HYDRO-1** and **HYDRO-4**, would ensure that impacts were less than significant.

Mitigation Measures

Implement **HYDRO-1** and **HYDRO-4**.

Significance Conclusion

Less than significant with mitigation.

Geologically Unstable Area

Significance Threshold

Would the proposed Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?

Impact Analysis

As described above, the expanded wellfield, pump station, spreading basins, and appurtenances needed to convert the natural gas pipeline would not be subject to unstable soils. The spreading basins and pump station would not be located within the wellfield drawdown area. Therefore, they would not be subject to subsidence. The impact would be less than significant.

Mitigation Measures

None required

Significance Conclusion

Less than significant.

Expansive or Corrosive Soils

Significance Threshold

Would the proposed Project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

Impact Analysis

As with the Groundwater Conservation and Recovery Component, geologic and soils maps have not identified expansive soils within the area of the proposed Project. Expansive soils generally occur in regions with moderate to high clay content. As discussed previously, mapped soil associations within the Project area contain very low to negligible amounts of clay material. Therefore, expansive soils would have no impact and no mitigation is required.

The Project site is located in areas where the soils are known to have lower pH levels and higher salt contents. The corrosive effects of such soil conditions could reduce the integrity of steel or concrete materials. This impact is considered less than significant because, in compliance with relevant state and local requirements, the facility design would be required to meet the minimum standards of the CBC, as required for areas with potential corrosive soils. Compliance with the CBC would ensure that the proposed facilities would be constructed to minimize the potential effects of corrosion. Therefore, impacts related to corrosion are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Soil Suitability for Septic System

Significance Threshold

Would the proposed Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

Impact Analysis

The development of the proposed Project would not include the addition, removal, or use of septic tanks or alternative wastewater disposal systems. Therefore, there would be no impact related to the issue of support for septic or alternative wastewater disposal systems and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.6-6 on the following page presents the impacts and mitigation summary for Geology and Soils.

TABLE 4.6-6
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction	None required	Less than significant
Soil Erosion and Loss of Topsoil	**HYDRO-1** and **BIO-6**	Less than significant with mitigation
Geologically Unstable Area	**GEO-1**	Less than significant with mitigation
Expansive or Corrosive Soils	None required	Less than significant
Soil Suitability for Septic System	None required	No impact
Imported Water Storage Component		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction	**GEO-2**	Less than significant with mitigation
Soil Erosion and Loss of Topsoil	**HYDRO-1** and **HYDRO-4**	Less than significant with mitigation
Geologically Unstable Area	None required	Less than significant
Expansive or Corrosive Soils	None required	Less than significant
Soil Suitability for Septic System	None required	No impact

4.7 Greenhouse Gas Emissions

The purpose of this Section is to analyze potential greenhouse gas (GHG) emissions associated with the development of the proposed Project and identify mitigation measures that would avoid or reduce any significant impacts. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.7.1 Environmental Setting

Greenhouse Gases Overview

Global warming is the name given to the increase in the average temperature of the Earth's near-surface air and oceans. The U.S. Environmental Protection Agency (EPA) reports that records from land stations and ships indicate that the global mean surface temperature warmed by about 0.9°F since 1880. These records indicate a near level trend in temperatures from 1880 to about 1910, a rise to 1945, a slight decline to about 1975, and a rise to present. The Intergovernmental Panel on Climate Change (IPCC) concluded in 2007 that warming of the climate system is now "unequivocal," based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.[1] Global warming is caused by natural processes and human actions. Specifically, the IPCC concludes that variations in natural phenomena such as solar radiation and volcanoes produced most of the warming from pre-industrial times to 1950 and had a small cooling effect afterward. [2] However, after 1950, increasing GHG concentrations resulting from human activity such as fossil fuel burning and deforestation have been responsible for most of the observed temperature increase. These basic conclusions have been endorsed by more than 45 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries. Since 2007, no scientific body of national or international standing has maintained a dissenting opinion.

Increases in GHG concentrations in the Earth's atmosphere are thought to be the main cause of human-induced climate change. GHGs naturally trap heat by impeding solar radiation that has hit the Earth from being reflected back into space. Some GHGs occur naturally and are necessary for keeping the Earth's surface habitable. However, increases in the concentrations of these gases in the atmosphere during the last hundred years have decreased the amount of solar radiation that is reflected back into space, intensifying the natural greenhouse effect and resulting in the increase of global average temperature.

The principal GHGs of concern are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFC), and hydrofluorocarbons (HFC). In terms of Global Warming Potential (GWP), each of these gases varies substantially from one another. GWP is a measure of how much a given mass of GHG will contribute to global warming,

1 Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007.

2 Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007.

comparing one GHG to the same mass of CO_2 on a relative scale.[3] The GWP depends on the absorption of infrared radiation by a given species, the spectral location of its absorbing wavelengths, and the atmospheric lifetime of the species. GHG emissions are measured in units of pounds or tons of CO_2 equivalents (CO_2e). GWP values for key GHGs are summarized in the following **Table 4.7-1**. The following sections contain a general discussion of the natural and anthropogenic sources of each GHG.

TABLE 4.7-1
GLOBAL WARMING POTENTIAL FOR GREENHOUSE GASES
(100-year given time horizon)

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	23
Nitrous Dioxide (N_2O)	310
Hydrofluorocarbons (HFCs)	11,700
Perfluorocarbons (PFCs)	6,500
Nitrogen Trifluouride (NF_3)	17,200
Sulfur Hexafluoride (SF_6)	23,900

SOURCES: U.S. Environmental Protection Agency, *PSD and Title V Permitting Guidance for Greenhouse Gases,* 2010; Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007, page 11; Intergovernmental Panel on Climate Change, *Summary for Policymakers, Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* , http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf , accessed, October 2011, pages 3-5.

Carbon Dioxide (CO_2). In the atmosphere, carbon generally exists in its oxidized form as CO_2. Natural sources of CO_2 include animal and plant respiration, ocean-atmospheric exchange, and volcanic eruptions. Anthropogenic sources of CO_2 include the combustion of fossil fuels, such as coal, oil, and gas in power plants, automobiles, industrial facilities, and other sources and specialized industrial production processes and product uses (i.e., mineral production, metal production, and use of petroleum-based products). The largest source of CO_2 emissions globally is the combustion of fossil fuels. Sinks of CO_2 include forests, wetlands, and agriculture. When CO_2 sources exceed CO_2 sinks, the Earth's natural balance is no longer in equilibrium. Since the late 1800s, the concentration of CO_2 in the atmosphere has risen approximately 30 percent.[4]

Methane (CH_4). Methane in the atmosphere is eventually oxidized, yielding carbon dioxide and water. Natural sources of methane include, but are not limited to, anaerobic production, wetlands, termites, oceans, methane gas hydrates (clathrates), volcanoes and other geologic structures, wildfires, and animals. Anthropogenic sources of methane include, but are not limited to, landfills, natural gas systems, coal mining, manure management, forested lands, wastewater treatment, rice cultivation,

3 California Department of Resources Recycling and Recovery, *Statewide Anaerobic Digester Facilities for the Treatment of Municipal Organic Solid Waste Draft Program Environmental Impact Report*, February 2011.

4 Climate Action Team, *Climate Action Team Report to Governor Schwarzenegger and the Legislature*, March 2006, page 7.

composting, petrochemical production, and field burning of agricultural residues. In California, agricultural processes contribute significant sources of anthropogenic methane.[5]

Nitrous Oxide (N_2O). In the atmosphere, nitrous oxide reacts with ozone. Primary natural sources of nitrous oxide include bacterial breakdown of nitrogen in soils and oceans. Anthropogenic sources of nitrous oxide include fertilizer application, production of nitrogen fixing crops, nitric acid production, animal manure management, sewage treatment, combustion of fossil fuels, and nitric acid production.[6]

Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF_6). HFCs are man-made chemicals containing the element fluorine. Developed as alternatives to ozone-depleting substances for industrial, commercial, and consumer products, they are used predominantly as refrigerants and aerosol propellants. PFCs are man-made as well, primarily used as replacements to ozone-damaging chlorofluorocarbons and hydrochlorofluorocarbons. Sources include aluminum production and semiconductor manufacturing. Man made, major releases of SF_6 come from leakage from electrical substations, magnesium smelters, and some consumer goods, such as tennis balls and training shoes. Each of these GHGs possesses a relatively high GWP and long atmospheric lifetimes.[7]

Intergovernmental Panel on Climate Change

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to assess "the scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change." The IPCC issued Assessment Reports in 1990, 1995, 2001, and the latest in 2007 linking climate change to human activities. The 1st Assessment Report, released in 1990, played an important role in the discussions of the Intergovernmental Negotiating Committee for the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC work was adopted in 1992 and went into effect in 1994; it provides the overall policy framework and legal basis for addressing the climate change issue. The 2nd Assessment Report was released in 1995. The most cited finding from that plenary, on attribution of climate change, has been consistently reaffirmed by subsequent research: "The balance of evidence suggests a discernible human influence on global climate." The 2nd Assessment report provided key input to the negotiations that led to the adoption in 1997 of the Kyoto Protocol by the UNFCCC. The 3rd Assessment Report was approved in January 2001. The predominant summary statements from the 3rd Assessment Report strengthened the 2nd Assessment Report's attribution statement: "An increasing body of observations gives a collective picture of a warming world and other changes in the climate system." The 3rd Report also states: "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

5 Climate Action Team, *Climate Action Team Report to Governor Schwarzenegger and the Legislature*, March 2006, page 11.
6 Environmental Protection Agency, *Nitrous Oxide, Sources and Emissions,* http://www.epa.gov/nitrousoxide/sources.html, accessed September 2011.
7 Climate Action Team, *Climate Action Team Report to Governor Schwarzenegger and the Legislature*, March 2006, page 12.

The IPCC completed its 4th Assessment Report in 2007. The IPCC's 4th Assessment Report Working Group I concluded with more certainty than in its previous reports that "warming of the climate system is unequivocal." The group's conclusions are based on a variety of evidence including historical, global average air, and ocean temperatures, widespread observations of melting snow and ice, and rising global average sea level. Global concentrations of three key GHGs—CO_2, CH_4 and N_2O—have increased "markedly" and "as a result of human activities" since the Industrial Revolution of the 18th century. Ice core data on historical levels of GHGs was used by IPCC scientists to conclude that modern concentrations of these three GHGs "now far exceed pre-industrial values." The report also states that fossil fuel use and changes in land use are the primary contributors to increased CO_2 concentrations globally, while agriculture is the primary source of increased CH_4 and N_2O.

Previously, the IPCC's 3rd Assessment Report stated that the average global temperature is likely to increase by between 3.6 and 8.1°F by 2100; it also found larger temperature increases to be possible, but unlikely. Temperature increases are expected to vary widely in specific locations, depending on many factors. The increase in temperature is expected to lead to higher temperature extremes, precipitation extremes leading to increased flooding and droughts, ocean acidification from increased carbon content, and rising sea levels.

Global Climate Trends and Associated Impacts

The rate of increase in global average surface temperature over the last hundred years has not been consistent; the last three decades have warmed at a much faster rate – on average 0.32 °F per decade. Eleven of the twelve years from 1995 to 2006 rank among the twelve warmest years in the instrumental record of global average surface temperature (going back to 1850).[8]

During the same period over which this increased global warming has occurred, many other changes have occurred in other natural systems. Sea levels have risen on average 1.8 millimeters per year (mm/yr); precipitation patterns throughout the world have shifted, with some areas becoming wetter and others drier; tropical cyclone activity in the North Atlantic has increased; peak runoff timing of many glacial and snow-fed rivers has shifted to earlier in the season; as well as numerous other observed conditions. Though it is difficult to prove a definitive cause and effect relationship between global warming and other observed changes to natural systems, there is high confidence in the scientific community that these changes are a direct result of increased global temperatures.[9]

Regional Setting

Almost all climate scenarios include a continuing trend of warming through the end of the century, given the vast amounts of GHGs already released and the difficulties associated with reducing emissions to a level that would stabilize the climate. Total GHG emissions in California have been approximated by the California Energy Commission (CEC), which found that 492

8 Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007, page 30.
9 Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007, page 30.

million metric tons of CO_2e ($MTCO_2e$) GHG emissions were produced in California in 2004.[10] The CEC study also found transportation to be the source of 41 percent of the State's GHG emissions; followed by electricity generation at 22 percent and industrial sources at 21 percent.

Potential impacts in California associated with global climate change may include less snow pack, sea level rise, more extreme heat days, more high ozone days, more large forest fires, and more drought years.

Climate change temperature projections identified in the 2009 California Climate Adaptation Strategy suggest the following[11]:

- Average temperature increase is expected to be more pronounced in the summer than in the winter season.
- Inland areas are likely to experience more pronounced warming than coastal regions.
- Heat waves are expected to increase in frequency, with individual heat waves also showing a tendency toward becoming longer and extending over a larger area, thus more likely to encompass multiple population centers in California at the same time.
- As GHGs remain in the atmosphere for decades, temperature changes over the next 30 to 40 years are already largely determined by past emissions. By 2050, temperatures are projected to increase by an additional 1.8 to 5.4 °F; (an increase one to three times as large as that which occurred over the entire 20th century).
- By 2100, the models project temperature increases between 3.6 to 9 °F.

The 2009 CNRA also states that 2.5 trillion dollars' worth of infrastructure in California is at risk from the various projected climate-related changes in our environment. The estimated cost of addressing the impacts on that infrastructure is about $3.9 billion, annually. The report identifies a number of steps to be taken in the near term to appropriately plan for and address this threat. Highlights of the actions include: the formation of a Climate Adaptation Advisory Panel; new approaches to water management; revised land-use planning to avoid construction in highly vulnerable areas; evaluation of all state infrastructure projects to avoid exacerbating threats to infrastructure; and, more specific planning by emergency response agencies, public health agencies, and others to fortify existing communities and resources, and prepare for future stressors.

There are also many secondary effects that are projected to result from global warming, including global rise in sea level, impacts to agriculture, changes in disease vectors, and changes in habitat and biodiversity. While the possible outcomes and the feedback mechanisms involved are not fully understood, and much research remains to be done, the potential for substantial environmental, social, and economic consequences over the long-term may be significant.

[10] California Energy Commission, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004,* December 2006.

[11] California Natural Resources Agency, *2009 California Climate Adaption Strategy Discussion Draft*, 2009.

Regional Water Resources

Depending on the climate model, precipitation is predicted to increase or decrease slightly. However, the form in which precipitation occurs could change substantially. Warmer winters would lead to less snow and more rain. As a result, the Sierra snowpack would be reduced and would melt earlier. This change could lead to increased flood risks as more water flows into reservoirs and rivers during the winter rainy period. Furthermore, late spring and summer flows to reservoirs would be reduced due to reduced snow packs, thereby reducing the chance of unrestricted water supplies for cities, agriculture, and rivers. Increased temperatures would also lead to a rise in the sea level, from both thermal expansion and melting land-based glaciers. The State Department of Water Resources (DWR) notes that "adapting to the current and future effects of climate change is essential for DWR and California's water managers. DWR addresses climate change in its California Water Plan, which is updated every five years. The California Water Plan provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. DWR continues to improve and expand the analysis of climate change in the California Water Plan. The 2009 California Water Plan Update includes multiple scenarios of future climate conditions and stresses the consideration of uncertainty, risk, and sustainability.[12]

During the past century, sea levels along the California coast have risen by approximately seven inches. Climate forecasts indicate the sea level would rise by seven to 23 inches over the next 100 years depending on the climate model. Substantial melting of either the Greenland or Antarctic ice sheets would lead to an even greater increase in sea levels; however, the IPCC models do not indicate that this would occur within the next 100 years, which is the boundary of most climate models. Longer forecast periods are inherently less reliable as they require more assumptions and tend to compound the effects of assumptions that may be incorrect. Increases in sea level could lead to increased coastal flooding, salt water intrusion into aquifers, and disrupt wetlands and estuaries.

Effects of Climate Change on Precipitation and Recharge

The effects of climate change on precipitation and recharge in the Bristol, Cadiz, Fenner, and Orange Blossom Wash Watersheds are uncertain. While global climate change has been modeled often, it is much more difficult to model and understand climate change impacts on a regional or local level. There is a general consensus that climate change will cause general warming, sea level rise, a shift in precipitation and runoff patterns (i.e. more winter precipitation falling as rain rather than snow), and increased flooding across the globe.[13] At a smaller scale, the ability to predict the impacts of climate change becomes more difficult. In particular, aquifer recharge can be difficult to quantify because it can be affected by many climatic and human factors, including the amount of precipitation; the density of streams that lose water to the aquifer; the ambient temperature, wind speed, and amount of solar radiation (potential evaporation); the type and amount of vegetative cover; the surface soil type and sub-surface geology; and depth to water.

[12] California Department of Water Resources, *California Water Plan Update 2009*, December 2009, page 6-20.
[13] The Public Policy Institute of California, *Adapting California's Water Management to Climate Change*, November 2008, page 6.

Additionally, relatively little has been written about the impacts of climate change on groundwater recharge.

Current geological assessments of the aquifer system at the Project area suggest that the Project's annual recharge rate is unlikely to be materially affected by climate change. Located in a non-urban, remote area, the basin's groundwater supply is mainly generated by precipitation (both rain and snow) that occurs in the upper elevations of two nearby mountain ranges. Once it has infiltrated and becomes groundwater, precipitation moves very slowly down gradient toward the Project area at the base of the Watershed. Groundwater beneath the Project area has been found to be hundreds, and in some cases thousands, of years old. Although climate change is expected to shift precipitation and snow melt patterns, which will cause significant impacts in areas that rely on surface runoff from snowmelt, any decline in the amount of precipitation falling on the mountains surrounding the Watershed tributary to the Project area is unlikely to significantly affect the natural recharge in the groundwater basin since it is reliant on seepage from the hard rock formations underlying the mountain ranges rather than surface runoff or alluvial recharge.[14]The total amount of natural recharge that occurs each year in the basin should be relatively unchanged over the long-term.

The basin in which the Project lies will be shielded from some of the other effects of climate change as well, given its location and characteristics, i.e. it will not be affected by sea level rise—seawater intrusion—given its inland, desert location.

DWR has made the following recommendations regarding how the state and local water agencies should address climate change: (a) provide sustainable funding for statewide and integrated regional water management; (b) fully develop the potential for integrated regional water management; (c) aggressively increase water use efficiency; (d) practice and promote integrated flood management; (e) enhance and sustain ecosystems; (f) expand water storage and conjunctive management of surface and groundwater resources; (g) fix Delta water supply, quality, and ecosystem conditions; (h) preserve, upgrade, and increase monitoring, data analysis and management; (i) plan for and adapt to potential sea level rise; and (j) identify and fund focused climate change impacts and adaptation research and analysis.[15]

Colorado River

Climate change impacts to the Colorado River are similar to those expected globally. DWR indicates that water supplies from the Colorado River may decrease in the future.[16] The report notes that a recent comprehensive modeling study projected an 8 to 11 percent decrease in runoff by the year 2100 for the Colorado River basin, depending on the emissions scenario. This study also found that water shortages for the basin may become more frequent.

14 California Department of Water Resources, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*, October 2008.
15 California Department of Water Resources, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*, October 2008.
16 California Department of Water Resources, *California Water Plan Update 2009*, December 2009.

Another report notes that climate model projections show longer and more intense future droughts in the Colorado River basin.[17] If these climate scenarios materialize, the Southwest will have to prepare for deeper and historically more unusual water shortages, and the sustainability of current water deliveries from the Colorado River will become less predictable.

The Bureau of Reclamation recently released a report on its climate change modeling efforts. The report concludes that annual variability in precipitation is expected to persist within the Colorado River Basin, and the basin likely will continue to experience both wet and dry periods throughout the 21st century.[18] Results of Reclamation's climate change modeling suggest that annual runoff will vary by location. Southern subbasins are expected to experience increased warming and precipitation as compared to more northern subbasins like the Green River basin. Warming is expected to lead to more rainfall-runoff during the cool season rather than snowpack accumulation. Generally speaking, streamflow variability over the Upper Colorado River Basin is expected to continue and increase under changing climate conditions. While annual maximum week runoff is predicted to remain stable throughout the Basin, annual minimum week runoff is expected to decrease.

Given that the Colorado River Basin is expected to experience both wet and dry periods throughout the 21st century, storage of excess River flows during wet years will be necessary to compensate for the low flows in dry years. The predicted shift in runoff patterns, combined with predicted periods of increased precipitation, will result in time periods during which Colorado River flows are likely to exceed storage capacity for those flows. In these years, these excess flows are available to be diverted to alternative storage sites. If they are not diverted to storage, the flows will flow outside the United States, and the local region will be deprived of an important water supply. At the opposite end of the spectrum, if the longer and more intense future droughts projected by Cayan et al. materialize, the ability to store excess Colorado River flows and other supplies, such as State Water Project water from the Bay-Delta, in wet years will become even more important. Storing surplus water in wet years will enable water providers to provide a more reliable water supply during periods of drought.

Regional Wildfires

Increased temperatures would lead to increases in evapotranspiration. The summers would likely be drier, and vegetation would also be more likely to dry out, resulting in increasingly larger areas of flammable forests and wild lands. In addition, warmer temperatures could lead to the expansion of pests that kill and weaken trees, leading to increases in the amount of highly flammable dead trees, also increasing the risk of large forest fires. Local wildfire hazards are addressed in Section 4.8 Hazards and Hazardous Materials.

[17] Cayan, Daniel R., et al., *Future Dryness in the Southwest U.S. and the Hydrology of the Early 21st Century*, Proceedings of the National Academies of Science Vol. 107, No. 50, December 2010, pages 21271-21276.

[18] U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011*, April 2011.

Regional Weather Extremes

The temperature increases presented in climate change models are yearly averages. Within those averages is the potential for substantially hotter summers and/or colder winters. As a result of global climate change, the weather is expected to become more variable, with larger extremes. An increase in the number of days with extreme heat has implications for public health as Californians would face greater risk of death or disability from dehydration, heat stroke/exhaustion, heart attack, stroke, and respiratory distress caused by extreme heat. In addition, increased temperatures have implications for agricultural crops, particularly long-term crops such as grapes and fruit trees that are planted in particular locations to take advantage of micro-climates. The crops grown on the Cadiz Property use water-saving drip irrigation and are not dependent on rain; rather groundwater from the aquifer system is used to irrigate all crops in production. The Cadiz agricultural operations currently exist in extremely hot conditions for long periods of the year.

Regional Air Quality

As indicated in the discussion of weather extremes, increased temperatures can increase air quality problems. Increased temperatures create the conditions in which ozone formation can increase. In addition, hotter temperatures would likely result in increased electricity use to power air conditioners and refrigerators. Increased power usage has the potential to result in increased air pollutant emissions as more electrical generation is needed to meet the demand. Climate change has been factored into local and regional air quality planning, as noted by the California Air Resources Board (CARB), through implementation of Assembly Bill 32 and related programs.

4.7.2 Regulatory Framework

Federal

In the past, the EPA has not regulated GHGs under the Clean Air Act because it asserted that the act did not authorize EPA to issue mandatory regulations to address global climate change and that such regulation would be unwise without an unequivocally established causal link between GHGs and the increase in global surface air temperatures. However, the U.S. Supreme Court held that EPA must consider regulation of motor vehicle GHG emissions. In *Massachusetts v. Environmental Protection Agency* et al., twelve states and cities, including California, together with several environmental organizations, sued to require the EPA to regulate GHGs as pollutants under the Clean Air Act (127 S. Ct. 1438 (2007)). The Court ruled that GHGs fit within the Clean Air Act's definition of a pollutant and EPA did not have a valid rationale for not regulating GHGs. In 2009 EPA responded to this ruling and made an endangerment finding that GHGs pose a threat to the public health and welfare. That was the first step necessary for the establishment of federal GHG regulations under the Clean Air Act.

In April 2010, EPA issued the final rule on new standards for GHG emissions and fuel economy for light-duty vehicles in model years (MY) 2017-2025. In November 2010, EPA published the "Prevention of Significant Deterioration (PSD) and Title V Permitting Guidance for Greenhouse

Gases," which provides the basic information that permit writers and applicants need in order to address GHG emissions regulated under the Clean Air Act. In that document, EPA described the "Tailoring Rule" in the regulation of GHG emissions. With the Tailoring Rule, EPA established a phased schedule in the regulation of stationary sources. The first phase of the "Tailoring Rule" began January 2, 2011 and focuses the GHG permitting programs on the largest sources with the most Clean Air Act permitting experience. Then, in step two beginning June 1, 2011, the rule expands to cover large sources of GHGs that may not have been previously covered by the Clean Air Act for other pollutants. The rule also describes EPA's commitment to future rulemaking that will describe subsequent steps of the "Tailoring Rule" for GHG permitting.[19]

EPA annually publishes the Inventory of U.S. Greenhouse Gas Emissions and Sinks for estimating sources of GHGs that is generally consistent with the IPCC methodology developed in its Guidelines for National Greenhouse Gas Inventories. The inventory identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gases is essential for addressing climate change. [20]

State

Assembly Bill (AB) 1493 (Pavley) of 2002, (Health and Safety Code Sections 42823 and 43018.5). AB 1493 requires CARB to develop and adopt the nation's first GHG emission standards for automobiles. These standards are also known as "Pavley I." The California Legislature provided in AB 1493 that global warming is a matter of increasing concern for public health and the environment. It cites several risks that California faces from climate change, including a reduction in the State's water supply, an increase in air pollution caused by higher temperatures, harm to agriculture, an increase in wildfires, damage to the coastline, and economic losses caused by higher food, water, energy, and insurance prices. The bill also states that technological solutions to reduce GHG emissions would stimulate California's economy and provide jobs. In 2004, the State of California submitted a request for a waiver from federal clean air regulations, as the State is authorized to do under the CAA, to allow the State to require reduced tailpipe emissions of CO_2. In late 2007, EPA denied California's waiver request and declined to promulgate adequate federal regulations limiting GHG emissions. In early 2008, California brought suit against the USEPA related to this denial.

In January 2009, President Obama instructed EPA to reconsider the Bush Administration's denial of California's and 13 other states' requests to implement global warming pollution standards for cars and trucks. In June 2009, EPA granted California's waiver request, enabling the State to enforce its GHG emissions standards for new motor vehicles beginning with the current model year.

Also in 2009, President Obama announced a national policy aimed at both increasing fuel economy and reducing GHG pollution for all new cars and trucks sold in the United States. The

19 U.S. Environmental Protection Agency, *PSD and Title V Permitting Guidance for Greenhouse Gases,* 2010.
20 Environmental Protection Agency, *U.S. Greenhouse Gas Emissions and Sinks,* April 2011. http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Executive-Summary.pdf, accessed October 2011.

new standards would cover model years 2012 to 2016 and would raise passenger vehicle fuel economy to a fleet average of 35.5 miles per gallon (mpg) by 2016. When the national program takes effect, California has committed to allowing automakers who show compliance with the national program to also be deemed in compliance with State requirements. California is committed to further strengthening these standards beginning in 2017 to obtain a 45 percent GHG reduction in the 2020 model year vehicles.

Executive Order S-3-05. Executive Order S-3-05 (State of California) states that California is vulnerable to the impacts of climate change. It states that increased temperatures could reduce the snowpack in the Sierra Nevada Mountains, further exacerbate California's air quality problems, and potentially cause a rise in sea levels. To address those concerns, the Executive Order established total greenhouse gas emission targets. Specifically, emissions are to be reduced to the 2000 level by 2010, to the 1990 level by 2020, and to 80 percent below the 1990 level by 2050.

The Executive Order directed the Secretary of the California Environmental Protection Agency (CalEPA) to coordinate a multi-agency effort to reduce greenhouse gas emissions to the target levels. The Secretary will also submit biannual reports to the Governor and State Legislature describing (1) progress made toward reaching the emission targets, (2) impacts of global warming on California's resources, and (3) mitigation and adaptation plans to combat these impacts. To comply with the Executive Order, the Secretary of CalEPA created a Climate Action Team (CAT) made up of members from various State agencies and commissions. CAT released its first report in March 2006. The report proposed to achieve the targets by building on voluntary actions of California businesses, local government and community actions, as well as through state incentive and regulatory programs.

Assembly Bill 32 (AB 32). The California Global Warming Solutions Act of 2006 (AB 32) requires CARB to design and implement emission limits, regulations, and other measures, such that statewide GHG emissions will be reduced to 1990 levels by 2020. In 2009 CARB mandatory reporting and verification regulations went into effect. Regulations require reporting for major facilities, those that generate more than 25,000 $MTCO_2e$ /year such as cement plants, oil refineries, power plants (electricity), cogeneration facilities, and hydrogen plants. These sources make up approximately 94 percent of the point source CO_2e emissions in California.[21]

Pursuant to AB 32, CARB adopted a Scoping Plan in December 2008, which was re-approved by CARB on August 24, 2011,[22] outlining measures to meet the 2020 GHG reduction limits. In order to meet these goals, California must reduce its GHG emissions by 30 percent below projected 2020 business as usual emissions levels, or about 15 percent from current levels. The Scoping Plan estimates a reduction of 174 million $MTCO_2e$ (about 191 million U.S. tons) from transportation, energy, agriculture, forestry, and other sources, with measures summarized in **Table 4.7-2**. CARB has identified an implementation timeline for the GHG reduction strategies in the Scoping Plan. Some measures may require new legislation to implement, some will require

[21] California Air Resources Board, *Mandatory Reporting of California Greenhouse Gas Emissions*, Presentation at Cal/EPA Headquarters, August 2007.

[22] California Air Resources Board, *Final Supplement to the AB 32 Scoping Plan Functional Equivalent Document,* August 2011.

subsidies, some have already been developed, and some will require additional effort to evaluate and quantify. Additionally, some emissions reductions strategies may require their own environmental review under CEQA or the National Environmental Policy Act (NEPA).

TABLE 4.7-2
LIST OF RECOMMENDED ACTIONS BY SECTOR

Measure No.	Measure Description	GHG Reductions (Annual Million $MTCO_2e$)
Transportation		
T-1	Pavley I and II – Light Duty Vehicle Greenhouse Gas Standards	31.7
T-2	Low Carbon Fuel Standard (Discrete Early Action)	15
T-3[1]	Regional Transportation-Related Greenhouse Gas Targets	5
T-4	Vehicle Efficiency Measures	4.5
T-5	Ship Electrification at Ports (Discrete Early Action)	0.2
T-6	Goods Movement Efficiency Measures • Ship Electrification at Ports • System-Wide Efficiency Improvements	3.5
T-7	Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Measure – Aerodynamic Efficiency (Discrete Early Action)	0.93
T-8	Medium- and Heavy-Duty Vehicle Hybridization	0.5
T-9	High Speed Rail	1
Electricity and Natural Gas		
E-1	Energy Efficiency (32,000 GWh of Reduced Demand) • Increased Utility Energy Efficiency Programs • More Stringent Building & Appliance Standards Additional Efficiency and Conservation Programs	15.2
E-2	Increase Combined Heat and Power Use by 30,000 GWh (Net reductions include avoided transmission line loss)	6.7
E-3	Renewables Portfolio Standard (33% by 2020)	21.3
E-4	Million Solar Roofs (including California Solar Initiative, New Solar Homes Partnership and solar programs of publicly owned utilities) • Target of 3000 MW Total Installation by 2020	2.1
CR-1	Energy Efficiency (800 Million Therms Reduced Consumptions) • Utility Energy Efficiency Programs • Building and Appliance Standards • Additional Efficiency and Conservation Programs	4.3
CR-2	Solar Water Heating (AB 1470 goal)	0.1
Green Buildings		
GB-1	Green Buildings	26
Water		
W-1	Water Use Efficiency	1.4†
W-2	Water Recycling	0.3†
W-3	Water System Energy Efficiency	2.0†
W-4	Reuse Urban Runoff	0.2†
W-5	Increase Renewable Energy Production	0.9†
W-6	Public Goods Charge (Water)	TBD†

Measure No.	Measure Description	GHG Reductions (Annual Million $MTCO_2e$)
Industry		
I-1	Energy Efficiency and Co-Benefits Audits for Large Industrial Sources	TBD
I-2	Oil and Gas Extraction GHG Emission Reduction	0.2
I-3	GHG Leak Reduction from Oil and Gas Transmission	0.9
I-4	Refinery Flare Recovery Process Improvements	0.3
I-5	Removal of Methane Exemption from Existing Refinery Regulations	0.01
Recycling and Waste Management		
RW-1	Landfill Methane Control (Discrete Early Action)	1
RW-2	Additional Reductions in Landfill Methane • Increase the Efficiency of Landfill Methane Capture	TBD†
RW-3	High Recycling/Zero Waste • Commercial Recycling • Increase Production and Markets for Compost • Anaerobic Digestion • Extended Producer Responsibility • Environmentally Preferable Purchasing	9†
Forests		
F-1	Sustainable Forest Target	5
High Global Warming Potential (GWP) Gases		
H-1	Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Services (Discrete Early Action)	0.26
H-2	SF_6 Limits in Non-Utility and Non-Semiconductor Applications (Discrete Early Action)	0.3
H-3	Reduction of Perfluorocarbons in Semiconductor Manufacturing (Discrete Early Action)	0.15
H-4	Limit High GWP Use in Consumer Products Discrete Early Action (Adopted June 2008)	0.25
H-5	High GWP Reductions from Mobile Sources • Low GWP Refrigerants for New Motor Vehicle Air Conditioning Systems • Air Conditioner Refrigerant Leak Test During Vehicle Smog Check • Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers • Enforcement of Federal Ban on Refrigerant Release during Servicing or Dismantling of Motor Vehicle Air Conditioning Systems	3.3
H-6	High GWP Reductions from Stationary Sources • High GWP Stationary Equipment Refrigerant Management Program: - Refrigerant Tracking/Reporting/Repair Deposit Program - Specifications for Commercial and Industrial Refrigeration Systems • Foam Recovery and Destruction Program • SF Leak Reduction and Recycling in Electrical Applications • Alternative Suppressants in Fire Protection Systems • Residential Refrigeration Early Retirement Program	10.9
H-7	Mitigation Fee on High GWP Gases	5
Agriculture		
A-1	Methane Capture at Large Dairies	1.0†

[1] This is not the SB 375 regional target. ARB will establish regional targets for each Metropolitan Planning Organization (MPO) region following the input of the regional targets advisory committee and a consultation process with MPO's and other stakeholders per SB 375.

† GHG emission reduction estimates are not included in calculating the total reductions needed to meet the 2020 target.

SOURCE: California Air Resources Board, *Final Supplement to the AB 32 Scoping Plan Functional Equivalent Document*, August 2011.

Senate Bill 1368 (SB 1368). (codified at Public Utilities Code Chapter 3) SB 1368 is the companion bill of AB 32. SB 1368 requires the California Public Utilities Commission (CPUC) to establish a greenhouse gas emission performance standard for baseload generation from investor-owned utilities by February 1, 2007. The bill also requires the CEC to establish a similar standard for local publicly owned utilities by June 30, 2007. These standards cannot exceed the greenhouse gas emission rate from a baseload combined-cycle natural-gas-fired plant. The legislation further requires that all electricity provided to California, including imported electricity, must be generated from plants that meet the standards set by the CPUC and CEC.

Senate Bill 104 (Updating the list of GHGs regulated under AB 32). Senate Bill 104 (SB 104), adopted in October 2009, authorizes CARB to regulate nitrogen trifluoride as a GHG. Nitrogen trifluoride is a gas emitted during the etching process during the manufacturing of various electronic products including televisions, computer monitors, solar panels, and microprocessors. SB 104 adds nitrogen trifluoride to the list of GHGs regulated by CARB under AB 32. CARB has developed and adopted a variety of rules to reduce fluorinated gas emissions (HFC, PFC, and SF6) in semiconductor and related electronic device manufacturing. Passage of this bill adds nitrogen trifluoride to the list of fluorinated gases regulated under the CARB rules for semiconductor and related electronic manufacturing.[23]

Senate Bill 97 SB 97 acknowledges that climate change is a prominent environmental issue that requires analysis under CEQA. As of March 18, 2010, CARB had established guidelines for the feasible mitigation or effects of GHG emissions.

Senate Bill 375. SB 375, signed in September 2008 (Chapter 728, Statutes of 2008), aligns regional transportation planning efforts, regional GHG reduction targets, and land use and housing allocation. SB 375 requires Metropolitan Planning Organizations (MPOs) to adopt a sustainable communities strategy or alternative planning strategy (APS) that will prescribe land use allocation in that MPO's regional transportation plan. CARB, in consultation with MPOs, will provide each affected region with reduction targets for GHGs emitted by passenger cars and light trucks in the region for the years 2020 and 2035. If MPOs do not meet the GHG reduction targets, transportation projects may not be eligible for funding programmed after January 1, 2012.

On August 9, 2010 CARB proposed regional GHG Emission reduction targets pursuant to SB 375. CARB developed proposed regional targets through an extensive public process, with significant contributions from the affected MPOs. Substantial data and analysis, developed by the regions, served as the basis for predicting the amount of change that can reasonably be expected in coming decades and demonstrated significant regional differences which are reflected in the targets.

Executive Order S-13-08: The Climate Adaptation and Sea Level Rise Planning Directive. On November 14, 2008, Governor Schwarzenegger issued Executive Order S-13-08 in order to reduce and assess California's vulnerability to climate change and sea level rise. The Executive Order initiated four major actions:

23 California Air Resources Board, *Senate Bill No. 104*, October 2009.

- Initiate California's first statewide climate change adaptation strategy that will assess the State's expected climate change impacts, identify where California is most vulnerable and recommend climate adaptation policies by early 2009;
- Request the National Academy of Science establish an expert panel to report on sea level rise impacts in California to inform state planning and development efforts;
- Issue interim guidance to state agencies for how to plan for sea level rise in designated coastal and floodplain areas for new projects; and
- Initiate a report on critical existing and planned infrastructure projects vulnerable to sea level rise. This report was released in 2009 as the California Adaptation Strategy (CNRA, 2009).

The Executive Order provides consistency and clarifies to state agencies how to address sea level rise and other climate change related impacts in current planning efforts.

California Cap and Trade Program. The AB 32 Scoping Plan identifies a cap-and-trade program as one of the strategies California will employ to reduce the GHG emissions that cause climate change. This program will help put California on the path to meet its goal of reducing GHG emissions to 1990 levels by the year 2020, and ultimately achieving an 80% reduction from 1990 levels by 2050. Under cap-and-trade, an overall limit on GHG emissions from capped sectors will be established by the program, and facilities subject to the cap will be able to trade permits (allowances) to emit GHGs.

CARB is working with stakeholders to design a California cap-and-trade program that is enforceable and meets the requirements of AB 32, including the need to consider any potential impacts on disproportionately impacted communities. Consistent with AB 32, CARB must finalize the cap-and-trade regulation, which must begin in 2012.

On October 20, 2011, CARB adopted the final cap-and-trade regulation and Resolution 11-32. The Final Rulemaking Package was filed with the Office of Administrative Law (OAL) on October 27, 2011. OAL has until December 13, 2011 to make a determination. The cap-and-trade regulation, Title 17 California Coded of Regulations §§ 95800 through 96023, will become effective January 1, 2012. In August and November 2012, the first auction of "compliance instruments" (i.e. GHG emissions allowances) will be held and on January 1, 2013 the compliance obligation for Covered Entities begins. Covered Entities are entities within California that have one or more of the processes or operations listed in the regulation under § 95811 and that have annual emissions greater than the 25,000 $MTCO_2E$ threshold (§ 95812). The cap-and-trade program allows for non-Covered Entities, including Voluntarily Associated Entities, to register with the program and purchase and hold GHG emission allowances (§ 95814). California is working closely with six other western states and four Canadian provinces through the Western Climate Initiative (WCI), described below, to design a regional program that can deliver GHG emission reductions within the region at costs lower than could be realized through a California-only program.

Western Climate Initiative. California is working closely with six other states and four Canadian provinces in the - WCI to design a regional GHG emissions reduction program that includes a cap-and-trade approach. California's participation in WCI creates an opportunity to provide substantially greater reductions in GHG emissions throughout the region than could be achieved by California alone. The larger scope of the program also expands the market for clean technologies and helps avoid leakage; that is, the shifting of emissions from sources within California to sources outside the State. The WCI partners released the recommended design for a regional cap-and-trade program in September 2008. The creation of a robust regional trading system can complement the other policies and measures included in this plan, and it provides the means to achieve the reduction of GHG emissions needed from a wide range of sectors, as cost-effectively as possible.

California Air Pollution Control Officers Association. In January 2008, the California Air Pollution Control Officers Association (CAPCOA) addressed a range of GHG emission thresholds that can be used. The range includes a GHG threshold of zero and several non-zero thresholds. Non-zero thresholds include percentage reductions for new projects that would allow the State to meet its goals for GHG emissions reductions by 2020 and perhaps 2050. These would be determined by a comparison of new emissions versus business as usual emissions, and the reductions of approximately 30 percent would be required in order to achieve 2020 goals; reductions of 90 percent (effective immediately) would be required in order to achieve the more aggressive 2050 goals. These goals could be varied to apply differently to new projects by economic sector or by State region.

Other non-zero thresholds discussed in the CAPCOA paper include:

- 900 $MTCO_2e$ /year (a market capture approach that would capture 90 percent or more of likely future discretionary developments);
- 10,000 $MTCO_2e$ /year (potential CARB mandatory reporting level with cap and trade);
- 25,000 $MTCO_2e$ /year (the CARB mandatory reporting level for the statewide emissions inventory);
- 40,000 to 50,000 $MTCO_2e$ /year (regulated emissions inventory capture – using percentages equivalent to those used in air districts for criteria air pollutants);
- Projects of statewide importance (9,000 $MTCO_2e$ /year for residential, 13,000 metric tons/year CO_2e for office project, and 41,000 $MTCO_2e$ /year for retail projects); and
- Unit-based thresholds and efficiency-based thresholds that were not quantified in the report.

Local

Mojave Desert Air Quality Management District

MDAQMD has jurisdiction over the desert portion of San Bernardino County and the far eastern end of Riverside County, and thus it has jurisdiction over the Project area. The MDAQMD has not established thresholds of significance for GHG emissions.

San Bernardino County GHG Emissions Reduction Plan

The County of San Bernardino has prepared a GHG Emissions Reduction Plan that aims to reduce current GHG emissions by at least 15 percent by 2020. The proposed Project is exempt from the County's zoning and development pursuant to Government Code section 53091. Therefore, the County GHG Plan is not applicable to the proposed Project but the measures are included to establish consistency between the Project and the proposed plan's emission reduction measures. The goals are consistent with AB 32 Scoping Plan and CARB's recommended greenhouse gas reduction goals for local governments by 2020. The plan aims to reduce emissions through improvements and modifications to internal and external County operations. External activities will be reduced by approximately 2,272,000 $MTCO_2e$ (compared to 2020 unmitigated levels) to a level of approximately 5,315,000 $MTCO_2e$, which constitutes a reduction of approximately 30 percent. External emissions include GHG emissions produced by private industry and development that is located within the area subject to the County's discretionary land use authority and its ministerial building permit authority (the "External Emissions Inventory"). Internal activities will be reduced by approximately 229,000 $MTCO_2e$ (compared to 2020 unmitigated levels) to a level of 289,000 $MTCO_2e$, which constitutes a total of approximately 42 percent. Internal emissions include GHG emissions associated with the County's services and internal operations (the "Internal Inventory"). Internal reductions include those from the following sectors: Stationary Sources (46 percent); Transportation and Land Use (23 percent); Building energy (22 percent); Solid Waste Landfills (9 percent); Water conservation (0.4 percent); and Agriculture and Resource Conservation (0.1 percent).

4.7.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to greenhouse gas emissions if it would:

- Generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment; or
- Conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of GHG (including AB 32, the California Global Warming Solutions Act of 2006, and the AB 32 Scoping Plan).

Methodology

At this time, there is no agreed consensus in the State of California among CEQA lead agencies regarding the analysis of global climate change and the selection of significance criteria. In fact, numerous organizations, both public and private, have released advisories and guidance with recommendations designed to assist decision-makers in the evaluation of GHG emissions given the current uncertainty regarding when emissions reach the point of significance. Several options are available to lead agencies.

First, lead agencies may elect to rely on thresholds of significance recommended or adopted by State or regional agencies with expertise in the field of global climate change (see *CEQA Guidelines* §15064.7(c)). To date, neither CARB nor MDAQMD have adopted significance thresholds for GHG emissions for residential or commercial development under CEQA. Other agencies have adopted thresholds as guidance including the San Joaquin Air Pollution Control District and the Bay Area Air Quality Management District. However, at this time there is no industry standard that has received wide application or general acceptance. Therefore, as the lead agency for the Proposed Project, SMWD has elected to determine as a benchmark for this Project only the significance of GHG emissions utilizing the GHG significance threshold adopted by the South Coast Air Quality Management District (SCAQMD) for certain industrial uses. The SCAQMD has adopted an interim operational significance threshold of 10,000 $MTCO_2e$ per year for stationary sources where SCAQMD is the lead agency.[24] Given the proposed Project's proximity to the SCAQMD, SMWD believes that the SCAQMD's significance threshold is the most relevant air district-adopted GHG significance threshold to use as a benchmark for the Project.

As noted above, the SCAQMD's adopted GHG significance threshold is intended for long-term operational GHG emissions. However, the SCAQMD has developed guidance for the determination of the significance of GHG construction emissions that recommends that total emissions from construction be amortized over 30 years and added to operational emissions and then compared to the threshold.[25] This analysis of the proposed Project applies SCAQMD's guidance with regard to the assessment of construction-related GHG emissions.

OPR recommends the following approach for analyzing GHG emissions:

1. Identify and quantify the project's GHG emissions;
2. Assess the significance of the impact on climate change; and
3. If the impact is found to be significant, identify alternatives and/or mitigation measures that would reduce the impact to less-than-significant levels.

This analysis incorporates an approach that is a combination of qualitative and quantitative considerations. The considerations are as follows:

A. Analyze potential conflicts with the CARB's 39 recommended actions in California's AB 32 Climate Change Scoping Plan.

B. Analyze the relative size of a project. The project's GHG emissions will be compared to SCAQMD's adopted threshold for industrial stationary sources of 10,000 $MTCO_2e$/year for which it is the lead agency. As discussed above, MDAQMD currently does not have adopted GHG thresholds of significance for CEQA review projects. SMWD's purpose in utilizing this threshold as a benchmark is to provide a context for the Project's GHG emissions.

[24] South Coast Air Quality Management District, Board Meeting, Agenda No. 31 – *Interim CEQA GHG Significance Threshold for Stationary Sources, Rules and Plans,* December 2008.
[25] South Coast Air Quality Management District, Board Meeting, Agenda No. 31 – *Interim CEQA GHG Significance Threshold for Stationary Sources, Rules and Plans,* December 2008.

C. Analyze the basic energy efficiency parameters of a project to determine whether its design is inherently energy efficient.

D. Analyze potential conflicts with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the emissions of GHGs.

The CARB-approved URBEMIS 2007 emissions model was utilized to determine emissions from construction equipment and haul trucks. EMFAC 2007 was utilized to determine emissions associated with worker and employee trips during construction and operations. In addition, GHG emissions from operations were obtained by calculating emissions from the provided amount of kilowatt-hour (kWh) needed for project operations. Output sheets are provided in Appendix E1.

Groundwater Conservation and Recovery Component

Greenhouse Gas Emissions

Significance Threshold

Would the proposed Project generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment?

Would the proposed Project conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the emissions of GHG (including AB 32, the California Global Warming Solutions Act of 2006, and the AB 32 Scoping Plan)?

Impact Analysis

GHG emissions are considered to be exclusively cumulative impacts; there are no non-cumulative GHG emission impacts from a climate change perspective.[26] Direct (i.e., on-road vehicles, off-road equipment, and Project turbine natural gas combustion) and indirect (i.e., usage of electricity that is generated in other regions) GHG emissions of the Project and whether these emissions conflict with plans or policies are assessed below, per the analysis criteria described in this section. The final determination regarding impact significance is based on the overall consideration of all these analysis criteria factors.

Criterion A Analysis: Conflict with CARB's Recommendations. With regard to Item A, the Project does not pose any apparent conflict with the CARB recommended actions listed in Table 4.7-2, in particular, water associated measures W-1 through W-5.

W-1: Water Use Efficiency

The proposed Project would utilize a minimal amount of water during construction for dust suppression during construction. The Water Providers' Urban Water Management Plans provide for conservation measures to reduce water demand and to more efficiently utilize water. Programs include increased use of recycled water (See Chapter 7 Alternatives for more information on Water Provider conservation efforts). In addition, the California Green Building Code includes

[26] California Air Pollution Control Officers Association, *CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act*, January 2008, page 35.

building standards that require water efficient fixtures and/or a reduced number of fixtures for new development. The proposed Project would not conflict with this measure.

W-2: Water Recycling

The Project is sustainable as it would conserve groundwater that would otherwise be lost due to migration to a brine sink and evapotranspiration. The Project would not conflict with this measure. The Project would not impede implementation of recycled water projects currently planned or in operation within each of the Water Provider service areas.

W-3: Water System Energy Efficiency

The Project would require less energy per gallon delivered than would the SWP.[27] As a result, the Project provides a more energy efficient alternative to the SWP. Furthermore, the Project would utilize excess capacity in the CRA when available. The CRA pump stations currently operate with multiple single-speed pumps (each pump having a 220 cfs rating). The water pumped into the CRA by the Project would be accommodated with the existing pump capacity, without increasing energy requirements at the lift stations. The proposed Project would be consistent with this measure.

W-4: Reuse Urban Runoff

There would be no urban runoff from the proposed Project. However, the Project does utilize recharge water from precipitation within the Watershed. The proposed Project would be consistent with this measure.

W-5: Increase Renewable Energy Production

The proposed Project as designed would not produce energy. However, in the future, the conveyance pipelines could be utilized to generate hydroelectric energy to help offset the energy needed to run the water pumps. The proposed Project would not be inconsistent with this measure.

Criterion B Analysis: Relative Size of the Project. With regard to Criterion B, direct GHG emissions associated with off-road equipment and on-road vehicles for construction of the Groundwater Conservation and Recovery Component were estimated to be approximately 106,470 lbs/day (409 $MTCO_2e$ /year). Total construction emissions would be 12,280 $MTCO_2e$/yr amortized over 30 years. This includes construction of the wellfield, pipeline, and intermediate pump station. **Table 4.7-3** summarizes construction related GHG emissions.

[27] California Energy Commission, *California's Water – Energy Relationship*, November 2005, Figure 2-2 and page 23.

TABLE 4.7-3
CONSTRUCTION EMISSIONS FROM GROUNDWATER CONSERVATION AND RECOVERY COMPONENT (lbs per day)[a]

Project Component	CO_2
Wellfield Construction (including mobilization, site clearing and grading, drilling, site access, and demobilization)	31,108
Conveyance Pipeline / CRA Tie-in (including mobilization, site clearing and grading, excavation, backfilling, site access, and demobilization)	50,265
Storage Reservoir/ Pump Station (including mobilization, site clearing and grading, excavation, backfilling, site access, and demobilization)	14,813
Construction Employee Trips	14,675
Unmitigated Total	110,861
Mitigated Total	106,470

a Project construction emissions estimates were made using URBEMIS2007, version 9.2. 4. See Appendix E1 for more information.

SOURCE: ESA, 2011.

In regards to operations, there are two options for supplying power to the wellfield pumps – either by natural gas or electrical power. First, if the wellfield and intermediate pump station are powered with natural gas, direct operational GHG emissions would be approximately 27,731 $MTCO_2e$/year from natural gas combustion. The wellfield may be equipped with solar bolt-ons to reduce natural gas consumption. Additionally, emissions from employee on-road vehicle trips would be 13 $MTCO_2e$/year. Therefore, total annual GHG emissions would be 28,153 $MTCO_2e$/year for the Project,[28] including amortized construction emissions and operational mobile source emissions. Direct emissions from the Project would exceed the 10,000 $MTCO_2e$/year benchmark. **Table 4.7-4** summarizes estimated operational GHG emissions.

Alternatively, if electricity from the grid is used to power the Project, indirect off-site emissions from power plants would be approximately 15,388 $MTCO_2e$/year, totaling 15,810 $MTCO_2e$/year when summed with on-road emissions and amortized construction emissions. These operational emissions would exceed the 10,000 $MTCO_2e$/year benchmark. Since the Project exceeds the benchmark, the Project's impact would be potentially significant. However, SMWD does not intend to adopt this as a threshold of significance. It is used as a benchmark to provide context for the Project's emissions.

It should be noted that SB 1078 requires retail sellers of electricity to provide at least 20 percent of their supply from renewable sources by 2017. This legislation also requires that each retail seller increase its total procurement of eligible renewable energy resources by at least an additional 1 percent of retail sales per year so that 20 percent of its retail sales are procured from eligible renewable energy resources. CARB also adopted the "Renewable Electricity Standard" on September 23, 2010, which requires 33 percent renewable energy by 2020 for most publicly owned electricity retailers. As a result, emissions from electricity consumption in the County would decrease, and at the time of the Project buildout, emissions would likely be less than current projections.

28 URBEMIS 2007 Version 9.2.4, February 2008; Appendix E1.

TABLE 4.7-4
ANNUAL GHG EMISSIONS

Activity	GHG Emissions (Metric tons CO_2e/year)
Construction	12,280
Amortized over 30 years	409
Operations	
Vehicle Trips	13
Natural Gas	27,731[a]
Electricity	15,388[a]
Total (with natural gas)	**28,153**
Total (with electricity)	**15,810**

[a] Electricity and natural gas emissions are based on the extraction value of 50,000 AFY. Natural gas consumption rates were obtained by using a 40% conversion efficiency for natural gas generators (thermal energy to electrical energy) and a 30% conversion efficiency for natural gas engines (thermal energy to mechanical energy). The natural gas engines that are used for the Project would be reciprocating (or internal combustion) natural gas engines, which typically offers energy efficiencies ranging from 25 to 45 percent (California Energy Commission, *California Distributed Energy Resource Guide,* http://www.energy.ca.gov/distgen/equipment/reciprocating_engines/-reciprocating_engines.html, accessed November 2011). Data shown are for 50,000 AFY. Emissions for the 75,000 AFY extraction value would be 37,330 MT/year and 21,610 MT/year for natural gas and electricity use, respectively.

NOTE: See Appendix E for detailed calculations

SOURCE: ESA, 2011.

Criterion C Analysis: Energy Efficiency. With regard to Item C, the Project would provide the ability to increase water supplies to urban uses in Southern California. As discussed in Section 4.13, the Project would require less energy per gallon delivered than used by the SWP. The CEC estimates that delivery of water via the SWP West Branch to northern Los Angeles County requires approximately 7,672 kWh/MG. The proposed Project would require the consumption of approximately 3,112 kWh/MG, which is less than half the energy required to convey the same amount of water through the SWP.[29] As a result, the Project provides a more energy efficient alternative to the SWP. Furthermore, the Project would utilize excess capacity in the CRA when available. The CRA pump stations currently operate with multiple single-speed pumps (each pump having a 220 cfs rating). The water pumped into the CRA by the Project would be accommodated with the existing pump capacity, without increasing energy requirements at the lift stations. As such, the proposed Project provides an efficient alternative to other imported water sources and would emit fewer GHG emissions.

Criterion D Analysis: Consistency with Applicable GHG Reduction Plan, Policy, or Regulation. With regard to Item D, MDAQMD currently does not have any GHG plan, policy or regulation and therefore, the proposed Project would not result in a conflict. Despite this, it would be consistent with DWP recommendations to fully develop the potential for integrated regional

[29] California Energy Commission, *California's Water – Energy Relationship*, November 2005, Figure 2-2 and page 23.

water management. However, the County of San Bernardino recently prepared a draft GHG Emissions Reduction Plan which identifies three external GHG emission water supply reduction measures. The three external GHG emission reductions are as follows:

R1. Existing and proposed State and regional water supply measures that do not require County action (Renewable Portfolio Standard (33 percent by 2020);

R2. Existing and new water supply measures that require County action. Reductions assume measure will affect water importation from the SWP only. The County's mandatory influence is for new development; impact on existing development must come through voluntary measures in cooperation with water providers; and

R3. Existing and new water supply measures—reductions not quantified or relied upon to achieve reduction goal (storm water runoff, conservations areas, financing mechanism, and opportunities.)

Goal R1 applies to GHG reduction goals identified by State and regional water supply entities. As discussed above, the Project would be consistent with AB32 goals. The proposed Project is consistent with the goals of R2, in that it is reducing reliance on SWP supplies. The Project is also consistent with R3 since it would reduce reliance on imported water from the SWP with a less energy intensive alternative. Therefore the proposed Project is consistent with the County's draft GHG reduction plan and policies.

In summary, based upon the analysis of Criteria A, B, C, and D presented above, the Project could result in a cumulatively considerable increase in GHG emissions such that the Project could indirectly and remotely impair the State's ability to implement AB 32. The impact would be potentially significant for both scenarios, regardless of whether the wellfield and intermediate pump station are powered with natural gas or electricity. The impact would be reduced to less than significant with mitigation through the purchase of carbon offset credits consistent with the policies and guidelines of AB 32.

Mitigation Measures

GHG-1: Within 90 days of completion of construction of the Groundwater Conservation and Recovery Component of the Project, carbon offset credits shall be purchased from the Climate Registry, or other source that is approved by CARB as being consistent with the policies and guidelines of the California Global Warming Solution Act of 2006 (AB 32), or that is approved by a local or regional agency with jurisdiction over or within San Bernardino County as local emissions credits under a GHG reduction plan or similar program, in sufficient quantity to reduce the Project's first year total (direct plus indirect) GHG emissions below 10,000 $MTCO_2e$ per year. The first year offsets identified in the binding agreement shall be purchased and retired no later than 12 calendar months from completion of the first full year of operation. The estimated amount of offsets required is 18,153 $MTCO_2e$ per year (i.e., 28,153 – 10,000 $MTCO_2e$ per year) if the wellfield and intermediate pump station are powered by natural gas. This volume may be reduced if less power is needed, solar power is provided, or diesel powered wells are retired at the Cadiz Ranch that would count as an offset.

If electricity from the grid is used, the required offsets are estimated to be 5,810 $MTCO_2e$ per year (i.e., 15,810 – 10,000 $MTCO_2e$ per year). Since offsets for off-site electricity generation is the responsibility of the energy generators, the Project may obtain verification of these offsets or purchase additional offsets as needed.

A GHG inventory shall be completed which will be verified by an accredited third-party verification body and reported to the Climate Registry. The Applicant shall purchase and retire such additional carbon offset credits (due to a net increase in emissions from the first full year of operations) as may be needed each year to ensure that the Project's total (direct plus indirect) GHG emissions are offset below the benchmark of 10,000 $MTCO_2e$ above existing 2011 conditions.

Significance Conclusion

Less than Significant with Mitigation.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Greenhouse Gas Emissions

Significance Threshold

Would the proposed Project generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment?

Would the proposed Project conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of GHG (including AB 32, the California Global Warming Solutions Act of 2006, and the AB 32 Scoping Plan)?

Impact Analysis

See Impact Analysis for the Groundwater Conservation and Recovery Component. The Imported Water Storage Component would increase energy usage and GHG emissions due to the conveyance of water from the CRA to the Fenner Valley and back to the CRA. The Imported Water Storage Component could require twice the power requirements of Phase I in a given year. However, in actuality based on water availability and in lieu storage opportunities, the energy use would not likely reach this amount. However, total new emissions associated with this operation may be greater than the 10,000 $MTCO_2e$ /year benchmark. Although these Project emissions may exceed this limit, the Project would not conflict with the AB 32 recommended actions listed in Table 4.7-2.

The additional storage provided by the Project would make up for the lack of water supplies during drought periods when other water supplies are unavailable. Therefore, it is consistent with DWR recommendations. The energy used to convey water in these years would be in place of SWP energy use since SWP deliveries would be reduced in these drought years. The Project would also provide underground storage that would reduce demands for additional above ground dry-year storage in Southern California, which would avoid the emissions required to construct this above ground storage. With mitigation measure GHG-2, impacts to Climate Change would be reduced to a less than significant level.

Mitigation Measures

GHG-2: Imported Water Storage Component. Within 90 days of completion of Project construction, carbon offset credits shall be purchased from The Climate Registry, or other source that is approved by CARB as being consistent with the policies and guidelines of the California Global Warming Solution Act of 2006 (AB 32), or that is approved by a local or regional agency with jurisdiction over or within San Bernardino County as local emission credits under a GHG Reduction Plan or similar program, in sufficient quantity to reduce the Project's total (direct plus indirect) GHG emissions below 10,000 $MTCO_2e$ per year, and each year purchase additional carbon offset credits (due to a net increase in emissions from first year operations) as may be needed to reduce emissions below 10,000 $MTCO_2e$.

Significance Conclusion

Less than significant with mitigation.

Mitigation Measure Summary Table

Table 4.7-5 presents the impacts and mitigation summary for Greenhouse Gas Emissions.

TABLE 4.7-5
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Greenhouse Gas Emissions	**GHG-1**	Less than significant with mitigation
Imported Water Storage Component		
Greenhouse Gas Emissions	**GHG-2**	Less than significant with mitigation

4.8 Hazards and Hazardous Materials

The purpose of this Section is to identify existing hazards and hazardous materials within the Project area, analyze potential hazards and hazardous materials associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.8.1 Environmental Setting

Regional Setting

The Project is located within the Eastern Mojave Desert consisting of a broad region of isolated mountain ranges separated by expanses of predominantly undeveloped desert plains. The valleys in the Mojave Desert are broad and the mountain ranges are widely spaced reaching heights of over 7,000 feet amsl. The region is crisscrossed with roadways and utilities and has historically supported varied hard rock mining ventures, mostly in the mountainous areas, and transportation corridor-related, small outpost communities. Many railroad outposts remain visible. Currently, active salt production occurs on the Bristol, Cadiz, and Danby Dry Lakes. The region has also supported historical military activities including desert training exercises and designated bombing ranges.

Local Setting

The Fenner Valley is located in the northern portion of the Project area. Elevations range from 7,532 feet amsl at the New York Mountains, located at the northernmost end of the Project area at the head of the Fenner Valley, to approximately 900 feet amsl at the Fenner Gap, where the production wells and spreading basins would be located. Generally, the Fenner Valley slopes south to southwest toward the Fenner Gap at the southern end of the valley. At this location, surface water drainage and groundwater flow down from the Fenner Valley and enter the Cadiz Valley to the south. The valley is considered one topographically-closed drainage system because all surface water and groundwater drain to the interior of the overall drainage basin.

Current and historical uses in the Project area include agriculture, aviation, former military use, historical mining activities, and existing natural gas pipelines. There are no residences, industrial facilities, or gasoline service stations within the Project area. Each of these uses, along with fire hazard issues, are discussed below with a focus on issues relative to hazards and hazardous materials.

Agriculture

Since at least 1986, the general Fenner Gap area has been used for agriculture. As previously discussed in Section 4.2, Agriculture and Forestry Resources, Cadiz Inc. currently grows grapes (dried-on-the-vine raisins), lemons, and seasonal row crops on approximately 1,600 acres in and

adjacent to the northern part of the Project area within Sections 21, 27, and 33 of Township 5 North, Range 14 East.

Above ground petroleum storage tanks and pesticide storage facilities in these areas support the Cadiz agricultural operations. The petroleum storage tank nearest to the proposed Project area is a diesel fuel tank located at Well 22, approximately 2-1/2 miles southwest of the proposed Project spreading basins. The tank is protected with a lined basin that provides secondary containment in the event of a leak or spill and prevents diesel fuel from entering the soil.

There are no hazardous materials storage areas in the immediate vicinity of the proposed Project spreading basins. Hazardous materials and pesticides are seldom used in connection with the Cadiz agricultural operations because the desert terrain produces fewer weeds and pests. Pesticide handling and application is performed by trained and certified employees of Cadiz Inc. and is conducted in accordance with Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and Occupational Safety and Health Administration (OSHA) regulations.

Aviation

The nearest public airports are located in Twentynine Palms, approximately 35 miles southwest of the Project and in Needles approximately 50 miles east of the Project. The nearest military airport is the Twentynine Palms Strategic Expeditionary Landing Field located approximately 40 miles west-southwest of the Project. The maximum FAA Notification Surface is within 20,000 feet or 3.79 miles of any point on the runway.[1] The CEQA criteria distance for a public airport is 2 miles. The proposed Project area is located well outside of the referenced distances to these public and military airports.

The privately-owned active Cadiz airstrip consists of a single asphalt airstrip and is located approximately 3 miles southwest of the Fenner Gap area and southwest of the location of the proposed production wells, spreading basins, and associated support infrastructure. The Cadiz airstrip has been operational since April 2002. The privately-owned active Danby airstrip consists of a single dirt airstrip located approximately 6 miles northeast of Fenner Gap and has been operational since June 1984. The largely-abandoned Rice airstrip consists of two non-maintained airstrips of uncertain construction and is located approximately 5 miles southeast of the location where the proposed pipeline is to connect to the CRA. The active Iron Mountain Pumping Plant airstrip consists of a single asphalt airstrip located approximately 6 miles southwest of the ARZC railroad tracks and has been operational since May 1976. The largely-abandoned Amboy airstrip consists of one 4,000 foot and one 2,000 foot non-maintained airstrips of uncertain gravel construction located just northwest of Amboy. None of these private airstrips have fueling or maintenance facilities.

Former Military Use and Existing Hazardous Materials Sites

The Project area is located within an area formerly used for military training. The Department of Defense (DOD) officially began using the area during the 1940s with the acquisition of various

[1] Code of Federal Regulations, *Title 14, CFR Part 77, Subpart B.*

tracts of land totaling tens of thousands of acres. Collectively, these areas were known as the Desert Training Center and, later, the California-Arizona Maneuver Area. The area currently has no military identification or uses. The former CAMA consisted of the Cadiz Lake Air to Ground Gunnery Range and Sonic Bombing Targets 1 through 10. Parts of the Cadiz Valley area were used by the Fourth Air Force stationed at March Field. The area was also used during World War II by General Patton's Armored Divisions for training in desert warfare, which involved the use of live ordnance.

A regulatory database search of existing sites with hazards or hazardous materials within and immediately adjacent to the Project footprint was conducted for the purpose of this analysis. The database search included a search of the Department of Toxic Substances Control[2] and State Water Resources Control Board[3] environmental website databases for sites with documented use, storage, or release of hazardous materials or petroleum products. The databases identified two former military sites in or near the Project area that are under active investigations for the presence of unexploded ordnance. The locations of the two sites are summarized below. The eastern portions of the former Cadiz Lake Sonic Target No. 5 are located at the westernmost portion of the proposed wellfield area where three production wells are proposed just inside or adjacent to the border of the former target area. The southeast corner of the former Cadiz Lake Sonic Target No. 9 is located at the optional proposed Equalization Storage Reservoir at the southernmost end of the proposed water conveyance pipeline. Both of these areas are former live ordnance target zones.

Cadiz Lake Sonic Target No. 5

A site inspection was conducted for the U.S. Army Corps of Engineers (USACE) at the former Cadiz Lake Sonic Target No. 5. The results were documented in a report dated September 2009 and summarized below.[4]

The Department of Defense acquired 2,560 acres from the Department of the Interior in accordance with a real estate directive dated July 3, 1946. It is likely that the DOD began using the site as early as 1942. The site was used by the Fourth Air Force stationed at March Field, California. It is believed that the site was used by General Patton's Armored Divisions for training in desert warfare in preparation for Operation Torch (the Allied invasion of North Africa during World War II). Some of this training may have involved the use of live ordnance. No known DOD improvements to the site have been documented. The site was declared surplus in 1948.

The September 2009 site investigation at the former Cadiz Lake Sonic Target No. 5 was performed to verify the site location and to evaluate evidence for the presence of munitions,

2 Department of Toxic Substances Control , *EnviroStor Database Results for Napa*, http://www.envirostor.dtsc.ca.gov/public/map.asp?global_id=&x=-119.1357421875&y=37.82280243352756&zl=5&ms=640,480&mt=m&findaddress=True&city=NAPA&zip=&county=&federal_superfund=true&state_response=true&voluntary_cleanup=true&school_cleanup=true&corrective_action=true&permit_site=true&permit_and_ca_site=true, accessed April 2011.

3 State Water Resources Control Board, *GeoTracker Database*, http://www.geotracker.swrcb.ca.gov/map/, accessed April 2011.

4 U.S. Army Corps of Engineers, *Final Site Inspection Report, Former Cadiz Lake Sonic Target No. 5, San Bernardino County, California*, September 2009, pages ES-1 to ES-3.

explosives of concern, and munitions debris at the former site. To accomplish this objective, qualitative reconnaissance and munitions constituents sampling were performed at the site. The site investigation identified the following issues:

- The site visit team found no munitions or explosives of concern. The team did find debris from M38A2 100-pound practice bombs, M1A1 spotting charges, .50-caliber cartridge casings, a link from two .50-caliber rounds, and numerous expended blank .308 cartridges.
- The munitions debris found during the site visit would have the potential to harm humans if they are contacted and are still functional. In addition, munitions debris found by the site visit team indicate the potential for other types of munitions debris at the site.

The report recommended conducting a remedial investigation/feasibility study to determine the need to further define the nature and extent of unexploded ordnance (UXO) at this site. The report did not recommend a removal action at this time based on the remote location of the site.

Cadiz Lake Sonic Target No. 9

A site inspection was conducted for the USACE at the former Cadiz Lake Sonic Target No. 9. The results were documented in a report dated September 2009 and summarized below.[5]

The former Cadiz Lake Sonic Target No. 9 site was acquired by the DOD in 1946 and was used by March Field for bombing practice between 1946 and 1948. The former site also lies within the former CAMA which was used during World War II between April 1942 and April 1944 to train soldiers and mechanized infantry in desert combat and survival techniques, to aid in the development of improved desert equipment, and to refine training techniques. Based on debris found, the site was determined to have been used for maneuvers and training as part of CAMA.

The September 2009 site investigation at the former Cadiz Lake Sonic Target No. 9 was performed to verify the site location and to evaluate evidence for the presence of munitions, explosives of concern, and munitions debris at the former site. To accomplish this objective, qualitative reconnaissance and munitions constituents sampling were performed at the site. The site investigation identified the following issues:

- The site visit team identified an intact M1 Tank projectile. The item was ultimately disposed of by the explosive ordnance disposal division from the Twentynine Palms U.S. Marine Corps Base.
- The munitions debris found during the site visit would have the potential to harm human receptors if they are contacted and are still functional. In addition, munitions debris found by the site visit team indicate the potential for other types of munitions debris at the site.

5 U.S. Army Corps of Engineers, *Final Site Inspection Report, Former Cadiz Lake Sonic Target No. 9, San Bernardino County, California*, pages ES-1 to ES-3.

The report recommended conducting a remedial investigation/feasibility study to determine the need to further define the nature and extent of UXO at this site. The report did not recommend a removal action at this time based on the remote location of the site.

Mining Activities

Other than the salt producing operations on the Dry Lakes, the USGS website for tracking active mining operations identified no active metals mining operations as of 2003[6] within the Project area. Although the Project area does not have any active mining operations, the region, including the Project area, does have a history of mining for mineral resources dating back to the 1800's. Various historical inactive and active mining operations exist within and near the Project area, along with the salt producing operations. (See Section 4.11) Most of these historical mining operations extracted metals such as gold, silver, copper, and lead. The historical mining sites are located in mountain ranges and hills. None of the historical mines are located at any of the Project's elements.

The salt producing operations on Bristol, Cadiz, and Danby Dry Lakes are often referred to as "mining" operations, although the process of recovering the salts does not involve excavation as is used for mining in hard rock. The salt producing operations at Bristol and Cadiz Dry Lakes recover sodium chloride (also called halite, rock salt, or table salt) and calcium chloride (commonly used for brine for refrigeration plants, ice and dust control on roads, and desiccation) by digging trenches to expose saline groundwater and then pumping additional saline water from wells into the trenches where evaporation removes water from the solution. Halite precipitates out as a solid, leaving the remaining solution concentrated with calcium chloride. The operations at Danby Dry Lake produce only halite. The salt producing operations are not located at any of the Project elements.

Existing Natural Gas Pipelines

Six interstate natural gas pipelines and appurtenant facilities are located in the Project vicinity (See Section 4.13) The EPNG natural gas Line 1903A or the PG&E Line 300 A&B could supply power to the Project facilities. As part of the Groundwater Conservation and Recovery Component, several options for powering the wells are being considered. One of the favored options would involve constructing a distribution system that would connect to the high pressure natural gas pipeline that traverses the Cadiz Property and would supply natural gas to a central power generator that would provide electric power for the pumps at each well. Some of the water conveyance pipelines to the water wells would cross the active natural gas lines.

Vegetation and Wildfire Hazards

Vegetation in the area includes blackbush scrub, desert dry wash woodland, desert saltbrush scrub, Mojave creosote bush scrub, Mojave mixed steppe, Mojave mixed woodland and succulent scrub, Mojave mixed woody scrub, Mojavean pinyon and juniper woodland, semi-desert

6 U.S. Geological Survey, *Mineral Resources Online Spatial Data*, http://mrdata.usgs.gov/mineral-resources/active-mines.html, accessed April 2011.

chaparral, and Sonoran creosote bush scrub. The Mojave creosote bush shrub is the most prevalent plant association and covers most of the valley floors; however, it is relatively sparse even in these areas. Further details of the flora and fauna is present in Section 4.4, Biological Resources.

The California Department of Forestry and Fire Protection (CAL FIRE) fire hazard severity zone map identifies the Project area as within the lowest level of its fire hazard severity zones, the lowest possible risk category.[7]

Hazardous Materials

Definitions

Chapter 6.5 of the California Health and Safety Code sets forth definitions and regulations related to hazardous materials management and disposal. The Code defines hazardous materials as

> "[Any material] that, because of its quantity, concentration or chemical characteristics, poses a significant present or potential hazard to human health or safety or to the environment if released into the workplace or the environment. Hazardous materials include, but are not limited to, hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment."

Hazards versus Risk

The health of workers and the general public are potentially at risk whenever hazardous materials have been used, or where exposure to such materials could occur. Inherent in the setting and analysis presented in this Section are the concepts of the "hazard" presented by these materials and the "risk" they pose to human health.

The level of risk to human health in a given environment is determined by the probability of exposure to a hazardous material and the severity of harm such exposure would pose. Therefore, a determination regarding the degree of risk takes into account the likelihood and means of exposure as well as the inherent toxicity of a material or hazard presented by a specific condition.

Responsible Agencies

Various regulatory agencies, such as the EPA and Cal EPA, the California Water Resources Control Board (SWRCB), the California Department of Toxic Substances Control (DTSC), and OSHA and California OSHA (Cal OSHA) are responsible for developing and/or enforcing risk-based standards to protect the public and the environment from hazards posed by hazardous materials. The California Department of Forestry and Fire Protection, Office of the State Fire Marshall, Pipeline Safety Division is responsible for developing and/or enforcing standards for

[7] California Department of Forestry and Fire Protection, *Very High Fire Hazard Severity Zone Map, Southeast San Bernardino County*, October 2008.

natural gas and petroleum product pipelines. Additional responsible agencies include the Santa Ana and Colorado River Basin Regional Water Quality Control Boards (RWQCB), MDAQMD, and Riverside County Community Health Agency, Department of Environmental Health (DEH).

4.8.2 Regulatory Framework

The term "hazardous materials" refers to both hazardous substances and hazardous wastes. Under federal and State laws, any material, including wastes, may be considered hazardous if it is specifically listed by statute as such or if it is toxic (causes adverse human health effects), ignitable (has the ability to burn), corrosive (causes severe burns or damage to materials), or reactive (causes explosions or generates toxic gases). A hazardous material is defined as any material that, because of quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment.[8]

In some cases, past industrial, military, or commercial activities on a site could have resulted in spills or leaks of hazardous materials to the ground, resulting in soil and/or groundwater contamination. Hazardous materials may also be present in building materials and released during building demolition activities. If improperly handled, hazardous materials and wastes can cause public health hazards when released to the soil, groundwater, or air. The four basic exposure pathways through which an individual can be exposed to a chemical agent include: inhalation, ingestion, bodily contact, and injection. Exposure can come as a result of an accidental release during transportation, storage, or handling of hazardous materials. Disturbance of subsurface soil during construction can also lead to exposure of workers or the public from stockpiling, handling, or transportation of soils contaminated by hazardous materials from previous spills or leaks. Areas with previous military operations may have UXO that may present explosion hazards or chemical hazards, as summarized above.

According to the EPA, materials and waste are considered hazardous based on four characteristics:

> **Ignitability** – Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F). Examples include waste oils and used solvents.
>
> **Corrosivity** Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels. Battery acid is an example.
>
> **Reactivity** – Reactive wastes are unstable under "normal" conditions. They can cause explosions or release toxic fumes, gases, or vapors when heated, compressed, or mixed with water. Examples include lithium-sulfur batteries and explosives.
>
> **Toxicity** – Toxic wastes are harmful or fatal when ingested or absorbed (e.g., wastes containing mercury, lead, etc.).

8 State of California, *Health and Safety Code*, Chapter 6.95, Section 25501(o).

According to the California Health and Safety Code (Section 25501), "hazardous material" means any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment. Hazardous materials released from historical land uses could be encountered within the footprint of the proposed Project.

Federal

The EPA is the lead federal agency responsible for enforcing federal regulations regarding hazardous materials and hazardous waste. The primary legislation governing hazardous materials and hazardous waste are the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund Amendments and Reauthorization Act (SARA).

Resource Conservation and Recovery Act

RCRA regulates the generation, transportation, treatment, storage and disposal of hazardous waste by "large-quantity generators" (1,000 kilograms per month or more) through comprehensive life cycle or "cradle to grave" tracking requirements. The requirements include maintaining inspection logs of hazardous waste storage locations, records of quantities being generated and stored, and manifests of pick-ups and deliveries to licensed treatment/storage/ disposal facilities. RCRA also identifies standards for treatment, storage, and disposal.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, also known as Superfund, created a tax on the chemical and petroleum industries to provide for response and cleanup of hazardous substances that may endanger public health or the environment. CERCLA established requirements for the treatment of abandoned hazardous waste sites and provided for liability of persons responsible for releases of hazardous waste at these sites.

Superfund Amendments and Reauthorization Act

SARA amended CERCLA to increase state involvement and required Superfund actions to consider state environmental laws and regulations. SARA also established a regulatory program for underground storage tanks (USTs) and the Emergency Planning and Community Right-to-Know Act.

Occupational Safety and Health Act

The OSHA administers the Occupational Safety and Health Act, which requires special training of handlers of hazardous materials, notification to employees who work in the vicinity of hazardous materials, and acquisition from the manufacturer of material safety data sheets (MSDS). An MSDS describes the proper use of hazardous materials. The Act also requires the training of employees to remediate any hazardous material accidental releases.

State

The DTSC is primarily responsible for the regulation of hazardous materials in California. DTSC is responsible for the management of hazardous substances and oversees the investigation and remediation of contaminated sites. The Colorado River RWQCB is primarily responsible for the protection of groundwater and surface-water resources from hazardous materials.

California Occupational Safety and Health Act

The Cal OSHA regulates worker safety similar to federal OSHA but also requires preparation of an Injury and Illness Prevention Program, an employee safety program of inspections, procedures to correct unsafe conditions, employee training, and occupational safety communication. In addition, Cal OSHA regulations indirectly protect the general public by requiring construction managers to post warnings signs, limit public access to construction areas, and obtain permits for work considered to present a significant risk of injury, such as excavations greater than five feet.

Unified Hazardous Waste and Hazardous Materials Management Regulatory Program

Cal EPA adopted regulations in 1996 to establish a Unified Hazardous Waste and Hazardous Materials Management Regulatory Program and designated local agencies called Certified Unified Program Agencies (CUPA). The local agencies regulate hazardous substances management with respect to the following areas:

- Hazardous waste generators and hazardous waste onsite treatment
- USTs
- Aboveground storage tanks
- Hazardous materials release response plans and inventories (business plans), including Unified Fire Code hazardous materials management plans and inventories
- Risk management and accidental release prevention programs

The CUPA in the Project area is the San Bernardino County Fire Department – Hazardous Materials Division.

Waters Bill of 1985 (Business Emergency Plan/Hazardous Materials Business Plan)

Administered by the CUPA, the Waters Bill requires facilities that meet minimum hazardous materials use/storage thresholds to file a Business Emergency Plan (BEP), or a Hazardous Materials Business Plan (HMBP). A BEP or HMBP includes a complete inventory of the hazardous materials being used and stored on a site. Employee training and emergency response plans and procedures for the accidental release of hazardous materials are also included in a BEP.

Safe Drinking Water and Toxics Enforcement Act (Proposition 65)

Administered by the CUPA, the Safe Drinking Water and Toxics Enforcement Act requires businesses that use hazardous materials to post public notices of the accidental release of hazardous materials or other potential exposures to materials known to the State of California to

cause cancer or reproductive toxicity. The Act prohibits such businesses from releasing hazardous materials into the environment at levels above identified risk levels.

Uniform Fire Code

The Uniform Fire Code is administered by the CUPA via regular site inspections. The code regulates the type, configuration, and quantity of hazardous materials that may be stored within structures or in outdoor areas.

Local

San Bernardino County

AB 2948 (Chapter 1504, Statutes of 1986), commonly known as the Tanner Bill, authorizes counties to prepare Hazardous Waste Management Plans (HWMPs) in response to the need for safe management of hazardous wastes. The HWMP was adopted by the County of San Bernardino Board of Supervisors and approved by the California Department of Health Services in February 1990. The HWMP serves as the primary planning document for the management of hazardous waste in San Bernardino County. The HWMP identifies the types and amounts of wastes generated in the County; establishes programs for managing these wastes; identifies an application review process for the siting of specified hazardous waste facilities; identifies mechanisms for reducing the amount of waste generated in the County; and identifies goals, policies, and actions for achieving effective hazardous waste management.

The San Bernardino County Fire Department – Hazardous Materials Division is the local agency responsible for the enforcement of a variety of hazardous materials management requirements. They are the State designated CUPA for the County of San Bernardino (excluding the City of Victorville). The purpose of the CUPA program is to provide a comprehensive approach to reduce the overlapping and sometimes conflicting requirements of different governmental agencies. The CUPA provides consolidation and consistency in reporting requirements, permit formats, inspection criteria, enforcement standards, and fees for various hazardous materials programs. The CUPA is required by State law to maintain a list of facilities within the County that are known to use, store, and/or generate hazardous materials/wastes. Facilities that handle hazardous materials or generate hazardous waste must obtain a permit from the CUPA. The San Bernardino County Fire Department manages the hazardous material and hazardous waste programs noted above.

4.8.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to hazards and hazardous materials if it would:

- Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials;

- Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment;
- Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school;
- Be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment;
- Result in a safety hazard for people residing or working in the Project area for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport;
- Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan; or
- Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands.

Methodology

The qualitative analysis in this Section focuses on potential public safety and hazards impacts, including the use, disposal, transport, or management of hazardous or potentially hazardous materials resulting from the construction and operation of the Project. The evaluation considered Project plans, current conditions at the Project area, and applicable regulations and guidelines.

Groundwater Conservation and Recovery Component

Routine Transportation, Use, Disposal or Release of Hazardous Materials

Significance Threshold

Would the proposed Project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

Would the proposed Project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?

Impact Analysis

The routine transport, use, and disposal of hazardous materials could result in hazards to people and the environment due to the potential for accidental release. Such hazards are typically associated with certain types of land uses, such as chemical manufacturing facilities, industrial processes, waste disposal, and storage and distribution facilities. As part of Project construction, potentially hazardous materials, including equipment fuel, paints, lubricants, antifreeze, solvents,

and other potentially hazardous materials would be transported to, stored, and used in the Project area. It is anticipated that one or more temporary, above-ground fuel storage tanks would be used throughout the proposed Project construction to service construction equipment. Because of the remote Project location, servicing and emergency repair of construction equipment may occur in the proposed Project area. Equipment servicing and repair could result in the generation of oily and hazardous wastes such as spent solvents, residual fuels, used oils, and filters. Potentially hazardous materials may also be required for operation of the Project, including natural gas that is proposed to power the well pumps. The site wells are currently powered by diesel fuel from an onsite above-ground storage tank located within a secondary containment structure. The wells' power also is to be converted to natural gas, thus removing the need for the storage of fuels for the well pumps.

Mishandling of these fuel materials could result in their accidental release to the environment, which could in turn result in a hazardous condition to workers, the public, or the environment. However, by following applicable laws and regulations, as described in Regulatory Framework above, the safe handling and use of hazardous materials and the safe disposal of the resulting hazardous wastes could be managed and achieved. More specifically, federal and State agencies would determine driver-training requirements, load labeling procedures, and container specifications to minimize the risk of accidental release.

The net result of compliance would be the reduction of risks and hazards to workers, the public, and the environment, to levels that are considered acceptable for all hazardous materials proposed for use. Implementation of Mitigation Measure **HAZ-1** would ensure that transportation, storage, and handling of hazardous materials would not result in accidental releases that could significantly impact neighboring land uses.

Mitigation Measures

> **HAZ-1**: On-site materials storage, fueling, and vehicle maintenance areas shall be equipped with secondary containment and spill containment equipment. Storage, handling, and disposal of hazardous materials shall comply with applicable regulations including submittal of a Business Plan to the County Fire Department.

Significance Conclusion

Less than significant with mitigation.

Hazardous Materials Use Near Schools

Significance Threshold

Would the proposed Project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?

Impact Analysis

There are no schools located within a quarter mile of the Project. Therefore, there would be no impacts to schools and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Hazardous Material Sites

Significance Threshold

Would the proposed Project be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment?

Impact Analysis

The facilities to be constructed as part of the Groundwater Conservation and Recovery Component are not located on a site listed on a hazardous material site list pursuant to Government Code Section 65962.5. However, the area has a known history of military use and UXO has been found in others areas. Moreover, construction of the Project facilities would involve grading and excavation, and therefore the potential of encountering previously unidentified hazardous materials is present. Encountering contaminated soil, surface water, and groundwater without taking proper precautions could result in the exposure of construction workers and the environment to hazardous conditions. Mitigation Measure **HAZ-2** would ensure that any previously unknown contamination is handled appropriately in coordination with the CUPA.

Project construction and operations would result in the installation of three production wells just within or along the border of the former Cadiz Lake Sonic Target No. 5. The southwestern corner former Cadiz Lake Sonic Target No. 9 intersects the location of the optional (Option A) Equalization Storage Reservoir and associated piping. Construction activities could encounter UXO and could result in exposing workers and equipment to a hazardous condition.

Explosive materials may become more unstable over time, increasing the possibility of harm if encountered. Although the USACE has conducted some field investigations, is it not possible to identify the exact locations and nature of these wastes in the Project area. However, based on previous military uses and records indicating the discovery of UXO in the proposed Project area, it is possible that some UXO may be encountered during construction. Therefore, construction of the water conveyance facilities, power distribution facilities, and Project wellfield may result in

significant adverse ordnance and explosive wastes hazards. Implementation of Mitigation Measures **HAZ-2** and **HAZ-3** would be required to reduce impacts to a less than significant level.

Mitigation Measures

HAZ-2: If excavation uncovers contaminated materials, excavation activities shall cease in the contaminated area. Soil samples shall be collected to characterize the soils and contamination. The CUPA shall be notified of the sample results. The construction contractor shall stockpile contaminated soils on plastic sheeting as necessary to prevent releasing contamination into the ground and shall ultimately dispose of the materials in coordination with the CUPA in compliance with hazardous material regulations.

HAZ-3: Prior to installation of the Project elements within 250 feet of the Cadiz Sonic Lake Target No. 5 and No. 9 areas, the USACE shall be requested to clear the proposed locations for the potential presence of unexploded ordnance from historical military uses. In the event that the USACE encounters unexploded ordnance, the USACE is obligated to remove the unexploded ordnance under their ongoing investigations.

Significance Conclusion

Less than significant with mitigation.

Airport Hazards

Significance Threshold

Would the proposed Project result in a safety hazard for people residing or working in the Project area for a project within the vicinity of a private airstrip or within an airport land use plan?

Impact Analysis

The Project is not located within an airport land use plan or within two miles of a public or public-use airport where no plan has been adopted. The nearest public airport is located approximately 35 miles from the proposed Project area. All of the local private airstrips are lightly-used single airstrips with no available facilities (e.g., fuel and maintenance) other than the landing airstrip. Only small single or twin-engine aircraft would be able to land. The airstrips are all located outside of the Project footprint and over 2 miles away from any Project component. The nearest airstrip (Cadiz airstrip) is located approximately three miles southwest of the wellfield area. Airstrips are not commercial airports, and therefore, none have airport land use plans. Nevertheless, once constructed, all Project facilities and components would be located below ground or at the surface with minimal height. As such, the potential for collision is considered very low. Therefore, the potential impact associated with local airstrips would be considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Emergency Response Plans

Significance Threshold

Would the proposed Project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

Impact Analysis

The elements of the Project are not located on any roads and do not interfere with adopted emergency response plans or evacuation routes defined by any local jurisdictions. The proposed Project area is not located in the immediate vicinity or flight path of a major airport. Private airstrips are located at Amboy, at the Cadiz agricultural operations and at the Iron Mountain Pumping Plant. The proposed Project area is sparsely vegetated, making the likelihood of wildland fires very low. Emergency responses to remote parts of eastern San Bernardino County typically involve helicopter transport, which would not be hindered by proposed Project construction or operation. Therefore, no impact would occur and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Grassland and Wildland Fires

Significance Threshold

Would the proposed Project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

Impact Analysis

The Project would be located within a sparsely-vegetated desert area. The CAL FIRE fire hazard severity zone map identifies the Project area as within its lowest fire hazard severity zone, the lowest possible risk category. Proposed Project impact areas associated with the Groundwater Conservation and Recovery Component are not located adjacent to urbanized areas or residences. The nearest residences are located in Chambless, approximately 5 miles from the Project site. Impacts associated with implementation of the proposed Project are considered less than significant and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Routine Transportation, Use, Disposal or Release of Hazardous Materials

Significance Threshold

Would the proposed Project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

Would the proposed Project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?

Impact Analysis

As with the Groundwater Conservation and Recovery Component, potentially hazardous materials, including fuels, paints, lubricants, antifreeze, solvents, and other potentially hazardous materials needed for construction and operations activities for the spreading basins, pipeline extension, and expanded wellfield would be transported to and stored in the Project area. Potentially hazardous materials may also be required for operations, including natural gas proposed for powering well pumps and chemicals used to prepare the existing natural gas pipeline for water conveyance.

Mishandling of these materials could result in their accidental release to the environment, which could in turn result in a hazardous condition to workers, the public, or the environment. However, by following applicable laws and regulations, as described in Regulatory Framework above, the safe handling and use of hazardous materials and the safe disposal of the resulting hazardous wastes could be achieved. The net result of compliance would be the reduction of risks and hazards to workers, the public, and the environment to levels that are considered acceptable for all hazardous materials proposed for use.

Therefore, impacts would be less than significant with implementation of Mitigation Measure **HAZ-1**.

Mitigation Measures

Implement Mitigation Measure **HAZ-1**.

Significance Conclusion

Less than significant with mitigation.

Hazardous Materials Use Near Schools

Significance Threshold

Would the proposed Project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?

Impact Analysis

There are no schools located within a quarter mile of the Project. Therefore, there would be no impacts to schools and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Hazardous Material Sites

Significance Threshold

Would the proposed Project be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment?

Impact Analysis

Project construction and operations activities associated with the Imported Water Storage Component of the proposed Project would result in the construction of recharge basins and associated piping. The recharge basins are not located on a site listed on a hazardous material site list pursuant to Government Code Section 65962.5. However, the area has a known history of military use and UXO has been found in others areas. As previously discussed, construction activities could encounter UXO and could result in exposing workers and equipment to a hazardous condition. Encountering contaminated soil, surface water, and groundwater without taking proper precautions could result in the exposure of construction workers and the environment to hazardous conditions.

The potential hazards to human health are associated with the presence of ordnance and explosive waste within the proposed Project area. The presence of ordnance and explosive wastes would pose the greatest risk during construction of the proposed Project when earth-moving activities

are likely to result in disturbance. Explosive materials may become more unstable over time, increasing the possibility of harm from residual wastes. Although the USACE has conducted some field investigations, is it not possible to quantify the risk associated with ordnance and explosive wastes in the proposed Project area as the exact locations and nature of these wastes are not known. However, based on previous military uses and records indicating the discovery of ordnance and explosive wastes in the proposed Project area, it is possible that some ordnance and explosive wastes may be encountered during construction. The presence of former ranges and bombing targets suggests that a greater concentration of ordnance and explosive wastes may exist at these locations but does not preclude the possibility that ordnance and explosive wastes may exist outside these areas. Therefore, construction of the recharge basins and associated pipelines and power distribution facilities may result in significant adverse ordnance and explosive wastes hazards. Implementation of Mitigation Measure **HAZ-3**, discussed above and copied below, would be required to reduce impacts to a less than significant level.

Mitigation Measures

Implement Mitigation Measure **HAZ-3**.

Significance Conclusion

Less than significant with mitigation.

Airport Hazards

Significance Threshold

Would the proposed Project result in a safety hazard for people residing or working in the Project area for a project within the vicinity of a private airstrip or within an airport land use plan?

Impact Analysis

As described with the Groundwater Conservation and Recovery Component above, the Project is not located within an airport land use plan or within two miles of a public or public-use airport where no plan has been adopted. The nearest public airport is located approximately 35 miles from the proposed Project area. All of the local private airstrips are lightly-used single airstrips with no available facilities (e.g., fuel and maintenance) other than the landing airstrip. Only small, single- or twin-engine aircraft are able to land. The airstrips are all located outside of the Project footprint and over 2 miles away from any Project component. The nearest airstrip is the Cadiz airstrip, located approximately 3 miles southwest of the proposed spreading basin area. Airstrips are not commercial airports, and therefore none have airport land use plans. Nevertheless, once constructed, all of the Project elements would be below ground or at the surface with minimal height. As such, the potential for collision is considered very low. Therefore, the potential impact associated with local airstrips would be considered less than significant.

The existing natural gas pipeline is located in proximity to the Barstow-Daggett Airport located between the community of Daggett and City of Bartow which is a county-owned public-use

airport, north of the pipeline. The airport consists of two paved runways. However, the pipeline alignment is not within an airport land use plan. The pipeline currently exists and construction would be conducted within the existing right-of-ways. The proposed pump stations and air valves would not create a safety hazards to the airports as the pump stations would be located at the 32 and 40 milepost from the Cadiz Property at a ridge crossing and the air valves locate at half-mile intervals would have a maximum height of four feet. The appurtenances would not subject people to hazards from the airport or affect operations at the airport. Therefore, impacts would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Emergency Response Plans

Significance Threshold

Would the proposed Project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

Impact Analysis

The elements of the Project are not located on any roads and do not interfere with adopted emergency response plans or evacuation routes defined by any local jurisdictions. The proposed Project area is not located in the immediate vicinity or flight path of a major airport. Private airstrips are located at Amboy, at the Cadiz agricultural operations and at the Iron Mountain Pumping Plant. The proposed Project area is sparsely vegetated, making the likelihood of wildland fires very low. Emergency responses to remote parts of eastern San Bernardino County typically involve helicopter transport, which would not be hindered by proposed Project construction or operation. Therefore, no impact would occur and no mitigation is required.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Grassland and Wildland Fires

Significance Threshold

Would the proposed Project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

Impact Analysis

The spreading basins would be located within a sparsely-vegetated desert area. The CAL FIRE fire hazard severity zone map identifies the Project area as within its lowest fire hazard severity zone, the lowest-possible risk category. Proposed Project impact areas associated with the Imported Water Storage Component are not located adjacent to urbanized areas or residences. The nearest residences are located in Chambliss, approximately 5 miles from the Project site.

The existing natural gas pipeline area is primarily characterized as arid desert terrain with limited sparse vegetation. The pipeline is located within a low fire hazard severity zone and now located adjacent to urbanized areas or residences. Impacts associated with implementation of the proposed Project are considered less than significant and no mitigation is required. Mitigation Measures

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Mitigation Measure Summary Table

Table 4.8-1 on the following page presents the impacts and mitigation summary for Hazards and Hazardous Materials.

TABLE 4.8-1
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Routine Transportation, Use, Disposal or Release of Hazardous Materials	**HAZ-1**	Less than significant with mitigation
Hazardous Materials Use Near Schools	None required	No impact
Hazardous Material Sites	**HAZ-2** and **HAZ-3**	Less than significant with mitigation
Airport Hazards	None required	Less than significant
Emergency Response Plans	None required	No impact
Grassland and Wildland Fires	None required	Less than significant
Imported Water Storage Component		
Routine Transportation, Use, Disposal or Release of Hazardous Materials	**HAZ-1**	Less than significant with mitigation
Hazardous Materials Use Near Schools	None required	No impact
Hazardous Material Sites	**HAZ-3**	Less than significant with mitigation
Airport Hazards	None required	Less than significant
Emergency Response Plans	None required	No impact
Grassland and Wildland Fires	None required	Less than significant

4.9 Hydrology and Water Quality

The purpose of this Section is to describe existing hydrology and water quality within the Project area, analyze potential impacts to hydrology and water quality associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. The primary information sources include Project-specific investigations that are compiled in **Appendix H** and available resources from the USGS and the CGS. Thresholds of significance for the impact analysis are from Appendix G of the 2011 *CEQA Guidelines*.

In addition to the *CEQA Guidelines*, FVMWC's operation of the Project would be overseen by a Technical Review Panel under a GMMMP (Appendix B1), which incorporates additional safeguards and action criteria if adverse conditions occur attributable to the Project.

4.9.1 Environmental Setting

This Section presents an overview of the regional setting that describes the watersheds, climate and vegetation, surface water and groundwater hydrology, and water quality, and identifies the locations of the Project elements within the setting. More comprehensive discussions of each of the local physiography, climate, hydrology, and water quality characteristics of the setting can be found in the references cited in each Section below.

Regional Setting

The Project area is located in the eastern Mojave Desert, San Bernardino County, California (part of the Mojave Desert Geomorphic Province[1, 2]), approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see Figure 3-1). The Mojave Desert Geomorphic Province is a broad interior region of isolated mountain ranges separated by expanses of desert plains. It has an interior enclosed drainage and many playas, also referred to as dry lakes.[3] Section 4.6, Geology provides a detailed description of the topography, geology, structural geology, and seismicity.

The Watersheds

The overall drainage basin in which the proposed Project would be constructed consists of four Watersheds, as shown on **Figure 4.9-1**. The Watersheds are considered one topographically-closed drainage basin because all surface water and groundwater drains to the interior of the overall drainage basin. The total area of the combined basin system is approximately 2,320 square miles and consists of the Fenner Watershed (1,090 square miles), the Bristol Watershed (640

1 Norris, Robert M. and Robert W. Webb, *Geology of California*, Second Edition, 1990, pages 220-225.
2 California Geological Survey, *California Geomorphic Provinces*, Note 36, 2002, page 3.
3 The terms playas and dry lakes are generally synonymous, but more specifically, dry lake areas are generally considered to be the innermost center areas of playas.

square miles, which is considered to include the 160 square mile Orange Blossom Wash Watershed), and the Cadiz Watershed (590 square miles).[4]

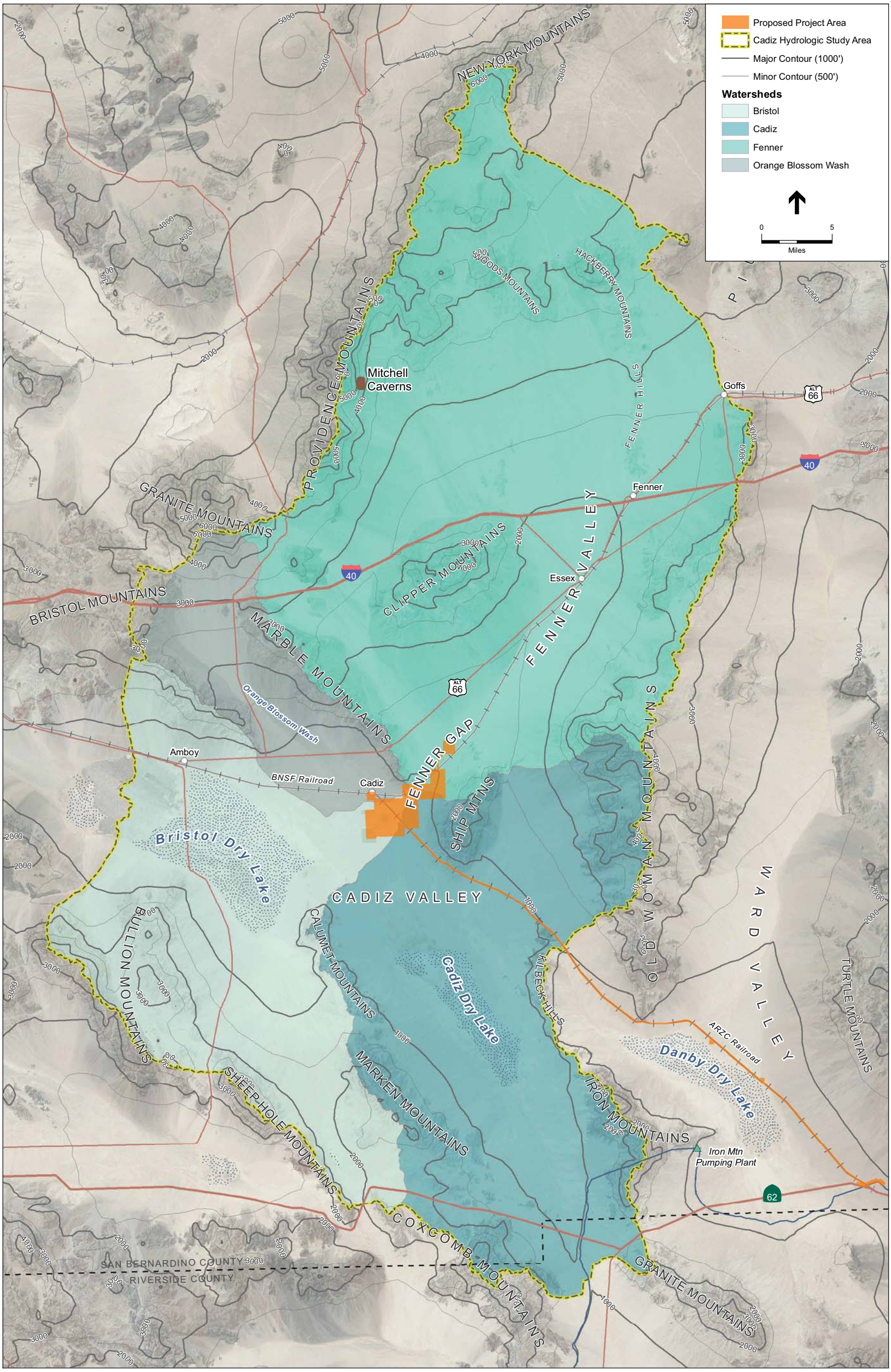
The Fenner Watershed is located in the northern portion of the Project area. The New York Mountains, located at the northernmost end of the Project area at the head of the Fenner Watershed, are the highest mountains in the Project area, rising to an elevation of approximately 7,532 feet National Geodetic Vertical Datum of 1988 (NGVD).[5] The mountains bounding the east and west sides of Fenner Valley range in height from 4,165 to 7,178 feet NGVD.[6] Generally, the Fenner Valley slopes south to southwest toward the Fenner Gap, located at the southern end of the valley between the Marble and Ship Mountains, at an elevation of about 900 feet NGVD. At this location, surface water drainage and groundwater flow from the Fenner Watershed enters the Bristol and Cadiz Watersheds to the south. Surface water has been observed to flow over the Fenner Gap each year at least once since 1991 after rain events of sufficient precipitation volume.[7]

The Bristol and Cadiz Watersheds are located in the southern portion of the Project area, surrounded by the Bristol, Iron, Bullion, Sheep Hole, Calumet and Coxcomb Mountains, ranging in elevations from 1,751 to 4,685 feet NGVD.[8] The surface water drainage and groundwater flow from the Watersheds in this Project area and drain into the Bristol and Cadiz Dry Lakes, which have surface elevations of approximately 595 and 545 feet NGVD, respectively.[9] The Bristol and Cadiz Dry Lakes are separated by a low topographic and surface drainage divide. Since the Watersheds are part of a closed drainage system, the only natural outlet for surface water and groundwater is through evaporation at the dry lake surfaces. These surfaces are normally dry but flash flooding from high intensity rain storms can result in standing water that can remain for weeks before evaporating.[10,11,12]

As noted above, the Orange Blossom Wash is generally considered a part of the Bristol Watershed. This Watershed is located along the western portion of the Project area between the Marble and Bristol Mountains. The Orange Blossom Wash begins at the Granite Mountains, which are located just outside the western border of the Project area and rise to 6,786 feet NGVD and drains to the southeast into the Bristol Watershed, discussed above.

Cadiz Inc. owns 34,000 acres located at the confluence of the Watersheds, as shown on Figure 4.9-1, and has maintained agricultural operations at this property since the early 1990s. The agricultural operation irrigates its crops with groundwater extracted from wells located in and south of Fenner Gap.

4 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.3.
5 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-1.
6 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.
7 Cadiz Inc., *Communication with ESA*, December 9, 2010.
8 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.
9 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.
10 Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*, U.S. Geological Survey Bulletin, 1045-D, 1959, pages 97-138.
11 Koehler, J.H., *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California*: USGS Water Resources Investigations Report 83-4053, 1983, page 2.
12 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume I, Report No. 1163*, November 1999, page 29.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-1

Topographic Map and Watershed Boundaries

This page left intentionally blank

Historical groundwater use is discussed further below. As discussed further below in subsection entitled "Groundwater Hydrology, Summary of Groundwater in Storage", the volume of groundwater in storage in the alluvium of the Fenner Valley and northern portion of the Bristol Valley area is estimated to be 17 to 34 MAF.[13] There is additional groundwater in the freshwater zone south of the Fenner Gap, estimated to be between 4 and 10 MAF. [14]

The area is also traversed by two active railroad lines: the east-west BNSF rail line traverses the Bristol and Fenner Watersheds; the northwest-southeast ARZC rail line starts at the connection to the BNSF rail line at Cadiz and travels southeast where it crosses the CRA south of Danby Dry Lake.

Relationship of Project Components to the Watersheds

As described in Chapter 3, Project Description, the Project consists of two distinct but interrelated components: the Groundwater Conservation and Recovery Component and the Imported Water Storage Component.

The Conservation and Recovery Component is designed specifically to extract and conserve water originating in the Fenner and northern portion of the Bristol Watersheds that would otherwise migrate to the area below the Dry Lakes in the Bristol and Cadiz Watersheds, where the water currently becomes saline and is lost to evaporation. Five of the existing and approximately 29 proposed production wells [15] would be located within and just south of the Fenner Gap area (see Figure 3-6b) and would extract an average of 50,000 AFY of groundwater over a 50-year period [16] from the alluvial and carbonate geologic units described in Section 4.6, Geology. In order to substantially reduce the loss of potable water to evaporation, subsurface hydraulic control would be created at Fenner Gap by lowering the water table to intercept natural recharge as well as retrieve groundwater to the south of the well field that would otherwise be lost to the Dry Lakes.[17] To create the hydraulic control, groundwater would be withdrawn from operational storage in a localized area, thus modifying the underlying groundwater gradient and preventing the present outflow of groundwater to the Bristol and Cadiz Watersheds, where the water would become saline and then evaporate at the Dry Lakes.[18]

13 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.
14 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Table 3-1.
15 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 5.5.
16 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.5.
17 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.6.
18 Geoscience's previous analysis demonstrated that pumping in excess of the natural recharge is necessary to reduce the evaporative losses to the dry lakes. Project pumping of 50,000 acre-ft/yr and 75,000 acre-ft/yr was used for determining the volumes of conservation using the ground water model. The analysis showed that conservation of evaporative losses increases with increased Project pumping by retrieving water that was moving down-gradient towards the dry lakes. In other words, Project pumping of 50,000 acre-ft/yr will result in increased conservation of evaporative losses above the natural recharge (32,000 acre-ft/yr) and Project pumping of 75,000 acre-ft/yr will further increase conservation by reducing outflows to the dry lakes. However, due to Project uncertainties with natural recharge, a pumping rate of 50,000 acre-ft/yr was selected for the Project to balance the objective of retrieving water before it can evaporate with the intent to minimize impacts. Pumping of less than the proposed 50,000 acre-ft/yr will result in an increase of loss to the dry lakes relative to Project pumping of 50,000 acre-ft/yr. GEOSCIENCE Support Services, Inc., *Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis*, November 2011.

For this Component of the Project, a production wellfield and manifold piping system would be constructed to carry the pumped groundwater to a new 43-mile conveyance pipeline, shown on Figure 3-1. The conveyance pipeline would be buried approximately 15 feet deep along the ARZC railroad ROW on privately-owned, pre-disturbed land (See Chapter 3, Project Description for details on the facilities).

The Imported Water Storage Component would allow participating water providers to send surplus surface water supplies, when available, to the Project area to be recharged into the groundwater aquifer system via spreading basins and held in storage until needed in future years. The spreading basins would be located at and just north of Fenner Gap and would recharge the aquifer system beneath the Project area. This second phase of the Project's operation would be limited to the same 50-year term as the Groundwater Conservation and Recovery Component. When needed, the stored surface water would be pumped out of the aquifer system and returned to the appropriate participating provider. The maximum capacity of the Project's Imported Water Storage Component is 1 MAF at any given time. Based on the available storage capacity in the Fenner Valley, withdrawal of groundwater stored in the aquifer, should the Imported Water Storage Component be implemented, would be limited to a combined maximum of 105,000 AFY. This reflects the maximum 75,000 AFY capacity of the 43-mile conveyance pipeline to the CRA and, potentially, an additional 30,000 AFY that could be conveyed through a converted natural-gas pipeline. The wellfield would be expanded so that 105,000 AFY of imported water could be returned to the CRA and, potentially, the SWP.

The facilities proposed for this component of the Project include an additional 10 to 15 wells in the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply, and distribution facilities; and a CRA diversion structure and pump station.[19] With the exception of the pipeline that would connect the Project to the CRA, the Project elements and any potential impacts would be located within the interior drainage basin of the Watersheds. The facilities for the Project would cover, depending on the wellfield configuration chosen; either 155 or 175 acres of the 25,000 acres owned by Cadiz and considered part of the Project. Chapter 3, Project Description provides a more detailed description of the proposed Project.

Climate

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower temperatures and higher precipitation at higher altitudes.

The seasonal weather patterns of the eastern Mojave Desert region are primarily controlled by semi-permanent high and low pressure systems located over North America and the Pacific

[19] CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.5.2.

Ocean.[20] During the summer months, a semi-permanent high-pressure cell (the Pacific High), centered over the north Pacific about 1,600 miles west of the California coast, typically diverts low-pressure, moisture-carrying weather systems north of California.[21] The Pacific High contracts and moves southward during the winter months, allowing storms to cross California. Another semi-permanent high-pressure cell (the Great Basin High) is centered over southern Idaho during the winter months and deflects cold Canadian low-pressure weather cells to the east of the Project area.[22] During the summer, a seasonal low-pressure weather cell (the California Low) often develops over the vicinity of the Project area as a result of intense surface heating.

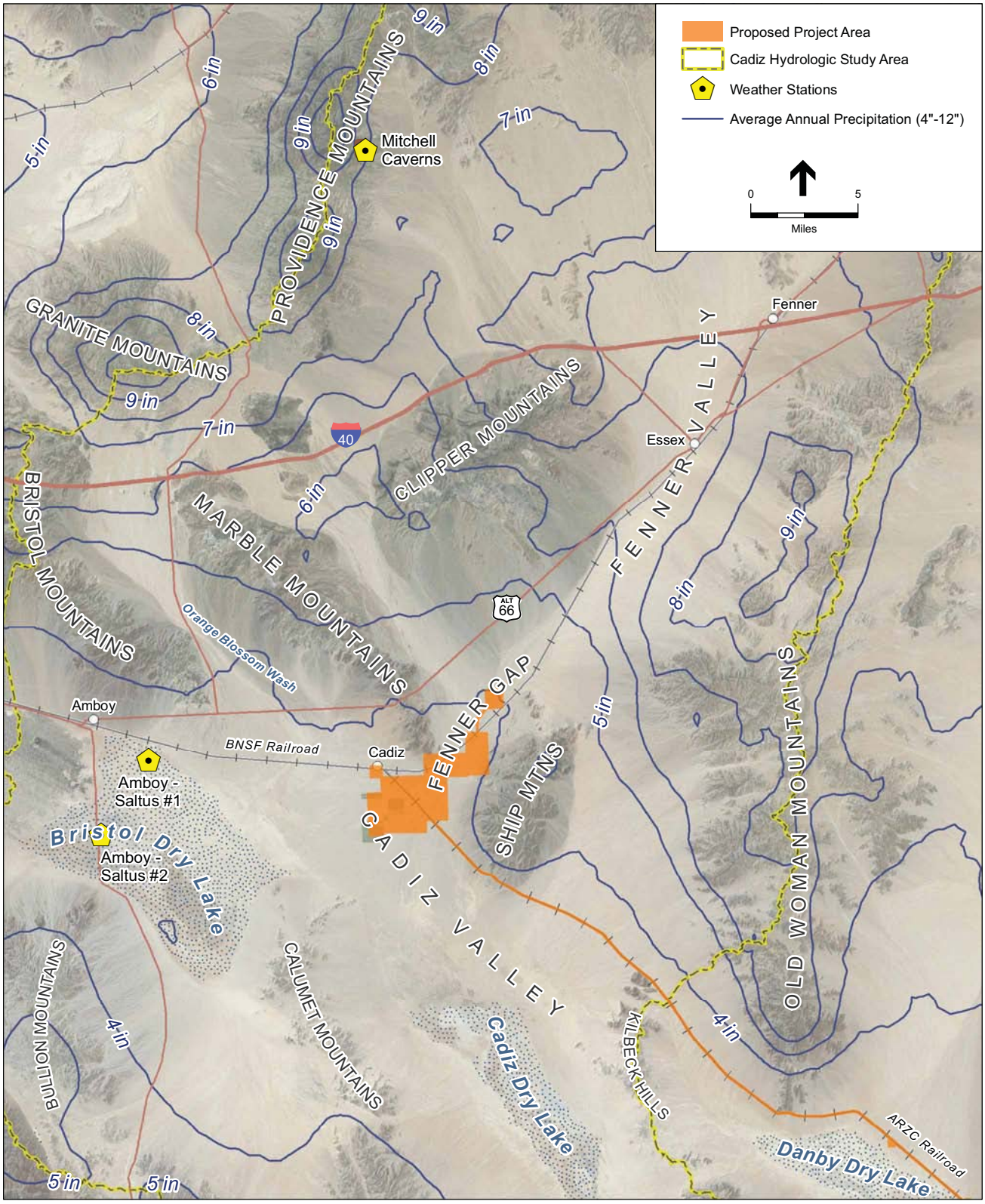
Two weather stations have provided long-term data in the vicinity of the Project area.[23] One of two Amboy weather stations is located on the northern margin of Bristol Playa at an elevation of 625 feet. Mitchell Caverns weather station is located on the flank of the Providence Mountains, northwest of Clipper Valley, at an elevation of 4,330 feet. Stations with shorter and less complete records in the vicinity include the San Bernardino County stations of Goffs, Essex, and Kelso. The weather station data was used for rainfall and runoff models in the analysis of this Project.

Precipitation

Most of the precipitation (both rainfall and snowfall) in the eastern Mojave Desert occurs during the months of November through March.[24] However, summer thunder storms and flash floods are not uncommon. The frequency and intensity of rainfall from year to year is unpredictable. Winter rainfall typically occurs in events lasting several hours to a day or more. These winter events are most commonly the result of frontal weather conditions, and rainfall during such events is generally steady. Snow tends to accumulate at elevations above 5,000 feet on the mountain ranges surrounding the Watersheds. On average, 20 to 30 frontal systems move through the region each winter.[25] Most of these systems weaken as they reach the Project area.

The amount of precipitation in the Watersheds varies with differences in elevation, as shown in **Figure 4.9-2**, which shows isohyets[26] of average annual precipitation based on the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) map for the period 1971 through 2000.[27] PRISM uses point estimates of climate data and a digital elevation model to generate estimates of climate elements, such as average annual, monthly, and event-based precipitation, among others.[28] This isohyet map shows average annual precipitation that varies from about 4 inches in Cadiz Valley to more than 12 inches in the New York Mountains.

[20] Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, *Nevada's Weather and Climate*, Nevada Bureau of Mines and Geology, Special Publication No. 2, 1975, page 8-11.
[21] Baldwin, John L., *Climates of the United States*, 1973, page 6.
[22] Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, *Nevada's Weather and Climate*, Nevada Bureau of Mines and Geology, Special Publication No. 2, 1975, page 8-11.
[23] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.
[24] U.S. Ecology, Inc., *California Low-Level Radioactive Waste Disposal Facility License Application*, 1989, page 2200-3.
[25] California Air Resources Board, *Climate of the Southeast Desert Air Basin*, July 1975, page 6.
[26] A line drawn on a map connecting points that receive equal amounts of rainfall.
[27] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, 2-3.
[28] PRISM Climate Group, *Latest PRISM Data*, www.prism.oregonstate.edu, accessed October 2010.



SOURCE: Bing Maps, 2011; PRISM Climate Group, 2004
ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-2

Precipitation Isohyets for the 1971-2000 Period

The long-term annual average precipitation at Mitchell Caverns weather station from 1948 and 2004 was 10.47 inches.[29] The Amboy weather station has two recording devices - Saltus Number 1 and Saltus Number 2 - located at different elevations along the north shore of Bristol Playa. Saltus Number 1, at elevation 625 feet, has recorded a long-term annual average precipitation of 3.36 inches from 1967 through 1988. Saltus Number 2, located at an elevation 595 feet, has recorded a long-term annual average precipitation of 3.63 inches (1973 through 1993).[30]

Temperature

Air temperature in the eastern Mojave Desert region follows a general pattern of high summer and low winter readings.[31] Daily patterns are also typical, with temperatures dropping to an early morning low and climbing to a mid-afternoon high, before falling again to the next morning's low temperature. During the winter, the Great Basin high-pressure zone generally protects the region from cold Canadian airflows, typically keeping temperatures above freezing at the lower elevations.

Average winter temperatures are between 50 degrees F and 55 degrees F, with average daily maximums near 65 degrees F and average daily minimums near 40 degrees F. Average daily temperatures in the summer months are over 85 degrees F. Maximum summer temperatures usually hover around 100 degrees F but occasionally exceed 120 degrees F. Average minimum summer temperatures are approximately 70 degrees F. The summer temperature typically varies 20 degrees F to 30 degrees F in one day.

The weather stations in the area at Saltus No.1 at Amboy and at Mitchell Caverns also record air temperature. The minimum monthly temperature at Amboy has been reported as 50.7 degrees F in January and the maximum monthly temperature is 94.7 degrees F in July. The minimum monthly temperature at Mitchell Caverns is 46.3 degrees F in January and the maximum monthly temperature is 82.1 degrees F in July. The average annual temperatures at Amboy and Mitchell Caverns are 71.8 degrees F and 62.6 degrees F, respectively.[32]

Relationship of Precipitation to Elevation

Davisson and Rose[33] describe environmental factors that complicate the distribution of precipitation through southeastern California and western Nevada. These factors include the rain-shadow effect of the Sierra Nevada, San Gabriel, and San Bernardino Mountains, and storms

[29] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.
[30] California Department of Water Resources, *Rainfall Records*, ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%202.xls and, ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%201.xls, accessed October 2010.
[31] U.S. Ecology, Inc., *California Low-Level Radioactive Waste Disposal Facility License Application*, 1989, page 2200-9.
[32] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-64.
[33] Davisson, M.L. and T.P. Rose, *Estimating Annual Precipitation in the Fenner Basin of the Eastern Mojave Desert, California*, U.S. Dept. of Energy, May 2000, page 1.

moving up from the Gulf of California that create more precipitation in the eastern Mojave Desert than in the western Mojave Desert. The rain-shadow effect of the Sierra Nevada Mountains has its greatest impact on precipitation just east of the Sierra Nevada and decreases eastward into Nevada. In general, Davisson and Rose show that precipitation versus elevation is higher east of the 116° W longitude than west of it. All of the Watersheds tributary to the Project area lie to the east of this demarcation and are therefore expected to have higher precipitation with increases in elevation as compared to watersheds in the western Mojave Desert.

The relationship of average annual precipitation to elevation within the Watersheds tributary to the Project area is important because estimates of average annual precipitation (both rain and snowfall) are employed in a variety of models used for estimating groundwater recharge. These models, including those used by Geoscience and CH2M Hill, as discussed further below, assume groundwater recharge with specified percentages of average annual precipitation within each watershed.

Climate Change

Although climate change impacts are uncertain and cannot be precisely modeled, existing evidence, including the effects of warming in the West over the last century, demonstrate that climate change will likely affect future snowpack accumulation, precipitation, water supply, runoff patterns, sea level, incidents of flooding and droughts, evapotranspiration rates, water requirements and water temperature.

U. S. Bureau of Reclamation Regional Study

The Omnibus Public Land Management Act of 2009 (Public Law 111-11) Subtitle F – SECURE Water was passed by Congress into law on March 30, 2009. Also known as the SECURE Water Act, the statute includes the finding that data, research, and development will help ensure future water supplies. In April 2011, the U.S. Department of the Interior, Bureau of Reclamation (USBR) published the *Reclamation Climate Change and Water, Report to Congress, 2011*.[34] This report presented a climate change evaluation of seven western U.S. basins (Colorado, Columbia, Klamath, Missouri, Upper Rio Grande and Pecos, Sacramento – San Joaquin, and Truckee-Carson).

The evaluation examined temperature and precipitation trends over the 20th century, predicted temperature and precipitation trends over the 21st century, and the potential effects on hydrology and water resources. The report cautions that there is considerable variation in data and that variations may be artifacts of analysis methodology. Overall, temperatures have risen over the past century and are expected to continue rising. Precipitation is expected to remain at about the same levels but will occur less as snow and more as rain. Geographically, the northwest will be somewhat wetter and the southwest will be somewhat drier. However, these trends have many variations and need to consider more at a regional level, as discussed below.

[34] U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress, 2011*, April 2011

The proposed Project is located immediately adjacent to the western edge of the Colorado Basin, with the Piute and Old Woman Mountains forming the boundary. Climate records from 1896 to 2009 were used to evaluate historical trends.[35] The 25-year moving average basis indicates that the mean temperature has risen about 2 degrees Fahrenheit (F) between 1908 and 2007. Precipitation has remained at approximately the same levels at about 14 inches. The data shows large annual variations (less than 9 to more than 20 inches).

With the increased temperatures, precipitation has been occurring as less snow and more as rain, although with many geographic variations. A June 2007 survey of western water conditions concluded that mountain recharge of groundwater basins may decline due to thinning snowpack and precipitation falling as rain rather than snow.[36] In contrast, while mountain recharge may decline, much of this recharged water may run off onto the region's fans and basins and potentially increase recharge on fans and groundwater basin floors. At present, whether the overall recharge will increase, decrease or stay the same is unknown at any scale in the West. As previously noted, variations may be artifacts of analysis methodology.

The results suggest that temperatures throughout the Colorado River Basin may continue to increase over the 21st century.[37] In the Upper Colorado River Basin, the basin-average mean-annual temperature is projected to increase by approximately 6 to 7 degrees F. When conditions are averaged across both the Upper and Lower Colorado River Basins, the expected increase is roughly 5 to 6 degrees F.

The same climate projections suggest that mean-annual precipitation averaged over the basin is only expected to change by a small amount during the 21st century. Annual variability in precipitation is expected to persist within the Colorado River Basin, and the basin likely will continue to experience both wet and dry periods throughout the 21st century.

The seasonality of runoff is also projected to change as summarized in **Table 4.9-1**, below, which summarizes the projected changes in the nature of runoff in the Colorado River above the Imperial Dam near the U.S.-Mexico border.[38] Warming is expected to lead to more rainfall-runoff during the cool season rather than snowpack accumulation. This logically leads to increases in December–March runoff and decreases in April–July runoff. However, the basin-wide results also show that seasonal runoff changes vary by subbasin and appear to be affected by factors other than annual warming (e.g., baseline climate, seasonal aspects of precipitation change).

35 U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, page 21.
36 Michael Dettinger, *Western Ground Water and Climate Change —Pivotal to Supply Sustainability or Vulnerable in its Own Right?*, National Groundwater Association, June 2007, page 5.
37 U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, pages 25-26.
38 U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, page 35.

TABLE 4.9-1
SUMMARY OF SIMULATED CHANGES IN DECADE-MEAN HYDROCLIMATE FOR THE COLORADO RIVER ABOVE THE IMPERIAL DAM

Parameter	2020s	2050s	2070s
Mean Annual Temperature (degrees F)	1.8	3.7	5.1
Mean Annual Precipitation (percent)	-0.4	-1.6	-0.7
Mean December–March Runoff (percent)	3.5	-3.0	1.3
Mean April–July Runoff (percent)	0.3	-6.6	-6.1

SOURCE: Table from U.S. Department of the Interior, Bureau of Reclamation, SECURE Water Act Section 9503(c) – *Reclamation Climate Change and Water, Report to Congress, 2011*, April 2011, page 35.

Based on current reservoir operational constraints (e.g., storage capacity, flood control rules, constraints on reservoir water releases to satisfy various obligations), it appears that projected reductions in natural runoff and changes in runoff seasonality would lead to reduced water supplies under current system and operating conditions. This follows the understanding that storage opportunities during winter runoff season currently are limited by flood control considerations at several tributary reservoirs in the Colorado River Basin and that increased winter runoff under climate change will not necessarily translate into increased storage of water leading into the spring season. Capture of snowmelt runoff traditionally has occurred during thelate spring and early summer seasons. Reductions in runoff during the spring and early summer season likely would translate into reductions in storage capture and likewise reductions in water supply for warm season delivery.

State Studies

In California, climate change is expected to result in similar responses. Mean annual temperatures are anticipated to increase. As with the Bureau of Reclamation study above, there is great uncertainty in the ongoing studies as to whether average annual precipitation over the upcoming 50-year time period would increase, decrease, or remain similar to the previous 50 years. The variation of annual precipitation amounts within that average is expected to become more extreme.[39] For surface water sources of supply, climate change can shift the timing of streamflow and alter the way water supply reservoirs are managed (i.e., filling and release). In contrast, climate change impacts on groundwater sources of supply are currently largely unknown due to the high degree of variability of aquifers and site-specific effects, such as surface groundwater interactions and rates of recharge.

The California DWR released a report in 2008 that used 2050 climate change projections for runoff and precipitation.[40] DWR used four climate change scenarios from the Intergovernmental Panel on Climate Change, and then applied its existing analytical tools to quantify possible

[39] California Climate Change Center, *Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment*, August 2009, page 13.
[40] California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources* (March 2008), page 3-1.

effects of climate change on California's water resources. Amongst other impacts, DWR concluded that climate change may produce changes in timing, location, quantity and variability of precipitation, which may be outside of the range for which current infrastructure was designed.

DWR released its comprehensive report, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, in 2010. This report is an exhaustive survey of previous DWR planning studies that addressed the impact of climate change in predicting future climate conditions and impact on water resources. Thirteen ongoing and past planning studies were reviewed in detail. Seventeen different analysis characteristics are highlighted for each study including planning horizon, spatial coverage, climate analysis approach, number of Global Climate Models (GCMs) used, scenario selection, sea level rise, hydrologic simulation period, and streamflow sequence for operations modeling.[41] DWR concluded that climate change is likely to increase storm frequency and severity with some increase in winter runoff in mountain basins due to higher-elevation snow levels during storms. Also, the snowpack will melt earlier in the season with less late-season runoff.[42]

NRDC and Terra Tech partnered to prepare a report focusing on regional climate change effects in *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*. The study found that more than 1,100 counties — one-third of all counties in the lower 48 — will face higher risks of water shortages by mid-century as the result of global warming. More than 400 of these counties will face extremely high risks of water shortages.[43] This report found that residents in Riverside and San Bernardino counties are at an "extremely high risk" of not having enough water to meet demands by mid-century if changes are not made to combat climate change and curb water use.[44] Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Evapotranspiration is the sum of evaporative loss of water from the ground surface and transpiration losses through vegetation. PET is a calculated metric used to represent evapotranspirative losses under idealized conditions, where a full water supply is available for evapotranspiration. Together, changes in precipitation and potential evapotranspiration have significant effects on available precipitation, estimated as water falling either as rain or snow that would not be consumed by the potential evapotranspiration.[45] With such potential for reduced precipitation, runoff may potentially be reduced in the short-term in the region.

In California, if heat-trapping emissions continue unabated, more precipitation would be expected to fall as rain instead of snow, and the snow that does fall would melt earlier, reducing the Sierra Nevada spring snowpack by as much as 70 to 90 percent.[46] How much snowpack would be lost depends in part on future precipitation patterns; the projections for which remain uncertain.

41 California Natural Resources Agency, Department of Water Resources, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, Dec 2010, page xiv.
42 California Natural Resources Agency, Department of Water Resources, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, Dec. 2010, page 2.
43 NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010
44 NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010, page 2.
45 NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010, page 2.
46 http://cal-adapt.org/snowpack/decadal/

However, even under wetter climate projections, the loss of snowpack would pose challenges to water managers; hamper hydropower generation, and recreational activities. By 2050, scientists project a loss of at least 25 percent of the Sierra snowpack. This loss of snowpack means less water will be available for Californians to use.[47]

While several studies have examined the impact of climate change on California's surface water resources, very little research has been conducted on the impacts of climate change on groundwater, namely "for specific groundwater basins, or for general groundwater recharge characteristics or water quality."[48] In fact, while "historic patterns of groundwater recharge may change considerably,"[49] it is unknown whether recharge rates will increase or decrease.[50] Warmer, wetter winters, leading to an increase in the amount and timing of runoff, could increase groundwater recharge.[51] Increased temperatures, which cause precipitation to fall as rain instead of snow, could increase the intensity of storm runoff that may overflow stream channels and recharge aquifers. In contrast, the intensity of the runoff could result in additional losses to the oceans. Further, this additional runoff may occur when basins are lacking storage space or are already being recharged at maximum capacity.[52] Alternatively, decreases in spring runoff and increases in evapotranspiration due to higher temperatures could reduce the amount of water available for groundwater recharge.[53]

While there is general consensus in this trend, the magnitudes and onset of impacts discussed in the planning recommendations are "uncertain and are scenario-dependent."[54] One recent report examines the effects of climate change on groundwater in California's Central and West Coast Basins.[55] The report identifies the oft-cited impacts to the state's surface water supply: reduction of annual snowpack, changes in the timing and intensity of precipitation, and sea level rise, but concedes that with regard to groundwater, "[v]ery simply, no one knows for sure, but close monitoring, planning, and responses to changes will likely be necessary."[56]

47 http://www.water.ca.gov/climatechange/

48 Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, page 20.

49 California Department of Water Resources, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*, October 2008, page 23.

50 Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005.

51 Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005.

52 Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, pages 17-18.

53 Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, pages 17-18.

54 California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources*, October 2008, page 16.

55 Water Replenishment District of Southern California, *Will Climate Change Affect Groundwater in the Central and West Coast Basins?*, Technical Bulletin Volume 10, 2007.

56 Water Replenishment District of Southern California, *Will Climate Change Affect Groundwater in the Central and West Coast Basins?*, Technical Bulletin Volume 10, Winter 2007, page 2.

In summary, due to the great uncertainty in the ongoing studies of the effect of climate change on groundwater, it is not possible to predict whether annual recharge rates at the Project site will increase, decrease, or remain the same due to climate change. The basin's groundwater supply is mainly generated by precipitation (both rain and snow) that occurs in the upper elevations of nearby mountain ranges. Once it has infiltrated and becomes groundwater, precipitation moves very slowly down gradient toward the Project area. Groundwater beneath the Project area has been found to be hundreds of years old.[57] Accordingly, any decline in the amount of precipitation falling on the mountains surrounding the Watershed tributary to the Project area is unlikely to significantly affect the Project area over the life of the Project. Even if natural recharge declines during the Project's 50-year timeframe, impacts from Project operations will be less than significant because to account for potential worst-case conditions, two additional scenarios were simulated assuming an average annual recharge of 16,000 and 5,000 AFY.

Even if natural recharge declines during the Project's 50-year timeframe, impacts on the aquifer from Project operations will be less than significant as discussed below in Section 4.9.3 (Impact and Mitigation Analysis.) To account for potential worst-case conditions, such as a drastic reduction in recharge rates over a 50-year period that could result from a changing climate, two conservative recharge scenarios were simulated for 100-years assuming an average annual recharge of 16,000 and 5,000 AFY. (See *Methodology* discussion in Section 4.9.3 below.) The Project impacts that were examined in light of long-term dry conditions include groundwater quality, the migration of saline water, groundwater in storage, subsidence, groundwater drawdown and depth impacts. The models discussed below demonstrate that even if the next 100 years were extremely dry and natural recharge was reduced by up to 85 percent, the Project would still result in a less than significant impact to groundwater resources.

Dry Lakes (Playas)

The Bristol and Cadiz Watersheds are topographically and structurally closed, so the only natural outlets for surface water and groundwater are evaporation from the lowest elevations in the Project area at Bristol and Cadiz Dry Lakes at 595 and 545 feet NGVD, respectively.[58] The terms playas and dry lakes are generally synonymous, but more specifically, dry lake areas are generally considered to be the innermost center areas of playas.

[57] M.L. Davisson, *Discussion Regarding Sources and Ages of Groundwater in Southeastern California*, Lawrence Livermore National Laboratory, March 2000, pages 5-6 (using radiocarbon dating to measure dissolved inorganic carbon in Fenner Gap groundwater).

[58] CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

The Dry Lake surfaces are devoid of vegetation due to the saline conditions and are usually dry. However, runoff from winter storms and late summer thunderstorms can result in occasional standing water.[59, 60, 61, 62, 63] As discussed above, the weather stations at Amboy have recorded that the Bristol Playa receives an average of more than 3 inches per year of rainfall. In addition, evidence of shallow streams and sheet flow from surrounding areas are observed on and adjacent to the playas (inspected November 9, 2010). Standing water has been observed on Bristol Dry Lake at least once each year since 1991.[64]

The playas are made up of a variety of surface types that change from the interior where the Dry Lakes are located, towards the outer perimeter where vegetation begins.[65] The sediments in the innermost area are generally composed of clay and silt with smaller amounts of sand. In the innermost areas of the playas, the soil beneath the surface can be damp to moist. The moist nature is predominantly due to the annual wetting from rainfall, surface runoff from surrounding areas, and some possible contribution from the capillary rise of groundwater.[66] The depth to groundwater at the lowest points of the Dry Lakes can be shallow and has been measured to be less than 15 feet, as discussed in more detail in the groundwater subsection below.

The evaporation of water from the Dry Lakes over the past several million years has resulted in thick deposits of salts (primarily sodium chloride [halite or table salt] and calcium sulfate [gypsum]) and brine-saturated sediments.[67,68] Deposits of economically viable evaporite salt minerals are currently being harvested by salt production companies, as discussed in Section 4.11, Mineral Resources. The salts bind the sediments of the playa surface in the innermost areas into a relatively hard, porous crust that is devoid of vegetation.[69, 70] The puffy surfaces are formed from surficial capillary water movement causing salts to precipitate and clays to swell on the surface, resulting in a network of polygons and hummocky relief.[71] The salts binding the surface

59 Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California,* U.S. Geological Survey Bulletin, 1045-D, 1959, pages 97-138.
60 Koehler, J.H., *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California: USGS Water Resources Investigations Report 83-4053*, 1983, page 2.
61 URS Consultants, Inc., *Draft Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development*, 1993, page 4-5.
62 Cadiz Inc., *Communication with ESA*, December 9, 2010.
63 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Report No. 1163, Volume 1*, November 1999, page 29.
64 Cadiz Inc., *Communication with ESA*, December 9, 2010.
65 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.
66 Capillary rise is the ability of a liquid to flow against gravity where liquid spontaneously rises in porous materials like soil. It occurs because of intermolecular attractive forces between the water molecules and soil surface particles. When the pore spaces are sufficiently small, the combination of surface tension (which is caused by cohesion within the liquid) and forces of adhesion between the liquid and soil particles act to lift the liquid. Capillary rise can be on the order to 10 to 20 feet.
67 Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, 1989, pages 39, 140.
68 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, pages 8-9.
69 Czarnecki, J.B., *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California*: USGS Water Supply Paper 2377, 1997, page 5.
70 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, pages 6, 8.
71 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, pages 6, 8.

sediments are predominantly composed of sodium, calcium, and chloride, a chemical signature significantly different from other playas in the western U.S. region.[72] The soil and water chemistry of the Bristol and Cadiz Playas have very low quantities of the sodium salts of carbonate, bicarbonate, and sulfate that are known to cause severe fugitive dust storms on the Owens Lake and Franklin Playas.[73] The dominance of chloride at the Bristol and Cadiz Playas results in salts that produce much less dust-producing salt efflorescence, and are more efficient at retaining water and maintaining the surface crust. Because of the difference in chemical composition, the salt crust is not dependent on groundwater; annual precipitation and surface runoff are sufficient to maintain its integrity.

Moving further out from the interior, the surface salt crust is still present but the soil beneath the salt crust becomes noticeably dryer with the subtle increase in elevation. This further indicates that the salt crust is maintained by rewetting from the annual rainfall and surface sheet flow from surrounding areas, and does not require the capillary rise of groundwater.[74] The depth to groundwater was measured on May 5, 2011, in two wells located at the northeast margin of the Bristol Playa approximately ½-mile northeast of the playa edge where vegetation begins to occur. The depths to groundwater in Wells HAL 1 and MW-5 (located at R Area Wells on Figure 4.9-5, below) were 93.40 and 85.05 feet below ground surface, respectively.[75] This suggests that the salt crust observed within the playa areas further out from the centers are not maintained by groundwater because the depth to groundwater is too deep to provide affect the surface by capillary action. A cross-sectional plot of depths to groundwater from the salt production trenches in the center of Bristol Dry Lake outward toward the Cadiz agricultural operation irrigation wells calculated the depth to groundwater at the playa edge where the vegetation begins to be 65 feet.[76] This depth is well below the maximum potential action of capillary rise again suggesting that the salt crust is not dependent on groundwater.

At the margins of the playas, the concentrations of salt in the soil decrease and plants are able to survive. Three dominant shrub species grow in the areas around the playa margins. These are the four-wing saltbush (*Atriplex canescens [Pursh] Nutt*), the cattle saltbush (*Atriplex polucarpa*) and creosote bush (*Larrea tridentata [D.C.] Coville*).[77] Four-wing saltbush dominates the area immediately adjacent to the playas with creosote and cattle saltbush absent or rare. The four-wing saltbush was observed to extend for at least one-half mile further out from the playa centers and has been observed more than one mile away. As discussed above, depth to groundwater in this area is over 65 feet below ground surface. Four-wing saltbush tends to root to a maximum depth of about 20 feet below ground surface and is a facultative phreatophyte, a plant that has the ability

72 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, page 9.
73 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California, Executive Summary,* August 2011.
74 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, page 14; Appendix C, page 29.
75 Cadiz Inc., *Communication with ESA, based on well measurements collected on* August 4, 2011.
76 HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, page 7.
77 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California,* August 2011, page 1.

to derive a portion of its water supply from groundwater, if present within the reach of its roots.[78] However, with the depths to groundwater in this area much deeper than the roots of this plant species, the four-wing saltbush around the Bristol and Cadiz Playas could not be deriving water supplies from groundwater, indicating that the existing surface water supply provides sufficient water for this plant life.

The other main plants in the playa margin area are creosote and cattle saltbush, both shallow-rooted species that harvest water near the surface; their roots are generally confined to the upper half meter of soil. As such, creosote and cattle saltbush are also not dependent on groundwater and both the existing, as well as the proposed, pumping of groundwater in this area would have no effect on vegetation.[79]

Surface Hydrology

Intermittent Streams

As previously discussed, the Watersheds form a closed drainage system with no surface outflow; all surface water in the Project area drains to Bristol and Cadiz Dry Lakes.[80] The only outlets for surface water are direct evaporation of precipitation and intermittent surface water flow, transpiration by vegetation, and evaporation from the Dry Lake surfaces.[81] Figures 3-2 and 3-3a provide conceptual illustrations of the flow of surface water and groundwater through the Fenner Gap and Orange Blossom Wash through Fenner Gap and ultimately to the Dry Lakes where the water becomes saline and evaporates.

In general, the amount of surface water flow is dictated by the intensity and duration of precipitation, topography, rock type, soil, and vegetation cover. A portion of the precipitation falling in any watershed area is intercepted by vegetation and retained in the vegetation or transpired back to the atmosphere. Another portion of the precipitation wets and adheres to the soil before returning to the atmosphere through evaporation. Another portion of the precipitation infiltrates into the soil and continues to migrate downward into the water table. In general, if precipitation exceeds infiltration capacity, overland flow occurs.

There are no perennial (year-round) streams in the Watersheds.[82] Intermittent streams are distributed throughout the Watersheds. Ephemeral runoff within the Fenner Watershed flows into the Schulyer Wash, the principal drainage in the Fenner Valley Watershed, and then flows through Fenner Gap to either Bristol or Cadiz Dry Lake. Ephemeral runoff within the Orange Blossom Wash flows into Bristol Dry Lake. Ephemeral flow in the Bristol and Cadiz Watersheds flows into the Bristol or Cadiz Dry Lakes, respectively.

---

78 National Conservation Resource Service, *Fourwing Saltbush (Atriplex canescens (Pursh.)Nutt,* Factsheet, January 2002.

79 HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, page 7.

80 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

81 Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA,* Southern California Edison Company, 1964, page 75.

82 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1,* September 2001, page 5-72.

Springs

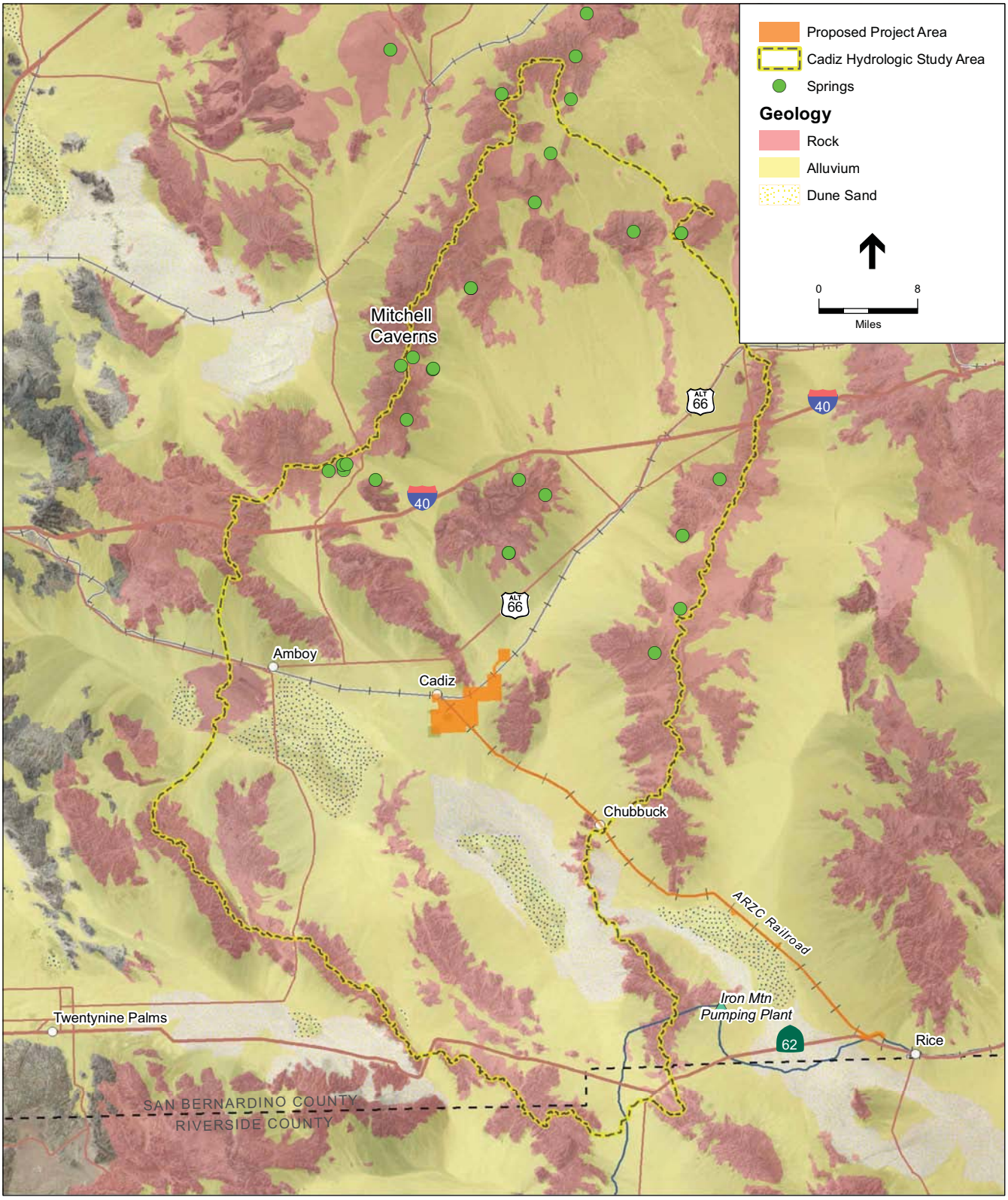
Spring water is any natural discharge of water from rock or soil defined as "water derived from an underground formation from which water flows naturally to the surface of the earth" at an identified location.[83] Some naturally-occurring springs and wet areas associated with the springs are present at higher elevations within the mountain ranges, as shown on **Figure 4.9-3**.[84] No springs, wetlands, or phreatophyte vegetation are known in the lower elevations within the intervening basins and washes because the depth to groundwater in the alluvium is too great. The closest naturally occurring spring to the Project elements (production wells and spreading basin) is the Bonanza Spring located more than 11 miles north of Fenner Gap in the Clipper Mountains. Bonanza Spring is at an elevation of about 2,100 feet NGVD, substantially above the adjacent Fenner Valley floor at about 1,350 feet NGVD. More distant springs are found in the upper elevations of the Granite, Marble, Clipper, and Old Woman Mountains. These natural springs and supporting man-made features provide important watering holes for big horn sheep. Recent field mapping of the Marble Mountains has revealed numerous ephemeral pools or tinajas[85] fed exclusively by surface run-off and guzzlers (a barrel reinforced by a concrete apron that directs rainfall into a pool).[86]

An evaluation of the springs concluded that there is no physical connection of the springs in the higher elevation mountains to the groundwater in the aquifer in the valleys where Project pumping would occur.[87] **Figure 4.9-4** provides a conceptual cross-sectional view that illustrates the locations of the springs relative to surface water and groundwater. The springs receive all of their water supply first before the remaining water flows down slope or infiltrates into the fractured rock, subsequently migrating down slope into the alluvium of the valley floors. In addition, the alluvium is likely to be unsaturated as it thins over bedrock highs, further demonstrating a lack of any hydraulic continuity between groundwater in the alluvial aquifer in the valley floor and springs located in the mountains. There is no observed hydraulic continuity between groundwater in fractured granitic bedrock where the springs exist and the regional groundwater table of the alluvial aquifer (See Appendix H-3).

Groundwater Hydrology

The following Sections discuss the setting for groundwater and water quality, including hydrogeologic units, groundwater flow patterns, estimated volume of groundwater in storage, and estimated annual recharge. The geology, soils, structural geology, and seismicity of the Project area are discussed in further detail in Section 4.6, Geology and Soils, which includes discussing potential subsidence impacts from the withdrawal of groundwater.

83 Code of Federal Regulations, Title 21, Chapter 165, Part 110(a)(2)(vi).
84 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.
85 A tinaja is a depression in bedrock that can temporarily hold rainwater.
86 Kenney GeoScience conducted several field visits from late 2010 to November 2011 in the Marble Mountains and was unable to identify any springs. A report of his field survey is included in Appendix H4.
87 CH2M Hill, *Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs,* August 2011, page 1.

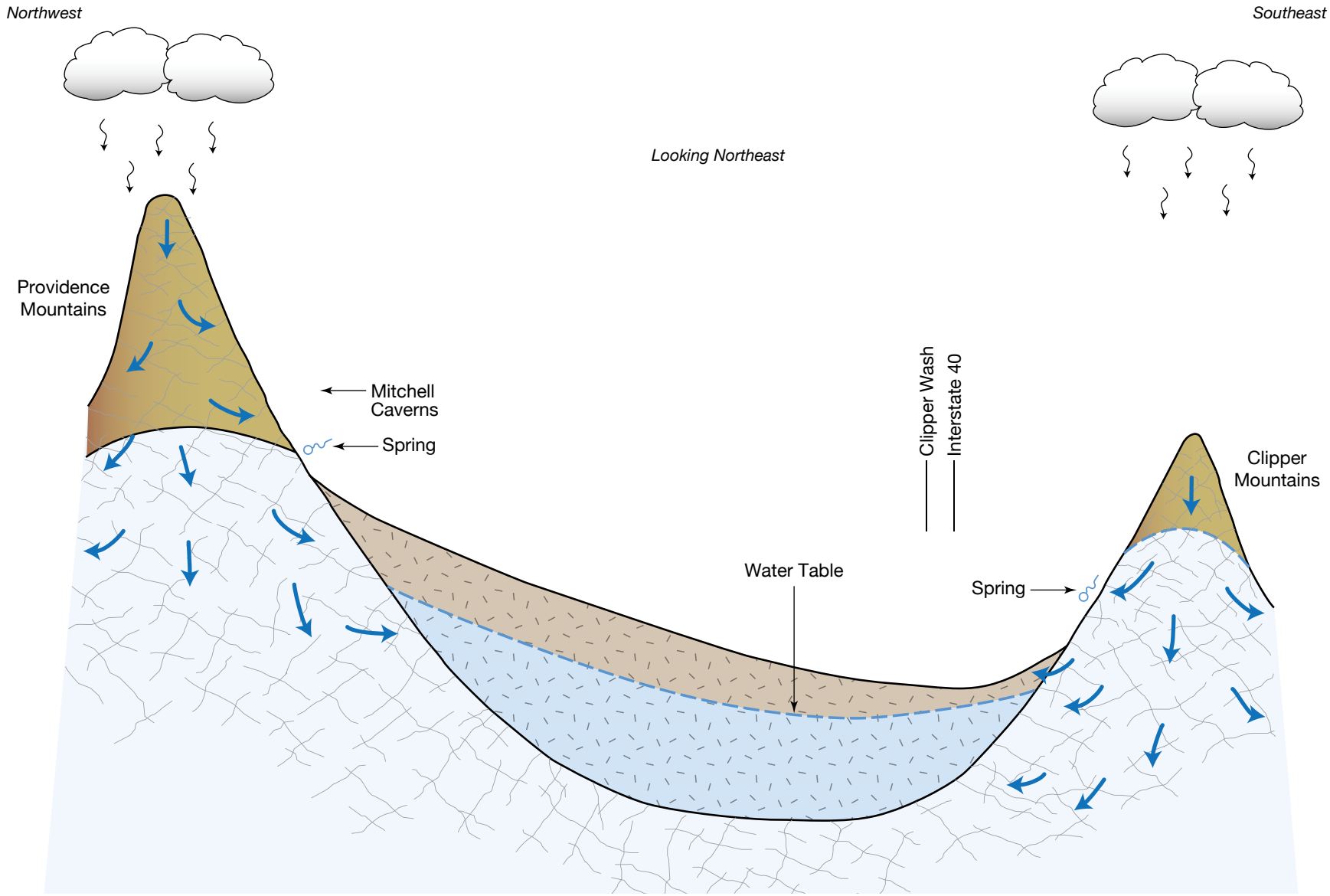


SOURCE: Bing Maps, 2011; ESRI, 2010
Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-3

Location of Springs in the Fenner Watershed



NOT TO SCALE

SOURCE: CH2MHill, 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-4

Conceptual Cross-Section Showing Water Sources of Springs in the Fenner Watershed

Overview of Groundwater Source and Movement

In general, groundwater within the Watersheds flows in the same direction as the slope of the land surface. In the Fenner Valley, groundwater flows southward and discharges through the Fenner Gap toward the Bristol and Cadiz Dry Lakes. In Orange Blossom Wash, located between the Marble and Bristol Mountains, groundwater flows southeast from the Granite Mountains and then turns south into the Bristol Dry Lake.[88]

The primary sources of replenishment to the groundwater system in the Project area include direct infiltration of precipitation (both rainfall and snowfall) into fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the Watersheds.[89] As previously discussed, the source of most of the groundwater recharge within the Watersheds occurs in the higher elevations, since the higher elevations receive the highest volumes of precipitation.[90,91]

Figures 3-2, 3-3a, and 4.9-4 present conceptual models of groundwater occurrence and movement in the Project area. The figures present schematic cross-sections showing the occurrence of groundwater in fractured bedrock in the mountain ranges that is recharged by precipitation. Precipitation flows down the mountain slopes by infiltrating into rock fractures or flowing overland if the volume of flow is sufficient to overcome infiltration. In some cases in the higher elevations, the infiltrating water may be diverted to the land surface or groundwater may intersect land surface creating a spring, but only in the higher elevations on the mountain slopes. Ultimately, this infiltrating water moves vertically downward into the alluvial materials and fractured bedrock of the regional groundwater system, tens to hundreds of feet below the ground surface. Groundwater continues to flow downgradient through principal aquifer systems.

Groundwater in the aquifers moves downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to the Dry Lakes. In addition, groundwater in the aquifers to the west, south, and east of the Dry Lakes also migrates downgradient to the Dry Lakes. As discussed above, evaporation of water from the Dry Lakes over the past several million years has resulted in thick deposits of salt (primarily sodium chloride and calcium sulfate) and brine-saturated sediments.[92] Additional groundwater recharge occurs from annual precipitation and as surface water runoff observed from the surrounding areas.[93]

Hydrogeologic Units

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater (aquifers) have been divided into three

88 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-9.
89 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-7, 2-8.
90 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-64.
91 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.
92 Rosen, M.R. *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, 1989, pages 39, 140.
93 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-7, 2-8.

general units: an upper (younger) alluvial aquifer; a lower (older) alluvial aquifer; and a bedrock aquifer consisting of Tertiary fanglomerate, Paleozoic carbonates, and fractured and faulted granitic rock as discussed in Section 4.6, Geology and Soils.[94] In general, these three units are in hydraulic continuity with each other and the separations are primarily due to stratigraphic differences.

The upper alluvial aquifer consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt.[95] The thickness of this aquifer ranges from approximately 200 to 800 feet.[96] To the west of the Fenner Gap, the upper aquifer is separated from the lower aquifer system by discontinuous layers of silt and clay. The average thickness of the upper aquifer in the Fenner Gap is approximately 500 feet. The upper aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more to wells with less than 20 feet of drawdown.

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of late-Tertiary to early age.[97] The maximum thickness of the lower alluvial sediments is unknown but may reach over 6,000 feet below Bristol Dry Lake.[98] Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments.[99, 100] The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm.[101]

Based on findings from recent drilling in the Fenner Gap, Tertiary fanglomerate, fractured and faulted granitic rock, and Paleozoic carbonates, located beneath the lower alluvial aquifer, contain groundwater and are considered a third aquifer unit.[102, 103] Groundwater movement and storage in the carbonates primarily occurs in secondary porosity features (i.e., fracture zones associated with faulting and cracks, and dissolution cavities that have developed over time). The full extent, potential yield, and storage capacity of this carbonate aquifer has not been fully quantified at this time. Approximately 1,000 feet of the carbonate unit is present in some portions of the Fenner

94 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 25.
95 Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*, California Department of Water Resources Bulletin 91-14, 1967, page 9.
96 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis*, Volume 1, September 2011, page 25.
97 Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*, California Department of Water Resources Bulletin 91-14, 1967, page 9.
98 Maas, J., *Depth to Basement Calculated from Gravity Data*, Proprietary Report to Cadiz Land Company, Inc., 1994, In CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-5.
99 Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties*, California, California Department of Water Resources Bulletin 91-14, 1967, page 9.
100 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 2, Report No. 1163*, November 1999, page 40.
101 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 25.
102 GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 13.
103 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-12, 4-13.

Gap.[104] As such, the carbonate aquifer would constitute an additional source of groundwater that has not been included in the storage and recovery estimate mentioned earlier in this Section and discussed further below. The result of this exclusion, despite the observed data demonstrating significant quantities of groundwater in the carbonate unit, would be that the storage and recoverable groundwater estimates for the area are conservative and substantially underestimate the actual volumes.

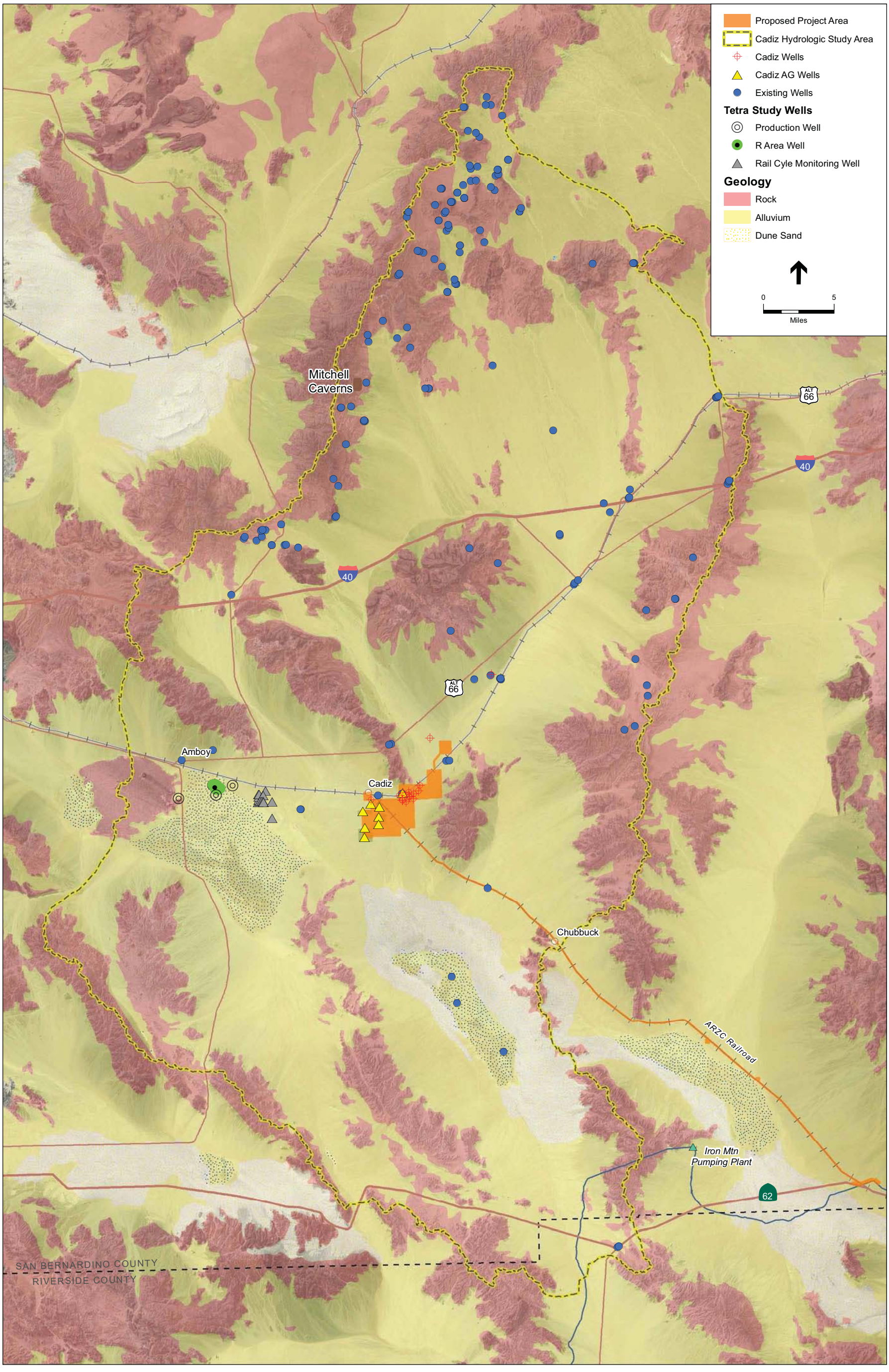
The mountain ranges that define the boundaries of the regional watersheds are comprised predominantly of granitic and metamorphic basement rock, as described above. This less permeable basement complex forms the margins and bottoms of the aquifer systems, is generally less permeable, and typically yields smaller quantities of water to wells.[105] However, as noted above, recent drilling into bedrock in the Fenner Gap indicates that the upper portions of the basement rock is fractured and yields significant quantities of groundwater.[106, 107] In addition, fracturing is more extensive along faults, resulting in additional storage volume as well as significant conduits for groundwater flow through the Fenner Gap.[108] The groundwater in the basement rock has also been excluded from the storage estimates discussed below. The result would be that the storage estimates are conservative and underestimate the actual volumes. The estimates for the storage volumes of groundwater are discussed further below.

Groundwater Use

The total amount of groundwater currently pumped in and surrounding the Project area has been minimal until the last decade. The primary groundwater uses in the region are the Cadiz Inc. agricultural operations, the BNSF railroad, the salt production companies, and the few residents in and around the communities of Chambless, Essex, and Goffs. **Figure 4.9-5** illustrates the locations of wells based on a well survey[109] and includes the Cadiz agricultural wells in addition to saline water wells at Bristol Playa.[110]

Freiwald [111] estimates that between 1954 and 1981, groundwater pumping in Fenner Valley remained constant at approximately seven to eight AFY. Shafer[112] reports that approximately 14,300 AF of fresh water were pumped from the Bristol and Cadiz Valleys from 1910 (when the first fresh water well was drilled) to 1964, or an average pumping rate of approximately

104 Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 16.
105 Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*, U.S. Geological Survey Water Resources Investigation Report 83-4082, July 1984, page 6.
106 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 40.
107 GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area,* April 2010, page 12.
108 Kenney Geoscience, *Geologic Structural Evaluation of the Fenner Gap Region located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, 2011.
109 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.
110 Tetra Technologies, *Location of Various Exploration Boreholes, Coreholes, Wells, and Production Pits, Bristol Dry Lake, California*, Plate 1, November 1999.
111 Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*, U.S. Geological Survey Water Resources Investigation Report 83-4082, July 1984, page 11.
112 Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-5

Location of Known Wells in the Fenner, Bristol, and Cadiz Watersheds

This page left intentionally blank

265 AFY. These historical pumping rates do not include the Cadiz Inc. agricultural operations, and it is assumed that these uses presently continue.

Yearly groundwater production for the Cadiz Inc. agricultural operations averaged between 5,000 to 6,000 AFY from 1986 through 1998. Between 1998 and 2002, agricultural use averaged 5,600 AFY. Annual use since 2002 is listed in **Table 4.9-2** below. [113,114,115,116]

TABLE 4.9-2
CADIZ ANNUAL GROUNDWATER USE FOR AGRICULTURE
2002 THROUGH 2010

Year	Acre-Feet
2002	5,495
2003	5,095
2004	4,255
2005	4,509
2006	4,439
2007	3,405
2008	1,970
2009	1,882
2010	1,867

SOURCE: Cadiz Inc., *6th Annual Groundwater Monitoring Report, January 2003 - December 2003, Cadiz Valley Agricultural Development,* January 2009, page 13; Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement*, September 2001, page 5-80; Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009, page 13; Cadiz Inc., *10th Annual Groundwater Monitoring Report, January 2007 - December 2007 & Five-Year Summary Report, Cadiz Valley Agricultural Development*, April 2008, page 14.

The decrease in recent years is primarily due to changes in crop cultivation and increased irrigation efficiency.[117] The Cadiz Inc. agricultural operations currently utilize seven wells for irrigation. These wells are all located downgradient of the Fenner Gap (see Figure 4.9-5**)**.

Tetra Technologies, the salt production company operating on Bristol and Cadiz Dry Lakes, is the only other groundwater user in the area that has identified and recorded groundwater production

113 Cadiz Inc., *6th Annual Groundwater Monitoring Report, January 2003 - December 2003, Cadiz Valley Agricultural Development*, January 2009, page 13.
114 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-80.
115 Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009, page 13.
116 Cadiz Inc., *10th Annual Groundwater Monitoring Report, January 2007 - December 2007 & Five-Year Summary Report, Cadiz Valley Agricultural Development*, April 2008, page 14.
117 Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011, page 12.

in excess of 25 AFY (see California Water Code Section 4999 et. seq. [Section 4999]). According to public records, Tetra Technologies pumps groundwater directly from beneath its property, which overlies the Bristol Dry Lake. Tetra's annual groundwater production has generally averaged about 500 AFY since 1986 with a high of 574 AF reported in 1996. Like Tetra Technologies, National Chloride Company has a similar salt production operation over Bristol Dry Lake but it is believed that it extracts a smaller but proportionately similar quantity of groundwater annually, as it is a smaller operation and it has not filed public records reporting its annual use.

As discussed in Section 4.11, Mineral Resources, calcium chloride and sodium chloride are produced by the salt production operations on both Bristol and Cadiz Dry Lakes. Highly saline water beneath the surface is pumped from saline groundwater wells and into trenches for the concentration of salts in evaporation ponds. These well locations are shown on Figure 4.9-5.

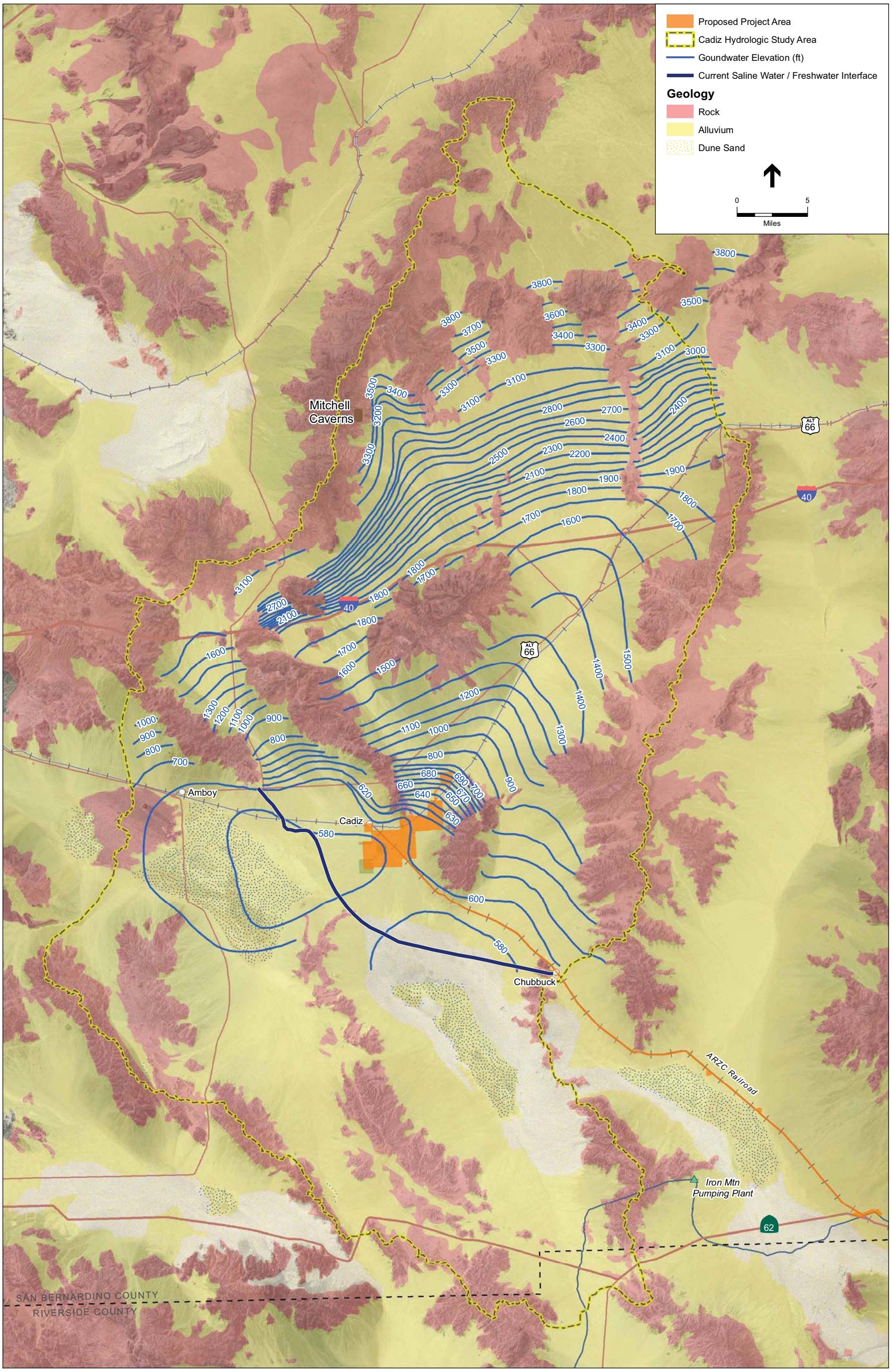
Other than the entities discussed above, there are no significant groundwater users in Fenner Valley that are known or that have filed a statement pursuant to Section 4999 stating that they are pumping in excess of 25 AFY. Significant groundwater users are defined by the State as users of in excess of 25 AFY. Within the Watersheds area there are only a few scattered residents or very small communities. For example, as of 2007, the community of Amboy had only four residents.[118] Estimates vary, but the USGS estimates each person's domestic use of water is approximately 80 to 100 gallons per day.[119]

Groundwater Flow Patterns and Depths

In general, groundwater within the Watersheds flows in the same general direction as the slope of the land surface.[120] **Figure 4.9-6** presents a generalized contour map of existing groundwater elevations and horizontal flow patterns in the Watersheds.[121] The contours in this figure are based on water levels measured in more than 80 wells.[122] In some cases, published water level elevations have been adjusted to reflect more accurate reference elevations, obtained from updated topographic maps of the area.

In the Fenner Valley, groundwater generally flows southward and downgradient, discharging through the Fenner Gap toward Bristol and Cadiz Playas. The depths to groundwater in the Fenner Valley range from 200 to 400 feet bgs.[123] Because the extinction depth [124] is about 15

118 Mike Anton, Los Angeles Times, *Destiny in the Desert*, January 2007
119 U.S. Geological Survey, Water Questions and Answers, accessed at ga.water.usgs.gov/edu/qa-home-percapita.hmtl
120 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-8, 2-9.
121 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figure 2-16.
122 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Report No. 1163*, November 1999, Table 19 and Appendix C.
123 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figures 2-2, 2-16.
124 The extinction depth is that depth below which minimal to no evaporation can occur.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-6

2009 Groundwater Elevation Contours

This page left intentionally blank

feet,[125] there would be only minimal to no evaporation of groundwater from the aquifer in the Fenner Watershed. The gradient ranges from approximately 180 feet per mile in the north central area of Fenner Valley to approximately 25 feet per mile around Essex between the Clipper and Piute Mountains.

In Orange Blossom Wash, groundwater flows generally southeast from the Granite Mountains and then turns south as it reaches Bristol Playa. The depths to water range from 1,300 feet bgs at the upper end of the wash to 350 feet bgs where the wash enters the Cadiz Valley. The gradient ranges from 104 feet per mile at the upper end of the wash to 26 feet per mile where the flow enters Cadiz Valley.

At the Fenner Gap, groundwater flow is from northeast to southwest at a gradient of approximately 10 feet per mile.[126] Depths to groundwater in Observation Well 5/14-13 ranged from 296.80 to 297.32 feet bgs in calendar year 2010.[127] Groundwater then flows through the Fenner Gap and into the playas.

Once in the playa areas and beneath the Dry Lakes, the gradient flattens out to zero. The gradients beneath the playas decrease to zero because the water has no outlet from these basins other than evaporation through the Dry Lake surfaces. Trenches dug in central portions of Bristol Playa for salt production show water levels ranging from 8 to 12 feet deep.[128] As previously noted, the depth to groundwater was measured on May 5, 2011, in two wells located at the northeast margin of the Bristol Playa approximately ½-mile northeast of the playa edge where vegetation begins to occur. The depths to groundwater in Wells HAL 1 and MW-5 (Figure 4.9-5) were 93.40 and 85.05 feet below ground surface, respectively.[129] The groundwater levels measured in the Cadiz agricultural wells, as reported in their annual reports, have changed very little since 1996, even on a month to month basis.[130] Figures 3-2 and 3-3a provide a schematic cross section from Fenner Valley to the Fenner Gap to Bristol Dry Lake. The depths to groundwater increase to about 65 to 80 feet bgs along the eastern margin of the playa. [131]

Aquifer Parameters

Within the Fenner Gap area, in general, the alluvial units and the carbonate unit are in hydraulic continuity with each other, and the separation is primarily due to stratigraphic differences or the extent of interconnecting secondary porosity with the carbonate unit.

125 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* page 36.
126 GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 12.
127 Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011, page A-8.
128 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Play, San Bernardino, California,* January 2011, page 7.
129 Cadiz Inc., *Communication with ESA*, August 4, 2011.
130 Cadiz, *13th Annual Groundwater Monitoring Report, January – December 2010, Cadiz Agricultural Development*, June 2011, page 10.
131 HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, pages 5-7.

In developing the aquifer model, Geoscience calibrated data from several pump tests to match the observed water level data.[132] Hydraulic conductivities, assuming an average annual recharge estimate of 32,000 AFY, were 0.2 to 543 feet per year (ft/yr) for the alluvium, 500 to 1,500 ft/yr for the carbonates, 60 ft/yr for the fanglomerate/lower Paleozoic sequence/weathered granitic rocks in the Fenner Gap, and 75 ft/yr for the weathered granitic rocks/detachment fault zone in the Fenner Gap. The unconfined storage coefficient (also referred to as the effective porosity or specific yield) was estimated at 0.15, and the confined storage coefficient was estimated at 0.00001. Cadiz's Production Well PW-1, located in the Fenner Gap, draws water primarily from the upper and lower alluvial aquifers and yields up to 3,000 gpm with less than 20 feet of drawdown.[133] Cadiz agricultural wells draw water from the upper alluvial aquifers and typically yield from 1,000 gpm to more than 2,000 gpm. The storativities reflect semi-confined conditions. The alluvial aquifer exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate unit.

Summary of Groundwater in Storage

CH2M Hill updated groundwater storage estimates[134] that had previously been developed by Geoscience.[135] To do so, they used recent field investigations that were conducted by both CH2M Hill and Geoscience. The volume of groundwater in storage was estimated by CH2M Hill to be about 17 to 34 MAF in the alluvium of the Fenner Valley, the freshwater portion of the Orange Blossom Wash, and northern portion of the Bristol Valley area (freshwater defined as total dissolved solids [TDS] of less than 1,000 mg/l).[136] Of this total, approximately 12 to 24 MAF of freshwater are within the Fenner Watershed, an estimate comparable to the previous Geoscience estimates. The freshwater zone south of the Fenner Gap in the Orange Blossom Wash and the northern portion of the Bristol Watershed is estimated to be between 4 and 10 MAF.[137]

As noted above, the storage estimate does not include the carbonate and fractured portion of bedrock units beneath the alluvium. Recent drilling has revealed that these units also store groundwater.[138] As such, the estimated volume of groundwater in storage is a conservative underestimate; the actual volume of groundwater in storage is larger by an undetermined amount.

Summary of Recharge Estimates

The following subsections discuss the development of recharge estimates. The estimates focus primarily on recharge to the Fenner Watershed because the Project proposes to intercept groundwater at the Fenner Gap and prevent it from being lost to evaporation at the Dry Lakes. The estimates do not account for the additional recharge to the Dry Lakes from the areas west, south, and east of the playas and therefore are conservative.

---

132 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 32-33.
133 GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area,* April 2010, page 2.
134 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, pages 3-1, 3-2.
135 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163,* November 1999, page 64-67.
136 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, pages 3-1, 3-2.
137 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, Table 3-1.
138 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project,* July 2010, page 3-1.

As discussed below, a number of earlier hydrology studies and recharge estimates have been made beginning as early as 1929 using a variety of approaches and methods. However, the earlier efforts were either general in nature (descriptive but no actual recharge calculations) or were relying on minimal sets of data and assumptions to account for the lack of extensive site-specific data. The earlier recharge estimates are summarized below for historical purposes only. The recent recharge estimates discussed further below include more local and site-specific information with larger data sets, thus enabling more reasonable and accurate recharge estimates. As a result, the most recent recharge estimates are used for modeling the aquifer response to groundwater pumping and evaluating the nature and extent of potential model-predicted impacts.

Previous Recharge Estimates

The Fenner Watershed and the surrounding local area has been the subject of numerous hydrology and water supply investigations since the USGS first studied the area in 1929, when the USGS published Water Supply Paper 578.[139] This study did not provide any recharge estimates, but noted the hydrologic characteristics of the region. Since then, numerous studies have been conducted. For example, two studies in the 1960s also evaluated the hydrologic characteristics of the Watershed, but again did not evaluate recharge rates. The first study that provided recharge estimates was conducted by Schafer for the Southern California Edison Company in 1964. [140] The second was conducted for the California Department of Water Resources in 1967.[141] However, these earlier studies relied on limited and incomplete precipitation, water well records, and elevation survey data. Consequently, these earlier recharge estimates vary greatly and are considered less reliable than more the recent estimates of recharge.

1980 to 1984 Estimates

In the 1980s, several recharge estimates were made for the Fenner Watershed resulting in varying recharge estimates. The USGS released two studies in 1984 analyzing recharge. While the first did not reach a conclusion on recharge amounts,[142] the second USGS study estimated the recharge at 270 AFY using assumptions for the gradient, cross-section, and transmissivity.[143] Later in 1984, Geothermal Surveys[144] conducted another study using site-specific transmissivity from new wells, but still with an assumed cross-section and gradient, arriving at an estimate of 18,000 to 36,000 AFY. An estimate of recharge as 1 percent to 10 percent of assumed average annual precipitation yielded results of 780-7,800 AFY. An estimate of recharge as 10 percent of assumed annual precipitation at elevation above 2,400 feet yielded a result of 20,600 AFY estimate of annual recharge. The same year, David Keith Todd, Consulting Engineers, using

139 Thompson, D.G., *The Mojave Desert Region, California*: *A Geographic, Geologic, and Hydrologic Reconnaissance*, USGS Water Supply Paper 578, 1929.

140 Schafer, R.A., *Report on Investigations or Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, California*, Southern California Edison Company, June 1964.

141 California Department of Water Resources, *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity*, Bulletin No. 91-14, 1967.

142 Bedinger, M.S., Langer, W.H., and Moyle, W.R., Maps Showing Ground Water Units and Withdrawal, Basin and Range Province, Southern California, U.S. Geological Survey Water-Resources Investigations Report 83-4116-A, July 1984.

143 Freiwald, David, A., *Groundwater Resources of Lanfair and Fenner Valleys and Vicinity*, San Bernardino County, California, U.S. Geological Survey Water Resources Investigation Report 83-4082, 1984.

144 Geothermal Surveys, Inc., *Ground Water Resources Investigation near Cadiz, San Bernardino County, California*, August 1984, prepared for Cadiz Agricultural Project I, In GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins*, September 1995, page 5.

assumed values for the gradient and area of saturated cross-section, as well as an estimated transmissivity, estimated the recharge in the Fenner Valley Watershed to be 11,000 AFY. [145]

1995-1998 Modeling

In 1995, Geoscience prepared the first aquifer model for the Project using the USGS aquifer modeling tool referred to as MODFLOW. MODFLOW is a modular finite-difference flow model, which is a computer code that solves the groundwater flow equation. The program is used by hydrogeologists to simulate the flow of groundwater through aquifers. Since its original development in the early 1980s, the USGS has released four major releases, and MODFLOW is now considered to be the *de facto* standard code for aquifer simulation. The initial Geoscience modeling effort estimated a range of recharge to the Fenner Watershed of 13,000 to 33,000 AFY.[146]

In 1997, Metropolitan conducted a series of studies for the Fenner Gap region in support of an environmental impact report. Utilizing a watershed model and MODFLOW, Geoscience updated their recharge estimates to between 15,000 and 37,000 AFY.[147] Two years later, the Technical Review Board for Metropolitan, using an assumption of recharge as 3 percent to 7 percent of precipitation, estimated recharge to range between 14,000 AFY and 33,000 AFY using a chloride balance calculation.[148]

The first detailed and extensive studies were conducted by Geoscience in support of the earlier Metropolitan EIS/EIR, beginning in the early 1980's and culminating with their 1999 Technical Report.[149] Geoscience based its work on precipitation records, water level data from 50 wells in the region, and isotopic data verifying the recent age of the water. Geoscience then had its work peer-reviewed by an outside firm. Their 1999 estimate of recharge to the Fenner Watershed indicated a range of 15,000 to 37,000 AFY with an average annual estimate of 30,000 AFY.[150] The extent of this range is due to uncertainty in the assignment of each model parameter value, with some parameters having greater influence on the total recoverable water estimate than others. For example, the model is highly sensitive to the parameter values of field capacity and soil thickness; uncertainty in the estimates of these values has a great influence on the total

145 Todd, David K., *Groundwater Resource Investigations near Cadiz, San Bernardino County, California*, October 1984; Todd, David K., *Supplemental Information on Groundwater Resources near Cadiz, California*, November 1984.

146 GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins, Prepared for Cadiz Land Company, Inc. and Mojave Water District*, September 1995, Table 9.

147 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 41.

148 Wood, Warren. W., *Use and Misuse of the Chloride Balance Method in Estimating Ground Water Recharge*, in Groundwater, Vol. 37, No.1, January 1999, Pages 2-3. This assumption was determined to be valid by using a chloride balance calculation developed by Wood (1999). The use of a chloride balance calculation is based on the principle that the recharge (the water mass flux) to a water table can be determined if the average chloride concentration for a given area are known in both precipitation and groundwater. Chloride is chosen for this evaluation because it is generally the most conservative ionic species (nonreactive with aquifer materials) commonly found in groundwater.

149 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999.

150 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 41.

recoverable water estimate. The model is relatively insensitive to values of soil moisture, however, which have very little influence on the total recoverable water estimate.[151]

Geosciences's prior watershed model was used to evaluate the available water resources within the Bristol, Cadiz, and Fenner Watersheds. The primary difference between the Bristol, Cadiz, and Fenner Watershed model of Geoscience and other models from USGS is the approach taken to determine the values of the individual components of the models. The USGS watershed model begins by calculating the amount of water infiltrating into the groundwater basin. That amount is subtracted from the total volume of water available to the watershed, and the models then determine the surface runoff and other components of the water balance as fractions of the remaining water. The approach for the Geoscience watershed model, on the other hand, was to determine the runoff component of the water balance first. Once established, the runoff was subtracted from the total amount of water, and all of the other components (i.e. infiltration, vegetation interception, evapotranspiration, soil moisture, and percolation) were calculated based on the amount of water remaining.

As a comparative analysis to the watershed model described above, a regional water balance was performed for the same watershed area (i.e. Bristol, Cadiz, and Fenner) by Geoscience. A water balance is the quantitative evaluation of the equation of hydrologic equilibrium which relates inflow, outflow, and the resulting change in storage. Inflow terms include percolation into the groundwater system and surface runoff. The only outflow terms for surface and subsurface water entering the Watershed are evaporation from Bristol and Cadiz Dry Lakes and groundwater pumping. No subsurface outflow occurs because the Watershed system is closed. Assuming that no change in storage occurs within the Watershed, the sum of the inflow terms (percolation plus runoff) should equal the sum of the outflow terms (evapotranspiration and pumping).[152]

The particular method of calibration used by Geoscience was the "history matching" technique. In this method, a transient calibration period from 1986 to 1997 was chosen to represent a historical time period where water levels, pumping, natural recharge, and evapotranspiration are known with a reasonable degree of accuracy. Once the initial model data was inputted, model-generated water levels for the period from 1986 to 1997 were compared with measured water levels for selected wells. Of equal importance, individual recharge and discharge components calculated by the model were compared to estimated historical recharge and discharge. Adjustments in hydrogeologic parameters, such as hydraulic conductivity, transmissivity, storativity and leakance, and extinction depth of evapotranspiration were then made within tolerable limits until a satisfactory match was obtained. Parameter changes during model calibration were assigned to groups of cells. Adjustment of individual parameters for individual model cells was not considered.

151 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 58.

152 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 59.

Geoscience estimated the range of groundwater recharge to the Fenner, Bristol, and Cadiz Watershed areas to be 20,000 to 58,000 AFY.[153] The volume of groundwater in storage within aquifers of the Fenner Watershed was estimated by Geoscience to range from 13 to 23 million AF.[154]

Maxey-Eakin Model Studies

A series of studies were conducted in 2000 to estimate recharge using the "Maxey-Eakin" model. The basic premise of a Maxey-Eakin recharge estimate is that the rate of groundwater replenishment is proportional to the annual rainfall. Recharge estimates using a Maxey-Eakin method requires predicting how precipitation (rain and snow) varies with elevation change on an annual basis in localized areas. From these data, a percentage of annual precipitation will contribute to groundwater recharge. Hence, a Maxey-Eakin model predicts recharge as a function of precipitation.[155]

Review comments by the U.S. Geological Survey, Water Resources Division on Metropolitan's Draft EIR on the Cadiz Groundwater Storage and Dry-Year Supply were accompanied by an independent recharge estimate to the Fenner Basin based on a Maxey-Eakin method.[156] The Maxey-Eakin model is a simple empirical model that utilizes estimates of recharge for elevation zones based on average annual precipitation. The model was developed for Central Nevada. Using the Maxey-Eakin model, the USGS estimated recharge at between 2,550 (worst case scenario) and 11,200 AFY.[157] Timothy Durbin conducted a separate review, and using the Maxey-Eakin model, estimated recharge at 5,000 AFY.[158] John D. Bredehoeft also conducted a review in 2000 using the Maxey-Eakin model, and determined that recharge was between 5,000 and 6,000 AFY.[159] These estimates did not use site-specific geological and hydrological parameters. Finally, a study conducted for the Lawrence Livermore National Library in May of 2000 applied the Maxey-Eakin model and determined that recharge was between 16,214 AFY using a regional precipitation elevation curve, and 29,185 AFY using the local curve.[160]

153 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, Report No. 1163*, November 1999, page 120 and Appendix F.

154 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 66.

155 Davisson, M/L. and T.P. Rose, *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*, Lawrence Livermore National Laboratory, May 2000, page 3.

156 U.S. Geological Survey, *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, 2000, Memorandum from J.F. Devine to M.S. Brady*, February 2000.

157 U.S. Geological Survey, *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, 2000, Memorandum from J.F. Devine to M.S. Brady*, February 2000.

158 Durbin Timothy, *Comments on Draft EIR/EIS Cadiz Groundwater Storage Project Cadiz and Fenner Valleys, San Bernardino County, California*: Prepared for County of San Bernardino, February 21, 2000, in Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001, page 8.

159 Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001, page 4.

160 Davisson, M/L. and T.P. Rose, *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*, Lawrence Livermore National Laboratory, May 2000, page 6.

Current Recharge Estimates

To address the discrepancies in recharge estimates in previous studies, in 2010, CH2M Hill reviewed previous Geoscience modeling studies and conducted additional studies to provide an updated assessment of: 1) potential recoverable water that could be conserved over the long term (by intercepting water that would otherwise discharge by evaporation from Bristol and Cadiz Dry Lakes), and 2) groundwater in storage in the Fenner Valley and northern Bristol Valley area. This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model, based on the USGS MODFLOW-2000 computer code, of the Fenner Gap area.[161] This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model, based on the USGS MODFLOW-2000 computer code, of the Fenner Gap area.

The USGS released INFIL3.0 in 2008, software technology previously unavailable for prior studies conducted by Geoscience in 1999.[162] INFIL3.0 computes daily, monthly, and annual average water-balance components for multi-year simulations.[163] MODFLOW-2000, another more recent model unavailable in the 1999 Geoscience study, is an enhancement to the previous MODFLOW numerical model originally documented by the USGS in 1984 because it requires that a conceptual model be developed of the groundwater system to be simulated, including, lateral and vertical extents of the system, definition of top and bottom of aquifers and confining units, boundary conditions (such as no-flow rock, specified inflows and outflows, constant heads where groundwater levels are maintained as constant, or some combination of these), hydrogeologic properties of aquifers, and observations to calibrate against (e.g., measured groundwater levels).[164]

The USGS computer program INFIL3.0 was used to assess the quantity of recharge to the groundwater system and, therefore, recoverable water. The USGS released INFIL3.0 in 2008. INFIL3.0 is a grid-based, distributed–parameter, deterministic water-balance watershed model used to estimate the areal and temporal net infiltration below the root zone.[165] The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone and is no longer affected by evapotranspiration and is capable of percolating to, and recharging, groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water runon (runoff and streamflow).

Using the USGS INFIL3.0 model and its three-dimensional groundwater flow model, CH2M Hill's assessments indicated that a reasonable estimate of potential recoverable water is about

161 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 1-2, 1-3.
162 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 1-3.
163 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page ES-3.
164 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-13.
165 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8, 4-9.

32,000 AFY and the volume of groundwater in storage is reasonably estimated to be between about 17 to 34 MAF in the alluvium of the Fenner Valley and northern Bristol Valley area.[166] CH2M Hill used estimates of the following variables: volume of aquifer, determined as the volume between the groundwater table and the base of the alluvium (saturated thickness), percent of aquifer saturated thickness that is expected to be an aquifer (to exclude clay and silt intervals that do not yield water readily), and estimated specific yield.[167] Using low and high ranges provided for each of these variables based on Geoscience's previous estimates from 1999, CH2M Hill concluded the range of groundwater in storage in the focus area fell within the above range.[168]

CH2M Hill also presented estimates of potentially recoverable water, water that would otherwise discharge to the Bristol and Cadiz Dry Lakes and then evaporate. The estimates were developed using the USGS INFIL3.0 watershed soil moisture budget model and then tested through application of the USGS MODFLOW-2000 model of groundwater flow through the Fenner Gap.[169] CH2M Hill found that total recoverable water is equal to the amount of recharge to the groundwater system in the Fenner Watershed, which is approximately equal to the amount of groundwater flow through Fenner Gap through the alluvial and carbonate rock units (flow through other rock units is expected to be substantially less than through these two hydrogeologic units).[170] By intercepting this groundwater flow through the gap, a reduction of evaporation from Bristol and Cadiz Dry Lakes is expected, but there would be no reduction in groundwater storage.

CH2M Hill's model provided an annual recharge estimate of approximately 32,000 AFY, consisting of 30,191 AFY from the Fenner Watershed and 2,256 AFY from Orange Blossom Wash.[171] The time period of input data was from 1948 to 2008. As discussed above, this volume of water currently migrates downgradient to the Dry Lakes where it becomes hypersaline and is then lost to evaporation. Consequently, over a 50-year time period, the cumulative evaporative loss would be 1.6 MAF.[172] The total volume of water migrating to the Dry Lakes is actually more than 32,000 AFY due to additional surface water and groundwater recharge from the areas west, south, and east of the Dry Lakes.

The annual quantities of recharge vary with annual precipitation. However, in general, the period prior to 1975 was much drier than the long-term average, while the period after 1975 was much wetter than average.[173] As such, the period 1958 through 2007 covers both long-term dry and long-term wet periods and represents a reasonable average. As previously noted in this chapter and in other sections of this Draft EIR, climate change is predicted to result in more extremes in precipitation year over year. Over the 50-year life of the Project, the annual average precipitation

166 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page ES-1.
167 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.
168 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page. 3-1.
169 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-13.
170 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8, 4-9.
171 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8.
172 GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery and Storage Project*, September 2011, page 4.
173 CH2`M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.

may or may not increase compared to the previous 50 years and weather events could be more extreme.

Water Quality

Fenner Watershed

The quality of the groundwater in the Fenner Gap and Fenner Valley area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L).[174] The federal secondary Maximum Contaminant Level (MCL) for TDS in drinking water is 500 milligrams per liter (mg/L).[175] However, all groundwater having a TDS below 3,000 mg/L is considered by the State to be a potential domestic or municipal source of water supply and the Upper Limit secondary MCL is 1,000 mg/L.[176]

More detailed water quality data is available from wells sampled in the Fenner Valley area between 1901 and 1961.[177] Laboratory analytical results indicted groundwater is predominantly a sodium (37 to 96 mg/L) bicarbonate (114 to 162 mg/L) water, with occasional higher concentrations of calcium (up to 43 mg/L). Chloride concentrations ranged from 35 to 67 mg/L, below the federal secondary MCL for chloride in drinking water of 250 mg/L.[178]

Dry Lakes

At Bristol and Cadiz Dry Lakes, the evaporation of surface water and shallow groundwater has concentrated dissolved salts, resulting in TDS concentrations as high as 298,000 mg/L.[179] Groundwater salts are predominantly made up of sodium chloride with lower concentrations of calcium, magnesium, and sulfate. The location of the interface between the low-TDS "fresh" groundwater and high-TDS "saline" groundwater underlying the Dry Lakes has been mapped on the basis of data from agricultural wells, observation wells, and historical data from other wells in the area using 1,000 mg/L TDS as the saline water/freshwater interface.[180] Figure 4.9-6 includes the current estimated saline water/freshwater interface located as a northwest to southeast contour between the playas and the agricultural operations.

174 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-81.
175 Code of Federal Regulations, *National Secondary Drinking Water Regulations*, Title 40: Protection of Environment, Chapter 1, Environmental Protection Agency: Part 143.3.
176 State Water Resources Control Board, *Adoption Of Policy Entitled Sources Of Drinking Water*, Resolution No. 88-63, as Revised by Resolution No. 2006-0008, 2006, Page 2.
177 Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964.
178 Code of Federal Regulations, *National Secondary Drinking Water Regulations*, Title 40: Protection of Environment, Chapter 1, Environmental Protection Agency: Part 143.3.
179 Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964, page 75.
180 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project, Phase I - Conservation Scenarios*, August 2011, page 11.

Colorado River Aqueduct

The USBR conducts water sampling at a number of locations in the Colorado River, including just below the Parker Dam that holds Lake Havasu.[181] The water quality of these samples would be expected to closely represent the water quality of water Metropolitan pumps from Lake Havasu for distribution through the CRA. **Table 4.9-3** summarizes the range of concentrations of various water quality parameters for 12 sampling events collected in 2007.

TABLE 4.9-3
SUMMARY OF 2007 WATER QUALITY PARAMETERS BELOW PARKER DAM (mg/L)

Total Dissolved Solids	647 to 673.8
Calcium	12.1 to 12.4
Magnesium	4.4 to 4.7
Chloride	14.1 to 14.3
Sulfate	40.0 to 40.7
Sodium and Potassium	15.9 to 16.1
Carbonate	12.5 to 12.9

SOURCE: Colorado River Basin Salinity Control Program, Monthly Salinity Data at 20 Key Stations in Colorado River Basin, http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf.

Water imported via the CRA has a TDS averaging around 650 mg/l during normal water years.[182] During the high water flows of 1983–1986, salinity levels in the CRA dropped to a historic low of 525 mg/l. However, during the 1987–1990 drought, higher salinity levels returned. High TDS in water supplies leads to high TDS in wastewater, which lowers the usefulness of the water and increases the cost of recycled water. In addition to the link between water supply and water quality, high levels of TDS in water supplies can damage water delivery systems and home appliances.

To reduce the effects of high TDS levels on water supply reliability, Metropolitan approved a Salinity Management Policy in April 1999. In addition to fostering interstate cooperation on this issue, the seven Colorado River basin states formed the Colorado River Basin Salinity Control Forum (Forum). To lower TDS levels in Colorado River supplies, the Forum develops programs designed to prevent a portion of the abundant salt supply from moving into the river system. The Colorado River Basin Salinity Control Program targets the interception and control of non-point sources, such as surface runoff, as well as wastewater and saline hot springs. As a result of the Salinity Management Policy, TDS levels in Colorado River water sampled just below Parker Dam have been reduced to below 600 mg/L since 1985.[183]

181 Colorado River Basin Salinity Control Program, *Monthly Salinity Data at 20 Key Stations in Colorado River Basin*, http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf, accessed August 2011.
182 Vallecitos Water District, *2010 Urban Water Management Plan*, http://www.vwd.org/uploads/I_Section_5_Water_Quality_Final.pdf, accessed August 2011.
183 U.S. Bureau of Reclamation, *Quality of Water, Colorado River Basin, Progress Report No. 22*, 2005, Appendix A, page 69.

4.9.2 Regulatory Framework

The following Sections provide the federal, state, regional, and local regulatory framework for the Project.

Federal

Clean Water Act

The Clean Water Act (CWA, 33 USC 1251-1376) is the major federal legislation governing water quality. The objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA established the basic structure for regulating discharges of pollutants into the waters of the U.S. and gave the EPA the authority to implement pollution control programs. Sections 303 and 304 provide for water quality standards, criteria, and guidelines. The statute employs a variety of regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) is the principal federal law in the United States that ensures safe drinking water for the public. Pursuant to the Act, the EPA is required to set standards for drinking water quality and oversee all states, localities, and water suppliers who implement these standards.

SDWA applies to every public water system in the United States. There are currently more than 160,000 public water systems providing water to almost all Americans at some time in their lives. The Act does not cover private wells.

The SDWA requires the EPA to establish National Primary Drinking Water Regulations (NPDWRs) for contaminants that may cause adverse public health effects. The regulations include both mandatory levels (Maximum Contaminant Levels, or MCLs) and non-enforceable health goals (Maximum Contaminant Level Goals, or MCLGs) for each included contaminant.

State and Regional

SWRCB Resolution 68-16

The SWRCB has broad authority over discharges to waters of the State. California has adopted a "non-degradation policy" (Statement of Policy with Respect to Maintaining the High Quality of Waters in California; Resolution 68-16; October 1968) for State waters, whereby actions that tend to degrade the quality of groundwater are prohibited. Oversight of this policy is done through the RWQCBs, although the RWQCB does not have permit authority over injection/extraction activities, which do not constitute a discharge to water. However, the RWQCB would review injection/extraction activities to ensure groundwater quality standards are met. The California Department of Public Health (DPH) regulates drinking water quality and may advise the individual RWQCBs on discharge requirement.

SWRCB Notice of Extraction and Diversion of Water

Division 2 of Part 5 of the California Water Code, commencing with Section 4999, requires every person who extracts groundwater within the counties of Riverside, San Bernardino, Los Angeles, and Ventura in excess of 25 AFY to file a notice with the SWRCB on forms provided by the SWRCB.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) provides the basis for water quality regulation within California and defines water quality objectives as the limits or levels of water constituents that are established for reasonable protection of beneficial uses. The SWRCB administers water rights, water pollution control, and water quality functions throughout the State, while the Colorado River Basin RWQCB conducts planning, permitting, and enforcement activities. The Porter-Cologne Act requires the RWQCB to establish a regional Basin Plan with water quality objectives, while acknowledging that water quality may be changed to some degree without unreasonably affecting beneficial uses. Beneficial uses, together with the corresponding water quality objectives, are defined as standards, per federal regulations. Therefore, the regional basin plans form the regulatory references for meeting state and federal requirements for water quality control. Changes in water quality are allowed if the change is consistent with the maximum beneficial use of the state, does not unreasonably affect the present or anticipated beneficial uses, and does not result in water quality less than that prescribed in the water quality control plans. The basin plan for this location is discussed below.

Colorado River Basin Regional Water Quality Control Basin Plan

The preparation and adoption of water quality control plans (Basin Plans) are required by the California Water Code (Section 13240). According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives. Because beneficial uses, together with their corresponding water quality objectives, can be defined per federal regulations as water quality standards, the Basin Plans are regulatory references for meeting the state and federal requirements for water quality control. In relevant part, Article X, Section 2 of the California Constitution declares:

> "[B]ecause of the conditions prevailing in this State, the general welfare requires that the *water resources of the State be put to beneficial use to the fullest extent of which they are capable*, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare…" (emphasis added)

The Colorado River Basin RWQCB is responsible for establishing the beneficial uses of surface water and groundwater within its basin. The beneficial uses listed in the Basin Plan applicable to the Project are listed below in **Table 4.9-4**.[184]

TABLE 4.9-4
GROUNDWATER BENEFICIAL USE DESIGNATIONS

Water Body	MUN	AGR	IND
Groundwater (Bristol Hydrologic Unit)	X	X	X
Groundwater (Cadiz Hydrologic Unit)	X	X	
Groundwater (Fenner Hydrologic Unit)			

MUN - Municipal and Domestic Supply - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
AGR - Agricultural Supply - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
IND - Industrial Service Supply - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
X = existing beneficial use

SOURCE: Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006, Table 2-5.

The Colorado River Basin RWQCB is responsible for issuing permits to ensure the protection of the above beneficial uses. All water placed for recharge in the spreading basins would have to comply with the water quality objectives (WQOs). The RWQCB recognizes that establishing specific numerical groundwater water quality goals involves complex considerations since the quality of groundwater varies with depth, location, and a variety of factors. For groundwater, the RWQCB's overall goal is to maintain the existing water quality of all non-degraded groundwater basins where feasible and minimize the quantities of contaminants reaching any groundwater basin. Specific relevant groundwater WQOs are as listed below.[185]

> **TDS:** Discharges of wastes or wastewater shall not increase the TDS content of receiving waters, unless it can be demonstrated to the satisfaction of the Regional Board that such an increase in total dissolved solids does not adversely affect beneficial uses of receiving waters.
>
> **Taste and Odors:** Ground waters for use as domestic or municipal supply shall not contain taste or odor producing substances in concentrations that adversely affect beneficial uses as a result of human activity.
>
> **Bacteriological Quality:** In ground waters designated for use as domestic or municipal supply (MUN), the concentration of coliform organisms shall not exceed the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 3.

184 Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006, Table 2-5.
185 Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006, Page 3-8.

Chemical And Physical Quality: Waters designated for use as domestic or MUN shall not contain concentrations of chemical constituents in excess of the MCLs. Ground waters designated for use as domestic or MUN shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, which provides the primary and secondary MCLs.[186] The specific TDS standards are 500 mg/L as the recommended maximum, 1,000 mg/L as the upper limit, and 1,500 mg/L as the short-term maximum. As previously discussed, the Project uses 1,000 mg/L to define the brine-freshwater interface.

NPDES General Construction Storm Water Permit

The RWQCB administers the National Pollution Discharge Elimination System (NPDES) storm water permitting program in the Colorado River Basin region. Construction activities disturbing one acre or more of land are subject to the permitting requirements of the NPDES General Permit for Discharges of Storm Water Runoff Associated with Construction Activity (General Construction Permit). The Project must submit a Notice of Intent to the RWQCB to be covered by the General Construction Permit prior to the beginning of construction. The General Construction Permit requires the preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must be prepared before construction begins. The SWPPP would include specific construction-related Best Management Practices (BMPs) to prevent soil erosion and loss of topsoil. BMPs implemented could include, but would not be limited to, physical barriers to prevent erosion and sedimentation, construction of sedimentation basins, limitations on work periods during storm events, use of swales, protection of stockpiled materials, and a variety of other measures that would substantially reduce or prevent erosion from occurring during construction.

Law of the River (Colorado River Allocations)

The Colorado River is the most important waterway in the Region. The River supplies water for use within the Region and elsewhere. Apportionment of water available for diversion from the River is made in accordance with a number of documents collectively referred to as the Law of the River. These include interstate compacts, federal legislation, water delivery contracts, state legislation, a treaty with Mexico, United States Supreme Court decrees, and federal administrative actions. Presently, California is receiving waters unused by other states. The 2003 Quantification Settlement Agreements created California's "soft landing" by reducing California's Colorado River water usage from 5.2 million AFY to 4.4 million AFY in a normal year over 15 years through the conservation and transfer of water from agricultural to urban uses in San Diego County Water Authority's, Metropolitan's, and Coachella Valley Water District's jurisdictions, through quantifying the agencies' priority water rights to the River and allocating water in times of shortage. This effort was called the "Interim Surplus Guidelines." The Interim Surplus Guidelines adopted rules for deciding when there was surplus water in the Colorado River, and how such a surplus could be used, as California wound down its excess use.

186 California Code of Regulations, Title 22, Chapter 15.

County and Local

San Bernardino County Groundwater Management Ordinance

The Desert Groundwater Management Ordinance (Title 3, Division 3, Chapter 6, Article 5, Section 33.06551 of the San Bernardino County Code of Ordinances) imposes permitting requirements and procedures for certain new groundwater extraction wells in the Desert Region of the County. The ordinance requires new wells to obtain a permit, which is a discretionary action subject to CEQA. The stated purpose of the ordinance is to ensure safe yield and health of aquifers in the Desert Region of the County. The ordinance does not apply to entities that are exempt, or have prepared a Groundwater Management Plan and that have entered into a MOU with the County governing operation, monitoring, and reporting procedures of the proposed new well(s).

4.9.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines, Appendix G*, a project may be deemed to have a significant effect on the environment with respect to hydrology and water quality if it would:

- Violate any water quality standards or waste discharge requirements;
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted);
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner, which would result in substantial erosion or siltation on- or off-site;
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner, which would result in flooding on- or off-site;
- Create or contribute runoff water, which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff;
- Otherwise substantially degrade water quality;
- Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map;
- Place within a 100-year flood hazard area structures, which would impede or redirect flood flows;
- Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam; or
- Result in inundation by seiche, tsunami, or mudflow.

Methodology

Various site-specific and regional reports and maps were reviewed to evaluate the potential impacts of the Project to hydrology and water quality. Hydrologic data was evaluated from regional investigations, as well as site-specific hydrologic data collected from wells on the Project site and generated from models of the aquifer behavior. The Conservation and Recovery and Imported Water Storage Components are evaluated separately below.

Using the available geologic and hydrologic data collected to date, Geoscience prepared a three-dimensional, density-dependant groundwater flow and transport model to simulate the aquifer system in the Project area, including the Fenner Valley, the Fenner Gap, and the Cadiz Valley area that includes most of the Bristol Playa and the northern portion of the Cadiz Playa (Appendices I1 and I2).[187, 188] The groundwater model was used to simulate the potential response of the aquifer system to Project operations using two variations of the wellfield configuration and three variations of potential annual recharge volumes over a period of 50 years of groundwater production at 50,000 AFY, followed by 50 years of recovery (no groundwater production). The output of the simulations are the modeled drawdown of groundwater levels, the potential movement of the freshwater-saline water interface, and the amount of potential subsidence (subsidence is addressed in Section 4.6, Geology).

The modeled scenarios vary by recharge amounts. The Project scenario assumes an annual recharge of approximately 32,000 AFY in the Fenner Watershed and Orange Blossom Wash based on CH2M Hill's updated evaluation of recharge.[189] This recharge volume estimate is derived from the USGS INFIL3.0 Model, is based on long-term precipitation records, and represents the long-term average annual recharge within the Fenner Watershed that ultimately migrates to the Bristol and Cadiz Dry Lakes, becomes saline, and evaporates. However, because a few earlier evaluations of available recharge predicted a lower potential range for recharge, two sensitivity scenarios were applied to model conservative, worst-case aquifer responses where the average annual recharge over a 100-year time period is reduced to 16,000 and 5,000 AFY respectively.[190] As previously noted, the modeling did not include recharge that occurs west, south, and east of the Bristol and Cadiz Dry Lakes. Consequently, the groundwater model provides the most conservative aquifer responses as the inclusion of recharge from other watersheds would reduce the predicted groundwater level drawdown and migration of the freshwater - saline water interface. The modeling also considered two different production well configurations: Well Configuration A would use five existing Cadiz agricultural wells, two new high capacity wells, and 15 new lower-capacity wells; Configuration B would use five existing

187 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011.
188 GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Conservation, Storage, and Recovery Project,* September 20, 2011.
189 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-8.
190 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 35.

Cadiz agricultural wells and 29 new lower-capacity wells.[191] (See Section 3.6.1 for further discussion of the proposed wellfield configuration options.)

The two wellfield configurations were used to address the potential range in recharge rates and thus transmissivity variations of the aquifer. Because the wellfield placement will be sited after initial modeling runs on an initial group of wells, the wellfield construction will be "phased." That is, a group of wells will be constructed initially in the Fenner Gap area. Initial pumping tests on these wells will be used to validate regional aquifer characteristics. Based on the findings from the field data, the model will be recalibrated and subsequent well locations will be placed in the optimum locations from the regional aquifer tests.[192]

Groundwater Management, Monitoring, and Mitigation Plan

The GMMMP prepared for the Project to provide for the adaptive management of the basin includes seven measures to monitor Project operations and potential effects on critical resources. Four of the seven measures include, as necessary, corrective actions to be implemented to insure protection of these identified critical resources (Appendix B1).[193] Three of the seven measures only include verification measures to confirm previous technical conclusions of no possible impacts. These monitoring and response measures are presented in Chapter 6 of the GMMMP. These measures are referred to as Project Design Features in this EIR and they are numbered according to the GMMMP section in which they are described (e.g., Project Design Feature 6.2 – Third Party Wells is Section 6.2 of the GMMMP). These Project Design Features from the GMMMP include a monitoring element, action criteria, and corrective measures to address a potential issue if the action criteria are triggered. The action criteria are set below the threshold for impact significance as established in accordance with CEQA for each impact area, thus insuring adequate time to implement the corrective actions and avoid significant impact. As described in the following impact analysis, where appropriate these GMMMP measures are incorporated into the EIR as mitigation measures to address issue areas where potentially significant impacts could occur and mitigation is required under CEQA. In these cases, implementation of these GMMMP measures would be required as part of the CEQA mitigation compliance process. In other cases, the GMMMP measures are not required as mitigation measures for CEQA purposes but they are summarized here where applicable so that the reader understands that, in accordance with the GMMMP, such measures would be implemented as part of the Project even though the impact for those resource issues is found to have no impact or to be less than significant and no mitigation is required. The Project Design Features from the GMMMP that are required to ensure less than significant impacts to hydrologic resources are listed below.

- GMMMP Project Design Feature 6.2 – Third Party Wells
- GMMMP Project Design Feature 6.4 – Induced Flow of Lower Quality Water From Bristol and Cadiz Dry Lakes

191 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 47.
192 GEOSCIENCE Support Services, Inc., *Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis,* November 2011.
193 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011.

Groundwater Conservation and Recovery Component

Impacts to Water Quality Standards or Waste Discharge Requirements

Significance Threshold

Would the proposed Project result in a significant impact by degrading water quality or violating waste discharge requirements?

Impact Analysis

Surface Water Quality

The Groundwater Conservation and Recovery Component of the Project would include the construction of production wells, piping, and associated pumps, controls, and power appurtenances to extract groundwater and transport the water southeast to the CRA. Construction of these facilities would disturb soils that could result in substantial erosion and/or siltation. In addition, construction equipment and the associated chemical usage could result in spills that could impact surface water quality. Construction of the Project wells and pipeline would not be subject to the NPDES Construction General Permit for Discharges of Stormwater since there are no Waters of the U.S. affected by the production the wells or pipeline. FVMWC would be required to obtain WDRs from the RWQCB for discharging well completion water to detention basins. This production water discharge is a routine action in developing potable wells resulting in de minimis impacts to water quality. The WDRs would establish conditions for ensuring that production water percolates into the ground and does not runoff into the neighboring washes.

In addition to the majority of the project facilities that would be constructed within the Watersheds, two observation wells would be installed as a part of Monitoring Feature 2 east and outside of the Watersheds to monitor groundwater levels in adjacent basins and verify that the Project would have no impacts on groundwater levels outside of the Watersheds. The Piute-1 observation well would be installed outside and east of the Watersheds in the Piute Wash Watershed north of the intersection of Interstate 40 and Highway 95, and the Danby-1 observation well would be installed in the Danby Basin along the ARZC rail line northeast of Danby Lake (Figure 3-4). Construction of these two wells and access to the wells would also disturb soils and could result in erosion and siltation.

Construction of Project facilities may not require coverage under the Construction General NPDES Permit for Discharges of Stormwater since the pipeline alignment and wellfield may not affect waters of the U.S. and since the Piute Wash observation well would affect less than one acre. As a result, preparation of a Stormwater Pollution Prevention Plan (SWPPP) may not be required. However, since construction activities may result in surface runoff quality impacts, Mitigation Measure **HYDRO-1** has been developed to ensure that construction-related Best Management Practices (BMPs) are implemented to prevent soil erosion and to control hazardous materials used during construction from adversely affecting surface water runoff. With implementation of Mitigation Measure **HYDRO-1**, impacts to surface water quality from construction activities would be less than significant.

Groundwater Quality

Figures 4.9-7, 4.9-8, and **4.9-9** present the model-predicted locations of the saline water/freshwater interface for the 32,000, 16,000, and 5,000 AFY recharge scenarios.[194] Each figure includes the model-predicted movement after 50 years of groundwater production at 50,000 AFY, followed by the recovery of groundwater levels after 50 years of no groundwater production.

The interface is predicted to migrate within the shallower alluvium layers but not the deeper rocks of the alluvial, carbonate, and granitic units because the alluvium is more transmissive. The interface migration is eastward and northward from the Dry Lakes toward the wellfield. **Table 4.9-5** summarizes the model-predicted migration distances.[195]

TABLE 4.9-5
SUMMARY OF MODEL-PREDICTED SALINE WATER-FRESHWATER INTERFACE MIGRATION DISTANCES

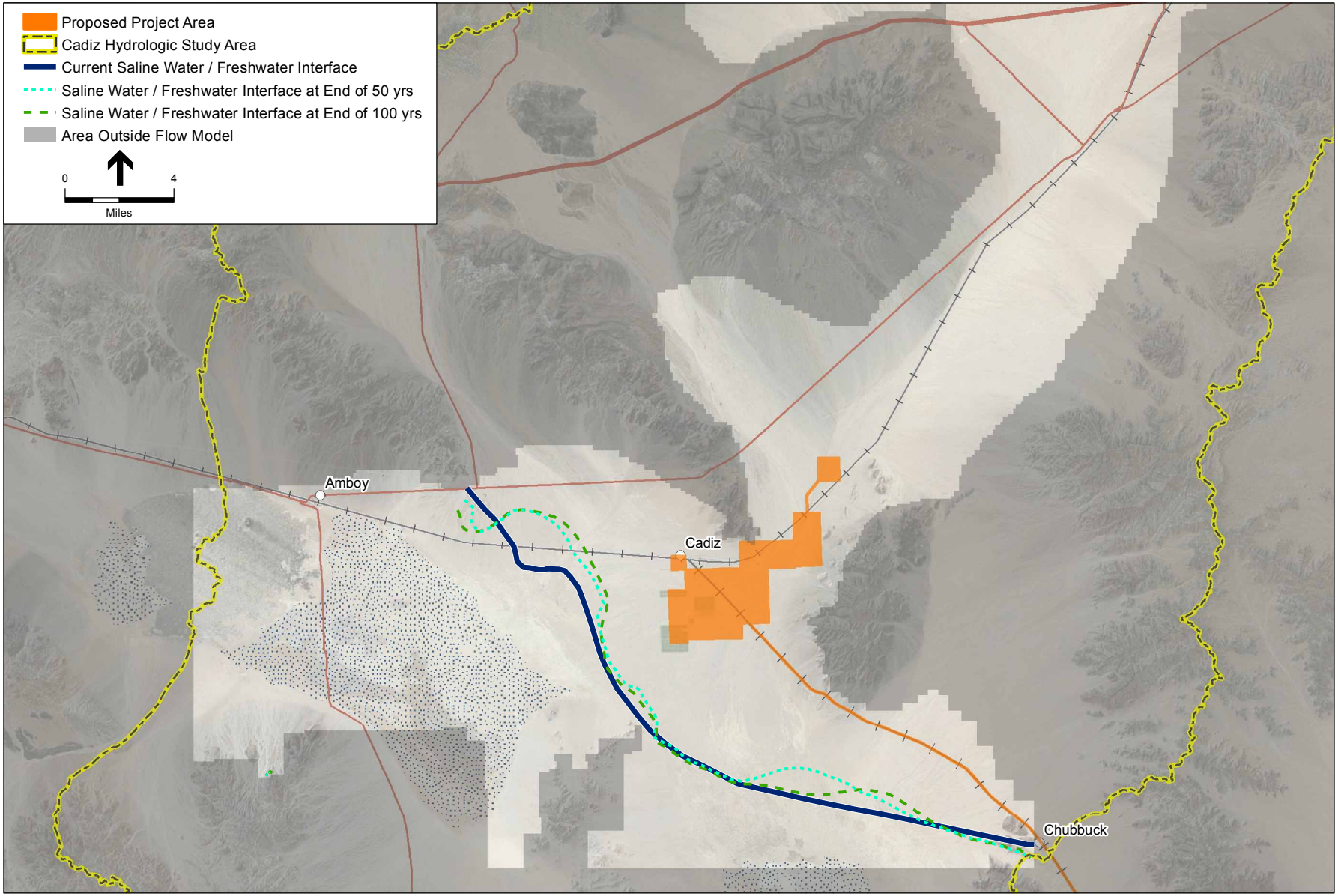
Scenarios	Maximum Migration of Saline Water/Freshwater Interface	
Model Scenario	End of 50 Years (Project Operation Period)	End of 100 Years (Recovery Period)
Project Scenario (32,000 AFY recharge)	10,400 feet northeast	11,500 feet northeast
Sensitivity Scenario 1 (16,000 AFY recharge)	9,700 feet northeast	11,100 feet northeast
Sensitivity Scenario 2 (5,000 AFY recharge)	6,300 feet northeast	9,200 feet northeast

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.

An average of 50,000 AFY of groundwater would be extracted from the aquifers in the Fenner Gap area for the 50-year life of the Project. The extraction of the groundwater would change groundwater flow patterns such that the freshwater/saline water interface currently located between the Bristol and Cadiz Playas and the proposed wellfield would migrate toward the production wells in the Fenner Gap.

As discussed in the Methodology section above, the potential response of the aquifer system to the extraction of an average of 50,000 AFY of groundwater for 50 years was simulated in a groundwater model based on site conditions and the anticipated long-term average recharge from precipitation to the Fenner Watershed and Orange Blossom Wash of approximately 32,000 AFY. In addition, to account for potential worst-case conditions, two additional scenarios were simulated assuming an average annual recharge of 16,000 and 5,000 AFY. In all cases, the saline water/freshwater interface down to about 1,200 feet bgs was predicted to migrate east and north toward the production wells. The maximum predicted migration distance was approximately 11,500 feet and occurs under the 32,000 AFY annual recharge scenario.[196]

[194] GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53.
[195] GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53.
[196] GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53, Figures 72-75.

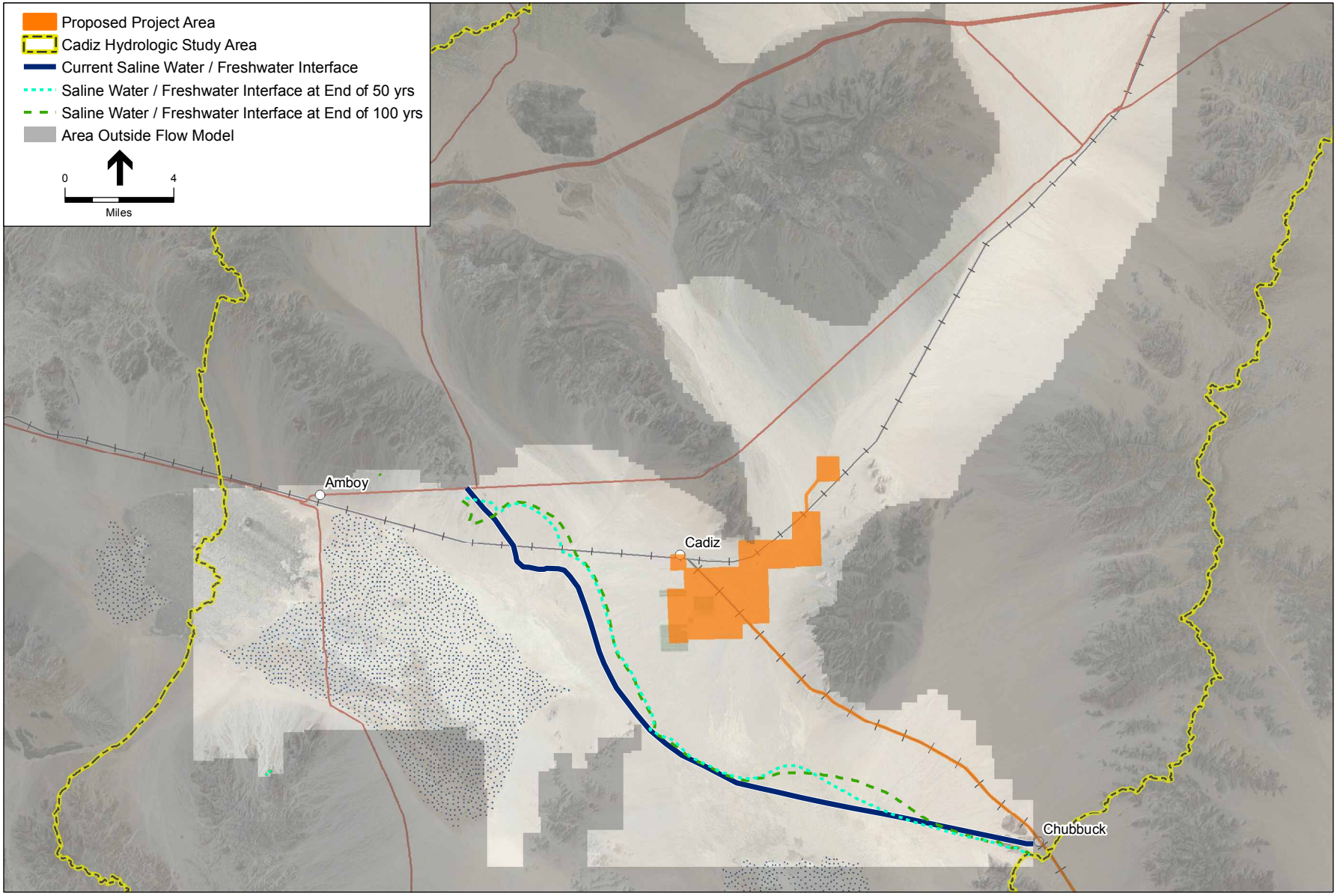


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-7

Model-Predicted Saline Water and Freshwater Interface Migration - Project Scenario (Assumes 32,000 AFY Recharge)

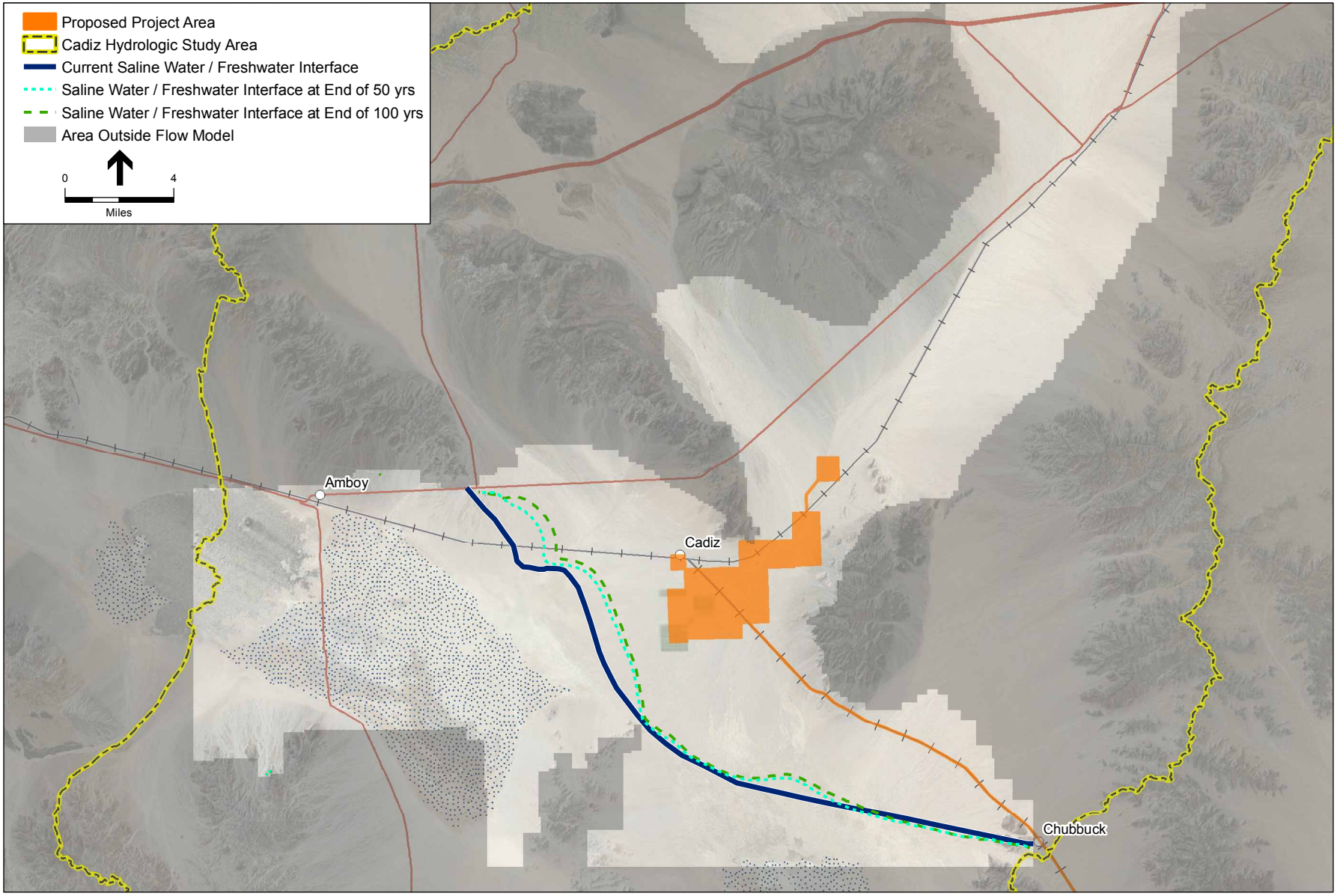


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-8

Model-Predicted Saline Water and Freshwater Interface Migration - Sensitivity Scenario No. 1 (Assumes 16,000 AFY Recharge)



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-9

Model-Predicted Saline Water and Freshwater Interface Migration - Sensitivity Scenario No. 2 (Assumes 5,000 AFY Recharge

As a result, water quality in wells located within the area between the playas and the Project wellfield could be degraded. However, much of this area including the community of Amboy[197] already overlies saline groundwater associated with Bristol Dry Lake. No active production wells are known to exist in the area where groundwater salinity would increase as a result of the saline interface migration. The only active wells in the playa areas are the wells already purposely located in saline water used by the salt production companies for the production of salt minerals. There are currently no active or known planned uses of groundwater in the potentially affected area.

The remaining overlying area affected by potential increased salinity is currently open space. Approximately ½-square mile of the area is currently zoned for agriculture. **Figure 4.9-10** identifies land ownership within the areas that could be affected by saline intrusion. In the future, those property owners within the area affected by the migration of the saline water/freshwater interface due to Project operations would not be able to install a well to pump freshwater from directly below their property. The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. Two project design features address the saline water/freshwater interface: 6.2 - Third Party Wells and 6.4 - Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes.[198] These project design features provide for either provision of an alternate supply of freshwater to affected property owners or revised operation of the project to remedy the saline interface migration. The Action Criteria and Corrective Measures for these two project design features are summarized in **Tables 4.9-6** and **4.9-7**.

Implementation of the project design features in Chapters 6.2 and 6.4 of the GMMMP would reduce potential water quality impacts to the third-party well owners from the potential saline/freshwater migration to less than significant. Therefore, for purposes of this CEQA analysis of the Project, the project design features presented in Chapters 6.2 and 6.4 of the

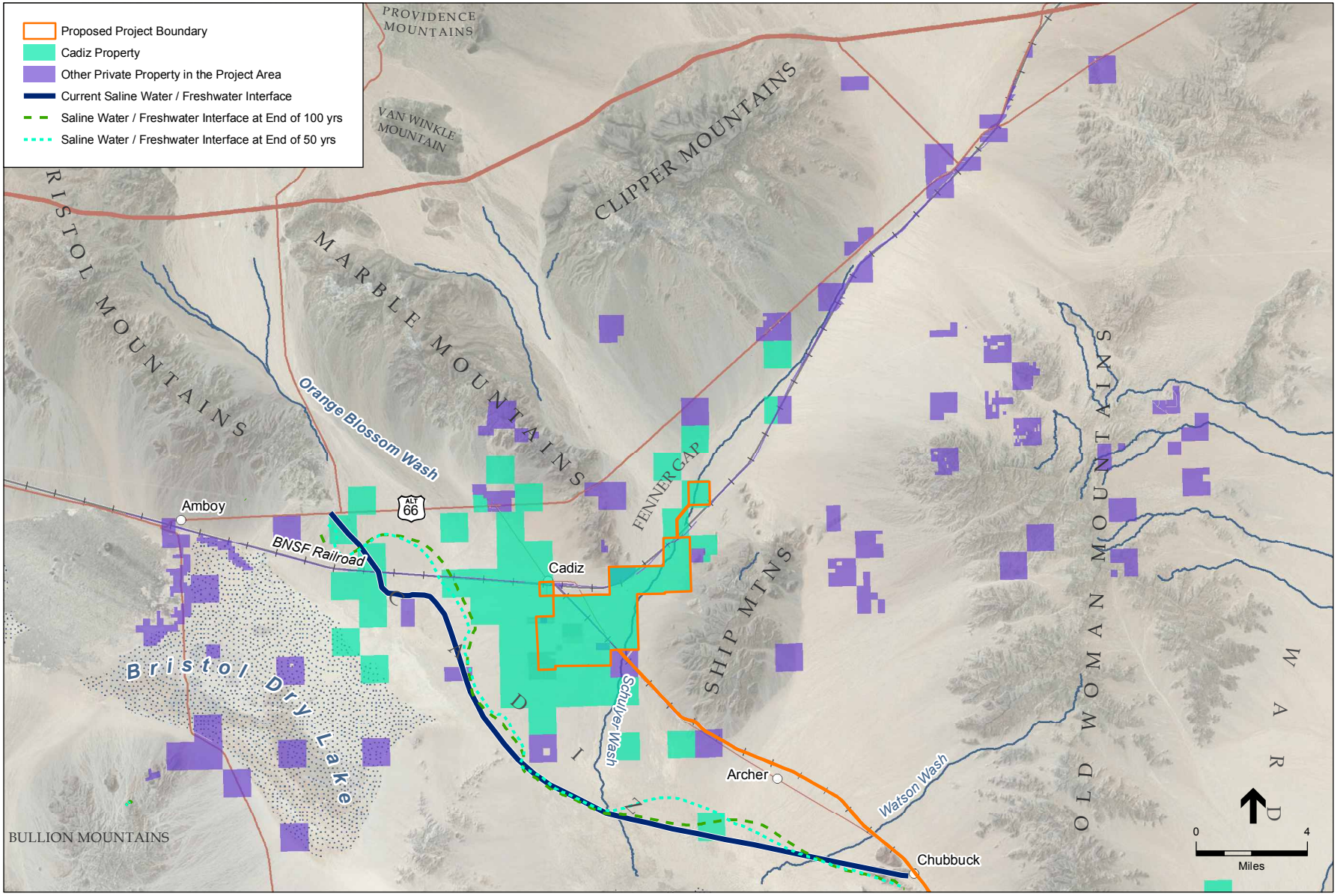
GMMMP are incorporated into this EIR as Mitigation Measures **HYDRO-2** and **HYDRO-3**. Implementation of Mitigation Measure **HYDRO-2** and **HYDRO-3** would ensure that the potential impacts from the water quality degradation and/or migration of the saline/freshwater interface are mitigated to less than significant for third-party wells.

Quality of Groundwater Pumped to the CRA

The following **Table 4.9-8** summarizes water quality parameters for water sampled from the alluvium, carbonate, and bedrock units in Fenner Gap and from the Colorado River just below Parker Dam. Parker Dam holds Lake Havasu on the Colorado River from which Metropolitan pumps water into the CRA. Thus, the Parker Dam water sample results are considered to represent CRA water quality.

197 Amboy had about ten buildings and a population of 4 as of January 17, 2007. Mike Anton, "Destiny in the Desert", Los Angeles Times, January 2007.

198 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Sections 6.2 and 6.4.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-10

Proximity of Private Property to Saline Groundwater Interface

TABLE 4.9-6
GMMMP PROJECT DESIGN FEATURE 6.2 – THIRD PARTY WELLS

Action Criteria	Corrective Measures
Drawdown at the Danby observation well (adjacent to Clipper Mountains) greater than projected by the pre-operational groundwater flow simulation models or the receipt of written complaints by well owners regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes	Upon receipt of the written complaint and during the decision-making process to determine if corrective measures are to be implemented, the FVMWC (or other Project management entity) would arrange for an interim water supply to the affected part as necessary. Additional corrective measures that would be implemented include one or more of the following actions: • Deepen or otherwise improve the efficiency of the impacted well(s); • Blend impacted well water with another local source; • Construct replacement well(s); • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells.

SOURCE: CH2M Hill, Groundwater Management, Monitoring, and Mitigation Plan, November 2011.

The secondary MCLs cited above list the water quality parameters that water purveyors are required to achieve at the point of distribution. In other words, this is the required level of quality at the tap after treatment by the water purveyor. All water that would be pumped from the Project production wells and the water currently in the CRA would be treated by the water purveyors before distribution to the public. As shown in the table above, both the CRA water and the Fenner Gap water currently meet the drinking water standards before treatment. After treatment by the water purveyors, the concentrations would be expected to be even lower.

For the Groundwater Conservation and Recovery Component of the Project, groundwater would be pumped from the alluvial and carbonate units in the Fenner Gap area (Project water) into the water conveyance pipeline from the wellfield to the CRA, where the water would be added to the CRA water and then sent on to the water purveyors. The Project water would have TDS concentrations less than the CRA water, while the sodium and chloride (salt) concentrations of the Project water may be slightly higher than the CRA water. However, as listed in Table 4.9-8 above, all of the parameter concentrations for both waters are currently below MCLs meaning that the water is acceptable for use as drinking water as is. Furthermore, all of the water would be further treated at the water purveyor's treatment facilities. In addition, the maximum volume of Project water that could be added into the CRA in any given year would be 75,000 AF. The maximum carrying volume of the CRA is 1,250,000 AFY. Consequently, the maximum percentage of Project water relative to CRA water would be 6 percent. Based on this overall evaluation, the potential impact would be considered less than significant.

TABLE 4.9-7
GMMMP PROJECT DESIGN FEATURE 6.4 –
INDUCED FLOW OF LOWER LOWER-QUALITY WATER FROM BRISTOL AND CADIZ DRY LAKES

Action Criteria	Corrective Measures
1. Monitored increases in TDS that are higher than projected by the groundwater flow simulation models or, 2. A change in TDS concentration in excess of 1,000 mg/l in the observation well clusters sited along the saline/freshwater interface line.	• Deepen or otherwise improve the efficiency of the impacted well(s); or • Blend impacted well water with another local source; or • Construct replacement well(s); or • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or • Modification of Project operations to reestablish the natural hydraulic gradient and background concentrations at the margins of Bristol and Cadiz Dry Lakes through one or more of the following: – Reduction in pumping from Project wells – Revision of pumping locations within the Project wellfield – Stoppage of groundwater extraction for a duration necessary to correct the predicted impact OR • Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

SOURCE: CH2M Hill, Groundwater Management, Monitoring, and Mitigation Plan, November 2011.

To monitor the water quality of water pumped into the CRA, the GMMMP would collect samples, analyze water quality and report results on a set schedule.[199] The results of the analyses would be evaluated to verify that the water quality of water pumped into the CRA is acceptable and that the impact would be less than significant.

199 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Appendices C and D.

TABLE 4.9-8
SUMMARY OF GENERAL WATER QUALITY RESULTS

Parameter	CA Primary MCL	CA Secondary MCL	Alluvium (Well TW-1) (4-Dec-2009)	Carbonate (Well TW-1) (10-Nov-2009)	Colorado River Below Parker Dam (Jan to Dec 2007)
Total Dissolved Solids (TDS)	n/e	500–1,000	260	220	647 to 673.8
Calcium	n/e	n/e	26	24	12.1 to 12.4
Magnesium	n/e	n/e	5.2	5.7	4.4 to 4.7
Chloride	n/e	250–500	34	38	14.1 to 14.3
Sulfate	n/e	250–500	11	32	40.0 to 40.7
Sodium and Potassium	n/e	n/e	52.9	656	15.9 to 16.1
Carbonate	n/e	n/e	100	130	12.5 to 12.9

California Secondary MCLs are Recommended and Upper Limit are from 17 CCR 64449
All concentrations in milligrams per liter (mg/L)
n/e = not established

SOURCES: CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, page 27; Colorado River Basin Salinity Control Program, *Monthly Salinity Data at 20 Key Stations in Colorado River Basin*, http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf., accessed October 2011.

Mitigation Measures

HYDRO-1: A construction Storm Water Pollution Prevention Plan shall be prepared and included in construction specifications for the Project. At a minimum, the plan shall include the following required Best Management Practices or equivalent measures:

- Install temporary sediment fences or straw waddles at stream crossings or washes to prevent erosion and sedimentation during construction, including at each ARZC railroad trestle along the pipeline alignment.
- Establish designated fueling areas equipped with secondary containment,
- Require drip-pans under all idle equipment on the construction sites,
- Ensure that spill prevention kits are present at all construction sites.

HYDRO-2: Project Design Feature 6.4 found in Chapter 6.4 of the GMMMP shall be implemented to address the potential impacts for the migration of the saline/freshwater water interface to adversely affect groundwater quality. If monitored increases in TDS result in impairment to beneficial uses of groundwater by overlying land owners, one or more of the following corrective measures shall be implemented:

- Deepen or otherwise improve the efficiency of the impacted well(s); or
- Blend impacted well water with another local source; or
- Construct replacement well(s); or
- Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or

- Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells; or
  - Revision of pumping locations within the Project wellfield; or
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or
- Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

HYDRO-3: Project design features in Chapter 6.2 of the GMMMP shall be implemented to address potential impacts to Third Party wells. If a written complaint by a well owner is received regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes, the following corrective measures shall be implemented:

1) Arrange for an interim water supply to the affected party as necessary.
2) Implement additional corrective measures that include one or more of the following actions:
   - Deepen or otherwise improve the efficiency of the impacted well(s); or
   - Blend impacted well water with another local source; or
   - Construct replacement well(s); or
   - Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or
   - Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
     - Reduction in pumping from Project wells; or
     - Revision of pumping locations within the Project wellfield; or
     - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse affect on existing wells.

Significance Conclusion

Less than significant with mitigation.

Impacts to Groundwater Supplies or Groundwater Recharge

Significance Threshold

Would the proposed Project result in a significant impact by substantially depleting groundwater supplies or interfering substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a significant lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

Impact Analysis

Springs

Figure 4.9-3 identifies recorded springs that occur in the Watersheds. Other man-made watering hole features (guzzlers) exist in the high elevations of the surrounding mountains including the Clipper Mountains, Marble Mountains, and Old Woman Mountains. The natural springs are located in the higher elevations of the mountains and occur from rock fractures on the higher slopes of the mountain ranges. There are no natural springs identified within 11 miles of the wellfield. All of the known springs in the Watershed are located in the higher elevations of the mountain ranges at elevations well above the aquifer system, which is located in the valleys at much lower elevations (see Figure 4.9-3). The springs are fed by recharge to the bedrock aquifer systems within the mountains. As shown on Figure 4.9-2, the proportion of precipitation recharging the mountainous bedrock system is relatively small in comparison to the volume of precipitation that migrates vertically downward through the rock formations eventually reaching the aquifer in the alluvial valleys below. Changes to the water table elevation in the alluvial aquifer do not have any effect on the volume of flow in springs because the springs derive their water from precipitation in the higher elevation mountains, not groundwater from the alluvial aquifer. Therefore, there is no known hydraulic connection between these higher elevation springs and the groundwater in the valley floors. As such, the springs in the mountains are well outside the influence of the proposed production wells that derive water only from the alluvial aquifer.

The lack of physical connection between the springs and groundwater in the aquifers in the Project area is discussed further in CH2M Hill's technical memorandum on springs, as well as earlier in this Section.[200] CH2M Hill evaluated two conceptual models of the Bonanza Spring, which are expected to apply to all the springs in the Fenner Watershed. Bonanza Spring is the closest known spring to the Project wellfield at 11 miles to the north. For both conceptual models, the source of water to the springs is precipitation in the mountains that infiltrates into the ground and travels to the springs. There is no information that suggests that these springs are a result of any other source of water, such as deeply circulating groundwater, confined groundwater, or other similar mechanisms attributable to spring formation.

The first concept is based on the observations that there is no information demonstrating a hydraulic connection of those identified springs in the local mountains to groundwater in the alluvial aquifer where the Project pumping would take place. In addition, the alluvium on the

[200] CH2M Hill, *Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs,* August 2011, page 1.

slopes of the mountains is likely to be unsaturated as it thins over bedrock highs, which further inhibits hydraulic continuity between the alluvial aquifer and springs located in the mountains. There is no observed hydraulic continuity between groundwater in fractured granitic bedrock where the springs exist and the regional groundwater table of the alluvial aquifer. Consequently, because there is little or no hydraulic connection, the Project would have no impact on springs.

In order to thoroughly address concerns about potential impacts on springs, and for the avoidance of doubt, CH2M Hill also considered a hypothetical second concept by assuming the existence of hydraulic continuity between groundwater feeding springs and groundwater in the alluvial aquifer just to see what impact the Project might have under this theoretical condition. The results of this hypothetical assessment demonstrated that, for many reasons, including distance between drawdown in the alluvial aquifer and springs, difference in elevation, the required low transmissivity of fractured bedrock, and hydraulic connectivity, any impact to spring flows would be very minor and likely within the natural climatic variability. Even under this hypothetical and worse case scenario, implementation of the Project would have a less than significant effect on the springs.

Although the physical evidence indicates that the groundwater aquifer is not connected to the springs within the Watersheds and thus that pumping of groundwater under the proposed Project would not affect these springs, to comport with the recommendations of the Groundwater Stewardship Committee (see Appendix B2), the GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features relative to springs is GMMMP Project Design Feature 6.7 – Springs.[201] Chapter 5 of the GMMMP describes Monitoring Feature 1 to be used to monitor springs within the Watersheds.[202]

The monitoring protocol would consist of periodic visual, non-invasive monitoring of spring flows from Bonanza Spring, Whiskey Spring, and Vontrigger Spring shown on Figure 3-4 to confirm the modeling results. The GMMMP provides for quarterly monitoring of the Bonanza Spring as an “indicator spring” because it is the spring that is in closest proximity to the Project wellfield (approximately 11 miles from the center of Fenner Gap), and of all springs within the Fenner Watershed, Bonanza Spring would be the first one that would be affected by the Project operations, if any springs were affected, which is not expected. The Whisky and Vontrigger Springs, located beyond the Project’s projected effects on groundwater levels in the alluvial aquifers of the Fenner Watershed, would also be monitored to compare variations in spring flow from those springs to variations in spring flow from the Bonanza Spring. This comparison would assist in determining whether any material reduction of flow at the Bonanza Spring is attributable to the Project operation, or instead, is attributable to regional climate conditions.

The springs would be monitored by visual observations and flow measurements. Visual observations would include starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing water, conductivity, pH and temperature of water, any colorations of water, and general type and extent of vegetation.

201 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Section 6.7.
202 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Section 5.2.

As discussed above, the physical evidence indicates that the groundwater aquifer is not connected to the springs within the Watersheds and therefore, pumping of groundwater under the proposed Project would have no impact on these springs and no mitigation is required.

Groundwater Management

As described above, the Project proposes to capture groundwater that is comprised of natural recharge and groundwater already held in storage that would be retrieved before it flows to the Dry Lakes where a portion is lost to evaporation. To capture the water, groundwater would be extracted from the wellfield to intentionally lower the water table. The water table would be lowered to a level at or below the water levels at the Dry Lakes to gain control of the flow and to prevent the water from flowing to the Dry Lakes. This Section explains that the Project would not substantially deplete groundwater supplies in the Project area because the intentional lowering of groundwater levels (1) is necessary to conserve water that would otherwise be lost to evaporation, (2) is part of a comprehensive groundwater management program that is subject to continuous monitoring and adaptive management, if necessary, and (3) would not cause any long-term material impacts to the aquifer system or surface uses within the Project area. Further, the Project is consistent with legal principles applicable to groundwater management in California as discussed below.

Legal Framework

As discussed in the Regulatory Framework Section above, the State Constitution states that water resources should be put to beneficial use to the fullest extent of which they are capable. The Project achieves this goal by maximizing the beneficial use of water in the Fenner and Orange Blossom Watersheds by preventing its loss to salinity and evaporation at the Dry Lakes.

Article X, Section 2 of the California Constitution requires that:

> *[T]he water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.*

All the waters of the State are subject to the mandate that water may only be used for beneficial purposes by reasonable means.[203] The mandate has been construed as applicable to groundwater by the California Supreme Court since 1934[204] and since then the California Supreme Court has approved several efforts to ensure that groundwater is put to maximum beneficial use. Beneficial uses include domestic, irrigation, industrial, municipal, recreational and environmental uses.[205] Water Code Section 106 provides a legislative declaration that domestic use is the highest use of water in the State.

[203] *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224, 1240-42.
[204] *Peabody v. Vallejo* (1935) 2 Cal.2d 351.
[205] Code of California Regulations: Title 23, Division 3, Article 659 *et seq.*

The State has defined the safe yield of an aquifer as the amount of water that can be withdrawn *without an undesirable result*.[206] This standard is not a rigid calculation of natural recharge. The California Supreme Court has held that the concept of safe yield and overdraft must reflect opportunities to increase the supply of groundwater from active management techniques. Basin management programs that seek to dewater aquifer systems in a controlled and deliberate manner to enhance groundwater recharge, avoid losses and waste of groundwater and optimize basin yields has been recommended and encouraged in technical papers, treatises and approved by the California Supreme Court as consistent with the California Constitution's requirement of fullest beneficial use of available water resources.

For example, the California Supreme Court has held that the quantity of water that can be safely extracted in excess of the natural recharge so to realize greater basin replenishment is a "temporary surplus," that is available for production within the notion of safe yield and consistent with the norm of fullest beneficial use.[207]

> *We agree with plaintiff that if a ground basin's lack of storage space will cause a limitation of extractions to safe yield to result in a probable waste of water, the amount of water which if withdrawn would create the storage space necessary to avoid the waste and not adversely affect the basin's safe yield is a temporary surplus available for appropriation to beneficial use. Accordingly, overdraft occurs only if extractions from the basin exceed its safe yield plus any such temporary surplus.*

As is the case with the Project, the form of waste sought to be addressed by the management strategy employed in the *San Fernando* opinion, included the curtailment of high groundwater levels that resulted in a waste of groundwater.[208]

The law treats beneficial use, safe yield and overdraft as dynamic thresholds that do not set arbitrary restrictions on groundwater use, but rather seek to ensure that the State's limited water resources are managed for optimal society welfare over the long-term. Likewise, through active basin management the yield of a groundwater basin can be increased in a manner that is consistent with long-term social welfare.

In recognition of these considerations, the Chino Basin Watermaster is presently implementing a groundwater management program that will remove 400,000 AF from the groundwater basin to lower water levels and reduce discharges to the Santa Ana River to de minimus quantities. As is the case with the Project here, the objective was to establish a hydraulic barrier by modifying water levels. The program was approved by the San Bernardino Superior Court in December of 2007.[209]

The San Bernardino County Desert Groundwater Ordinance also applies a dynamic, and fact-specific approach to its definition of safe yield. Section 33.06553 of County ordinance defines

---

206 *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 278.
207 *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 280.
208 *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 280.
209 *Chino Basin Municipal Water District v. City of Chino et al.*, San Bernardino County Superior Court Case No. RCV 51010, Order Concerning Motion for Approval of Peace II Documents, December 21, 2007.

Groundwater Safe Yield as the "maximum quantity of water that can be annually withdrawn from a groundwater aquifer (i) without resulting in overdraft (ii) without adversely affecting aquifer health and (iii) without adversely affecting the health of associated lakes, streams, springs and seeps or their biological resources. The safe yield of an aquifer can be increased by management actions such as artificial recharge, including infiltration and other similar actions." Thus, consistent with State policy and the County ordinance, the Project seeks to increase the recoverable safe yield by strategic management of basin groundwater levels.

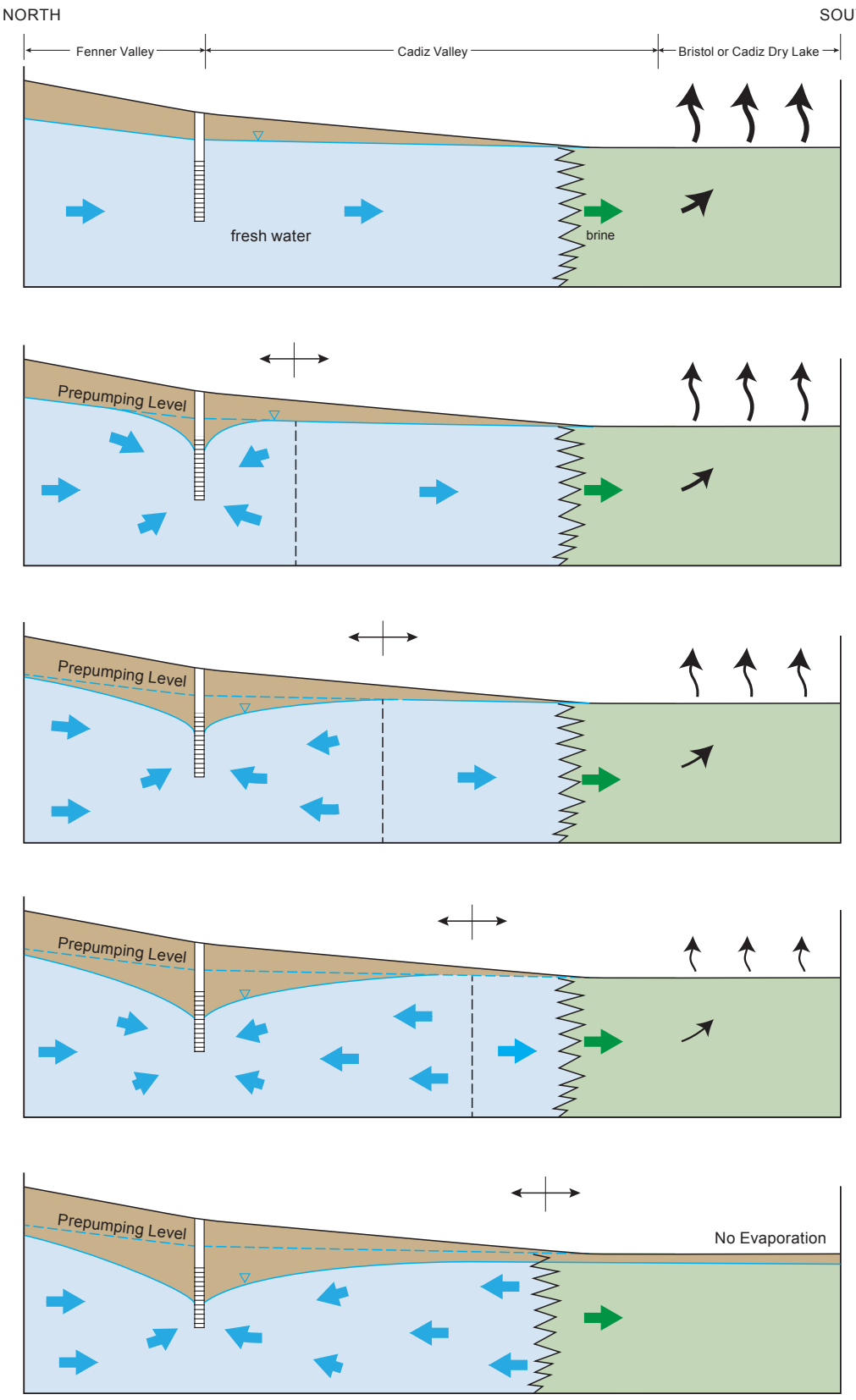
Groundwater Drawdown

The Project proposes to capture an average of 50,000 AFY of groundwater, a portion of which that would otherwise flow through the Fenner Gap as natural recharge and then to the Dry Lakes, become saline, and evaporate. In addition, there is also 4 to 10 MAF of groundwater already in storage down gradient to the west and south of the proposed well-field. Unless management practices can alter the natural gradient, this water will continue migrating towards the Dry Lakes where it will become saline and evaporate. To intercept natural recharge and to retrieve the migratory groundwater below the wellfield, so that it may be conserved and made available for the highest and best use, groundwater would be extracted from the wellfield at Fenner Gap to intentionally lower the water table. The water table would be lowered to at or below the water levels at the Dry Lakes in order to intercept natural recharge and reverse the gradient and prevent the water from flowing to the Dry Lakes.

Figures 4.9-11a and **4.9-11b** present conceptual cross sections depicting the flowpaths of groundwater (shown as arrows) over time for the pumping phase followed by the recovery phase. Initially, Time 0 on Figure 4.9-11a depicts the current condition. Under the influence of gravity, groundwater flows from Fenner Valley through Fenner Gap (approximately where the well is shown) into the lower elevation Cadiz Valley. As the groundwater migrates to the dry lakes, the water becomes saline and ultimately is lost to evaporation at the dry lakes.

After pumping begins (Time 1, Figure 4.9-11a), a cone of depression or radius of influence (ROI) is formed at the wellfield, drawing groundwater into the well. Time 1 through Time 4 on Figure 4.9-11a show that the ROI expands over time, broadening its influence and drawing groundwater toward the wellfield away from the dry lakes. As the pumping continues, the water table beneath the dry lakes is anticipated to become deeper such that the rate of evaporation would decrease to essentially zero, further preventing the loss of water to the atmosphere. This illustrates that managing the groundwater basin through the expansion and increased influence of the ROI increases the amount of water conserved, or prevented from comingling with the brine zone and ultimately lost to the atmosphere.

Figure 4.9-11b depicts the changes anticipated after the 50-year term of Project operations. Once the pumping stops, the extent of the ROI will decrease and the water table will completely recover to the current level, as shown at Time 4 on Figure 4.9-11b. Also note that groundwater flow in all areas will return to flowing toward the dry lakes. The evaporation of water from the dry lakes will return to its current rate and water will again be lost to the atmosphere.



Time 0
No pumping. Groundwater flows equal to rate of natural recharge (southeast) toward the dry lake and evaporates.

Time 1
Pumping begins. Groundwater near well is captured, but most groundwater downgradient (southeast) of well continues to flow toward the dry lake and evaporates.

Time 2
Pumping continues. Groundwater is captured further from the well, but a significant volume of groundwater downgradient (southeast) of the well continues to flow toward the dry lake and evaporates.

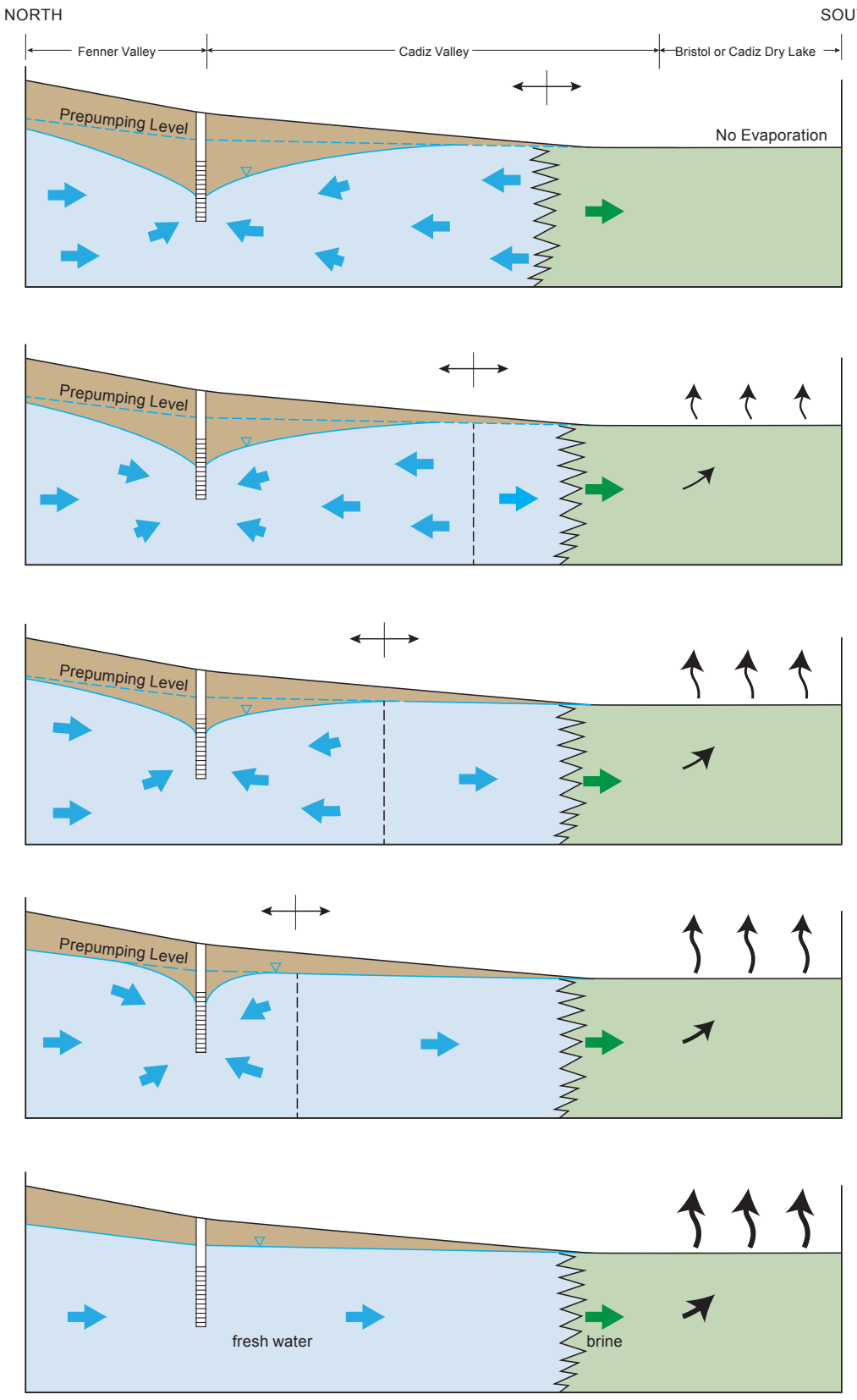
Time 3
Pumping continues. Most groundwater is captured and now only a small volume of groundwater downgradient (southeast) of the well flows toward the dry lake and evaporates.

Time 4
Pumping continues. All groundwater is now captured downgradient (southeast) of the well and no groundwater flows toward the dry lake or evaporates. Some of the brine near the dry lake moves slightly toward the pumping well.

SOURCE: CH2M HILL, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-11
Conceptual Cross Section Showing Groundwater Flow and Evaporation



Time 0
Pumping has been ongoing for a long time. All groundwater is captured downgradient (southeast) of the well and no groundwater flows toward the dry lake or evaporates.

Time 1
Pumping stops. Groundwater elevations begin to recover to pre-pumping levels and a small volume of groundwater downgradient (southeast) of the well begins to flows toward the dry lake and evaporate.

Time 2
Continued no pumping. Groundwater elevations continue to recover to pre-pumping levels and a greater volume of groundwater downgradient (southeast) of the well now flows toward the dry lake and evaporates.

Time 3
Continued no pumping. Groundwater elevations continue to recover to pre-pumping levels and a greater volume of groundwater downgradient (southeast) of the well flows toward the dry lake and evaporates.

Time 4
Continued no pumping. Groundwater elevations return to pre-pumping levels and groundwater again now flows directly toward the dry lake and evaporates at a rate present during pre-pumping conditions.

SOURCE: CH2M HILL, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-11b
Conceptual Cross Section Showing Groundwater Flow and Evaporation during Recovery

Figures 4.9-12, 4.9-13 and **4.9-14** present the model-predicted regional groundwater level drawdown simulations for the 32,000, 16,000, and 5,000 AFY recharge scenarios.[210] Each figure presents the simulated drawdown after 50 years of groundwater production at an average of 50,000 AFY. All show similar patterns with the majority of drawdown occurring at the area of the production wells in the Fenner Gap area, with decreasing amounts of drawdown moving away from the production wellfield. The groundwater drawdown is limited to the Watersheds. **Table 4.9-9** summarizes the drawdown at the wellfield and beneath Bristol Dry Lake.[211]

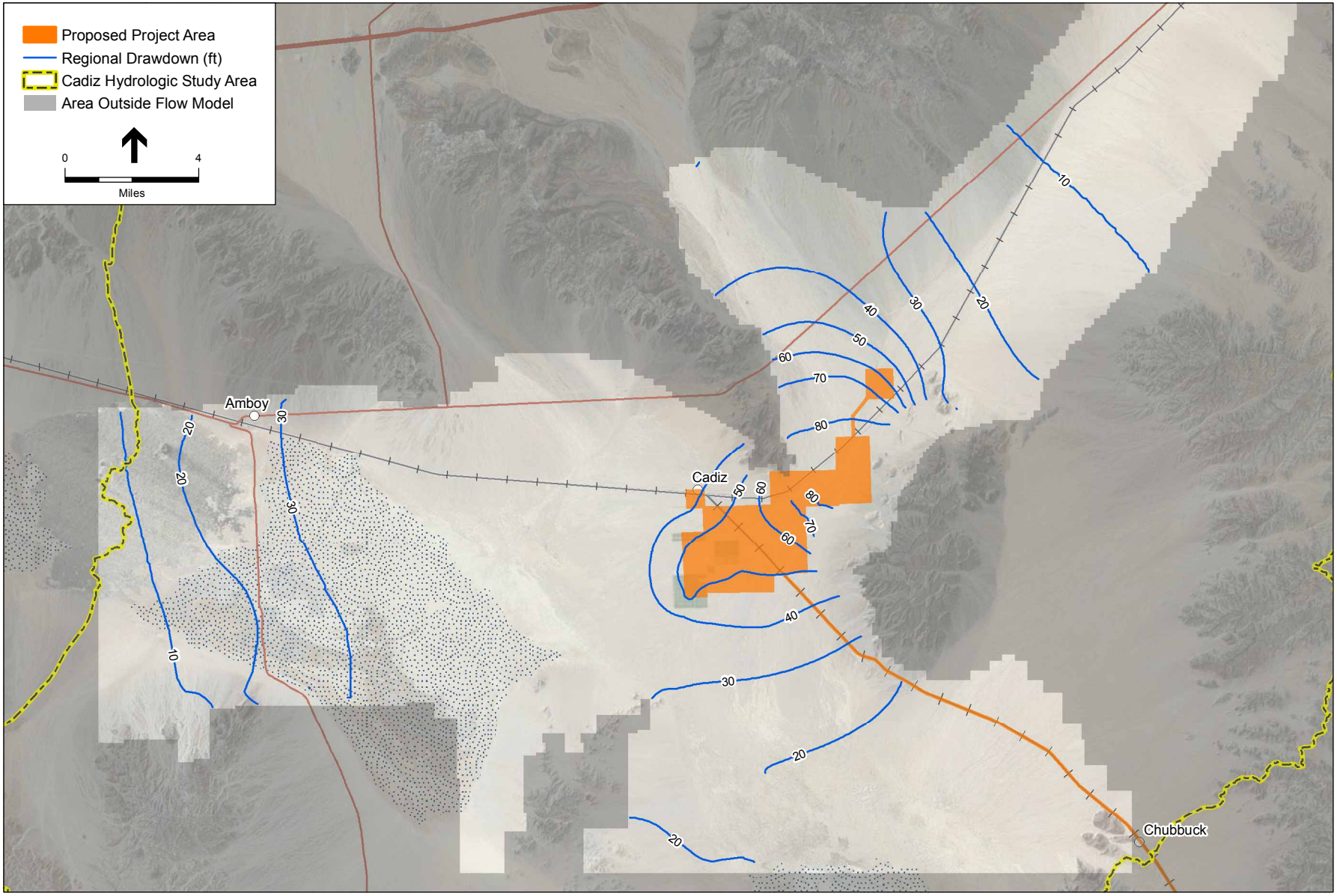
Water levels would begin to recover once the 50-year pumping period concludes. Complete recovery of water levels to pre-Project levels is estimated to occur at 67 years after the Project pumping stops.[212] This model demonstrates that the declines in groundwater levels and storage are anticipated to be a condition resulting from management of the basin for beneficial uses that would recover to current pre-Project conditions over time. As discussed below, this drawdown should not result in a significant adverse impact to any critical resource.

With respect to impacts on vegetation, existing depths to groundwater in the Fenner Valley are well over 100 feet bgs. At this depth, no phreatophytic plants can access the water. The plant communities in the region have been found to survive entirely on surface water.[213] (See Section 4.4, Biological Resources for further discussion of vegetation resources in the project area).

Near the edge of the Bristol Dry Lake, the depth to groundwater remains over 65 feet deep which is still too deep for phreatophytic plants to access. Near the edge of Cadiz Dry Lake water levels are closer to the surface, but no phreatophytic plants have been identified in this marginal area. Once on the Dry Lake, there is no vegetation due to the salt content in the soil. As a result, any drop in groundwater levels would have no affect on the overlying vegetation.[214]

With respect to local water supply wells, the extraction of groundwater would lower groundwater levels that could affect local water supply wells if the groundwater levels were to drop to below the pump intakes on the wells. Local water demands include the Cadiz Inc. agricultural operations, a few local residents within the Watershed, and the salt production operations at Bristol and Cadiz Dry Lakes. The existing Cadiz agricultural wells would be converted for use by the Project or may remain active as agricultural wells, but would not be adversely affected by the Project.

210 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 49-50, Figures 64, 66, and 68.
211 The model does not take into account the second Phase of the Project, the Imported Water Storage Component, which will be subject to further environmental review under CEQA.
212 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.
213 HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, pages 5-7.
214 HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011, page 7.

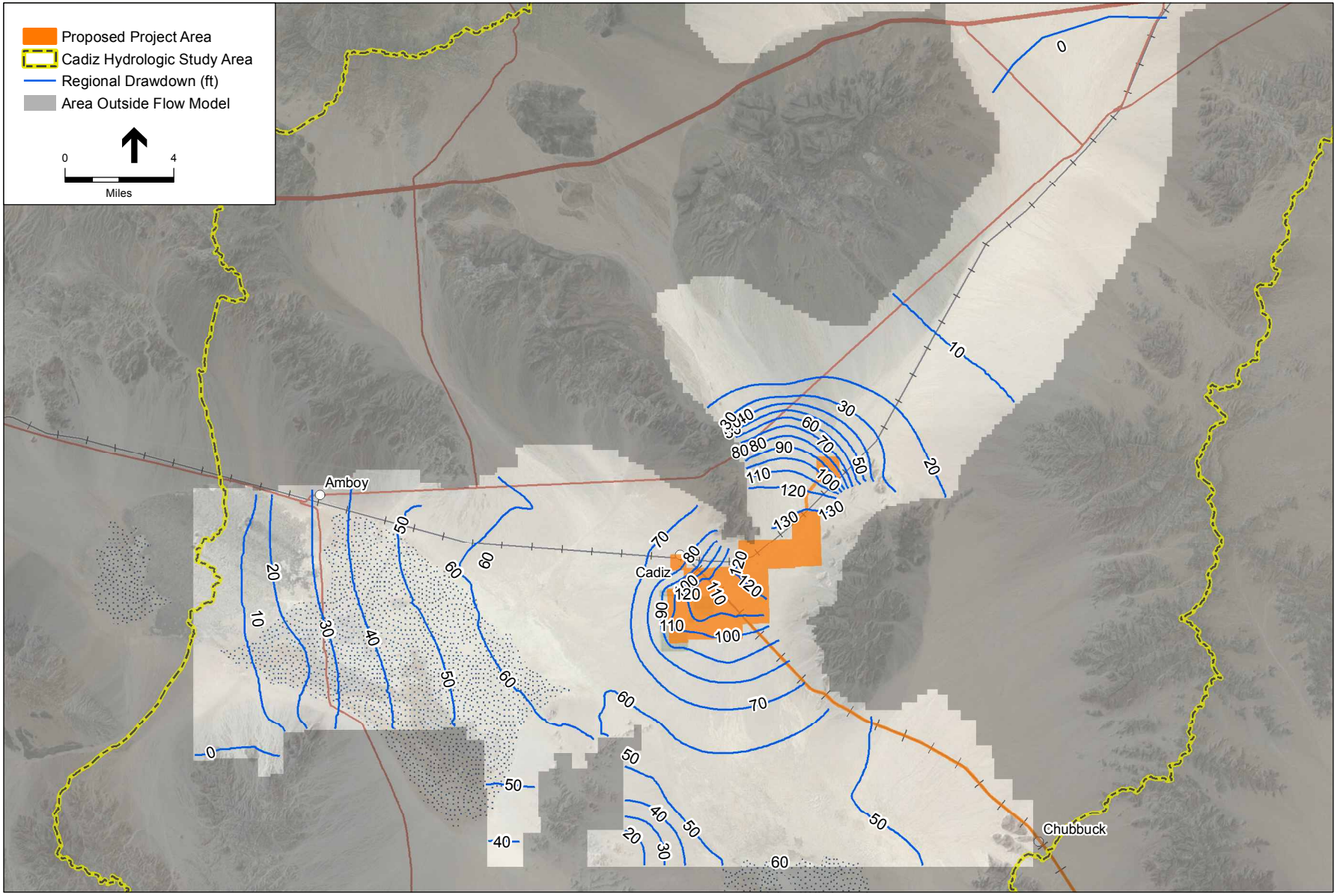


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-12

Model-Predicted Regional Drawdown - Project Scenario after 50 Years
(Assumes 32,000 AFY Recharge)
Well Configuration A

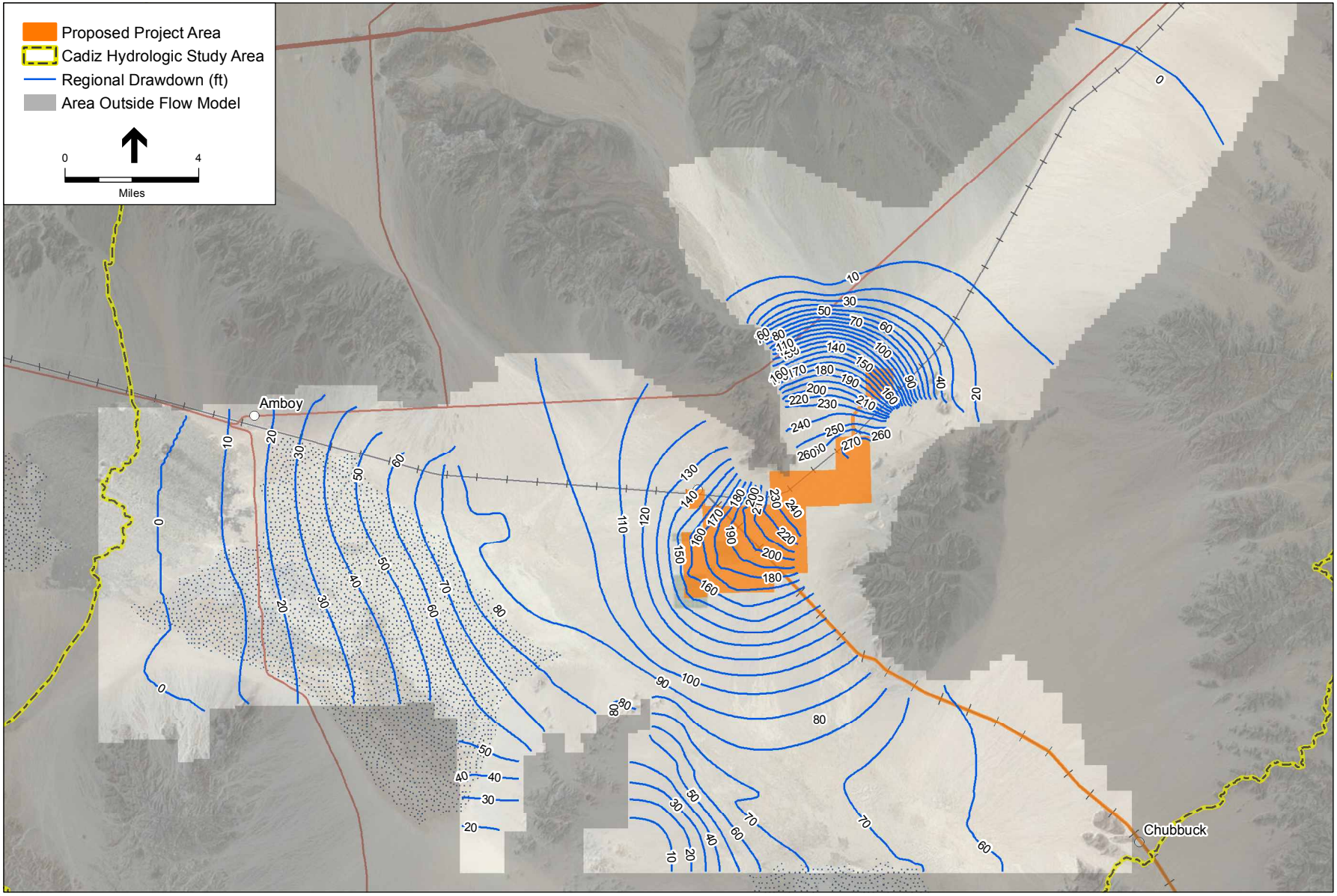


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 4.9-13

Model-Predicted Regional Drawdown - Sensitivity Scenario No.1 after 50 Years
(Assumes 16,000 AFY Recharge)
Well Configuration B



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-14

Model-Predicted Regional Drawdown - Sensitivity Scenario No.2 after 50 Years Sensitivity (Assumes 5,000 AFY Recharge) Well Configuration B

TABLE 4.9-9
SUMMARY OF MODEL-PREDICTED DRAWDOWN AMOUNTS

	End of 50 Years (End of Project Pumping)		End of 100 Years (End of Model Simulation)	
Model Scenario	**Drawdown at Wellfield (feet)**	**Drawdown at Bristol Dry Lake (feet)**	**Drawdown at Wellfield (feet)**	**Drawdown at Bristol Dry Lake (feet)**
Project Scenario (32,000 AFY Natural recharge)	70 to 80	10 to 30	0 to 10	10 to 20
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	120 to 130	10 to 60	10 to 20	30 to 40
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	260 to 270	0 to 80	50 to 60	10 to 70

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.

The model-predicted depths to groundwater in the area of the Cadiz agricultural wells were 197 feet bgs for the 32,000 AFY recharge, 241 feet bgs for the 16,000 AFY recharge, and 315 feet bgs for the 5,000 AFY recharge.[215] Figure 4.9-5 shows the recorded wells in the Project drawdown area. These wells would experience gradual increase in depth to groundwater over the 50-year Project period. If groundwater levels decreased to below the pump intakes, then the wells would be unable to pump water. The salt production wells used by Tetra Technologies for the production of saline water for their salt production operations are reportedly about 160 feet deep with their pumps set at 120 feet bgs.[216] The model-predicted depths to groundwater along the edge of the Bristol Dry Lake were 68 feet bgs for the 32,000 AFY recharge, 95 feet bgs for the 16,000 AFY recharge, and 118 feet bgs for the 5,000 AFY recharge.[217] The modeled drawdown is not predicted to reach below the saline water well pump intakes and therefore, the drawdown would be a less than significant impact.

The salt production operations initially excavate trenches to access the source saline water. The recharge trenches often consist of approximately 10-foot deep trenches up to 100 feet long dug at the lowest elevations of the Dry Lakes. In areas where the groundwater is less than 10 feet bgs, the trenches initially recharge with saline groundwater. As the water evaporates, more saline water is pumped into the trenches from saline water supply wells to add more salts. The water evaporates and the resulting salts concentrate and are sold as a mineral resource. Over time, these trenches lose their ability to recharge groundwater as the trench sides become solidified with halite. As modeled, the lowering of groundwater would occur slowly over time, but could eventually reach depths of 40 feet below current levels beneath the dry lake centers after 50 years. If groundwater levels dropped 40 feet, this method of initially filling the evaporation trenches

215 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 51-52.
216 Cadiz Inc., *Communication with ESA*, August 4, 2011.
217 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, Section 6.2.

would become ineffective at some point in the future and all of the saline water would have to be pumped from saline wells into the trenches.

The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features for the groundwater drawdown are GMMMP Project Design Features 6.2 – Third Party Wells.[218] The Action Criteria and Corrective Measures are summarized in Table 4.9-6.

Implementation of the Project Design Features 6.2 as described in Chapter 6.2 of the GMMMP would reduce potential impacts to the third-party well owners due to groundwater drawdown to less than significant. The project design features presented in Chapter 6.2 of the GMMMP are incorporated into this EIR as Mitigation Measure **HYDRO-3**. Implementation of Mitigation Measure **HYDRO-3** would ensure that the potential impacts from groundwater drawdown are mitigated to less than significant for third-party wells.

Storage

As detailed in the Methodology Section above, the overall extraction of up to 2.5 MAF of water from the groundwater basin over a 50-year period would temporarily reduce the volume of water in storage in the groundwater basin, which is currently estimated at between 17 and 34 MAF. The amount of reduction is dependent upon the quantity of natural recharge and discharge from the Basin. The following **Table 4.9-10** summarizes the volumes of storage change at Year 50, when Project pumping stops, and at Year 100, the end of the model simulation depending on the variability in recharge.[219] The recovery is also extrapolated to estimate the number of years for the storage to recover to pre-Project levels.

TABLE 4.9-10
SUMMARY OF MODEL-PREDICTED STORAGE RESPONSE

	Cumulative Change at End of 50 Years (End of Project Pumping)		Cumulative Change at End of 100 Years (End of Model Simulation)		Time for Groundwater Storage to Recover after Project Pumping Stopped in Year 50
Model Scenario	**Volume (AF)**	**Percent of Total Storage**	**Volume (AF)**	**Percent of Total Storage**	
Project Scenario (32,000 AFY Natural recharge)	-1,090,000	3 to 6	-220,000	1	67
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	-1,680,000	5 to 10	-870,000	3 to 5	103
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	-2,160,000	6 to 13	-1,870,000	6 to 11	390

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 54.

218 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, pages 76-78.
219 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 53-54.

As summarized above, the 50-year pumping period under the anticipated Project scenario would fractionally reduce the total estimated storage between 3 to 6 percent, after which the Project would terminate and groundwater extraction would cease. Water levels would then completely recover in about 67 years after Project pumping stops. In other words, the decline in storage is anticipated to be a temporary condition and storage would recover to current pre-Project conditions over time. **Table 4.9-11** summarizes the volumes of water that would be saved from evaporation for beneficial uses under the three modeled recharge scenarios.[220]

TABLE 4.9-11
SUMMARY OF CUMULATIVE NET SAVINGS OF WATER

Model Scenario	Natural Recharge (AFY)	Cumulative Reduction of Evaporative Losses (AF)	Cumulative Depletion of Storage (AF)	Cumulative Net Water Saving from Project (AF)
Project Scenario (32,000 AFY Natural recharge)	32,000	2,210,000	220,000	1,990,000
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	16,000	1,544,000	870,000	674,000
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	5,000	470,000	1,870,000	-1,400,000

SOURCE: GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery and Storage Project*, September 2011, pages 6-7.

As summarized in Table 4.9-11, as much as 1,990,000 AF of water would be conserved for beneficial uses under the Project scenario instead of being lost to evaporation. The savings are calculated over a 100-year period, comparing the evaporative losses that would have occurred without the Project and the depletion in storage at the end of 100 years that would occur with the Project. However, as discussed above, the levels of storage are anticipated to fully recover 67 years after the pumping ceases. The only scenario that has a negative net savings is the 5,000 AFY natural recharge scenario. However, there are no permanent adverse impacts even with this scenario because the levels of storage are still anticipated to fully recover.

As described in Section 4.6 of this Draft EIR, groundwater extraction may result in some subsidence from the compression of dewatered clay soils within the wellfield. The reduction of storage space would be minor compared to the availability of storage space in the valley. Depth to groundwater is generally over 100 feet bgs. The minor loss of storage capacity in the basin would not adversely affect future management or beneficial use of the basin. The loss of storage capacity would be a less than significant effect.

The predictive modeling performed by Geoscience concludes that pumping at higher rates during the initial period of the 50-year Project period would reduce evaporation rates more effectively,

220 GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Storage Project,* September 2011, pages 6-7.

thereby conserving larger amounts of water for beneficial use that would otherwise evaporate. For example, pumping rates in excess of natural recharge (in excess of 50,000 AFY) during the first 25 years would increase the quantity of groundwater conserved.[221] Figure 4.9-11a illustrates groundwater flow reactions with implementation of the Project operations. Groundwater in storage to the southwest of the wellfield that has already passed through the Fenner Gap is estimated to be between 4 and 10 MAF,[222] and is moving toward the Dry Lakes where it would ultimately join the saline groundwater and evaporate. As shown in Figure 4.9-11a, the proposed Project would reverse the groundwater flow to reduce the hydraulic pressure toward the Dry Lakes and capture some of the water that has already passed through the Fenner Gap and is headed toward the Dry Lakes. Since this extraction in excess of natural recharge as shown in Figure 4.9-11a is necessary to capture water that would otherwise be wasted to salinity and evaporation and since no other groundwater user would be adversely affected, the Project would not result in a significant impact to the aquifer system.

Recharge

The Project will have no impact on the recharge areas, runoff, or percolation of rainfall and snowmelt in the upper areas of the watershed. The continuous natural recharge of groundwater will be completely unaffected. However, as noted above, managing a groundwater basin to maximize beneficial uses that results in temporary extraction greater than annual natural recharge will have beneficial impacts by optimizing yield and reducing waste. The Project will strategically lower groundwater levels to conserve and make beneficial use of the basin while resulting in a less than significant impact with respect to storage capacity or the long-term health of the basin.

The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features relative to impacts on the basin are GMMMP Project Design Features 6.2 – Third Party Wells[223] and GMMMP Project Design Features 6.4 – Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes.The Action Criteria and Corrective Measures for Project Design Features 6.2 and 6.4 are summarized in Tables 4.9-10 and 4.9-7 previously described above.

Summary

The Project will not substantially deplete groundwater supplies or interfere with groundwater recharge. First, the Project's temporary drawdown of water will not result in a significant adverse impact to any critical resource, including vegetation. Second, pumping of groundwater under the proposed Project would have no impact on springs and therefore no mitigation is required. Third,,the minor loss of storage capacity in the basin would not adversely affect future management or beneficial use of the basin and is therefore considered less than significant effect. Fourth, the Project will have no impact on the recharge areas, runoff, or percolation of rainfall and snowmelt in the upper areas of the watershed. Lastly, the effects of drawdown on third party

221 GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Storage Project,* September 2011, page 10.
222 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, page 9.
223 CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Section 6.2.

wells would be less than significant with implementation of Project Design Features 6.2 and 6.4 as confirmed in Mitigation Measures **HYDRO-3** and **HYDRO-2**.

Mitigation Measures

Implement Mitigation Measure **HYDRO-3.**

Significance Conclusion

Less than significant with mitigation.

Impacts to Drainage Patterns

Significance Threshold

Would the proposed Project result in a significant impact by altering the existing drainage patterns of the area and the courses of streams in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

Impact Analysis

The Groundwater Conservation and Recovery Component of the Project would include the construction of production wells, piping, and associated pumps, controls, and power appurtenances to extract groundwater and transport the water southeast to the CRA. The placement of the constructed infrastructure could result in changing the existing drainage patterns by blocking or re-routing existing flow patterns. The changed flow path of water could result in erosion or siltation that could result in damage to structures or the environment from erosion or flooding.

The production wells and monitoring features would be installed in locations outside of defined washes. The well head for each production well would be placed within an approximately ten foot by ten foot pad, slightly raised above grade. The pad would be constructed such that surface water flow from the occasional rain events would be routed around the pad and designed to reduce flow velocities and potential scour. The pipelines connecting the wells to the water conveyance pipeline to the CRA would all be placed underground at about 15 feet below grade. Pipeline locations at the existing railroad drainage crossings would also be underground and covered with an at-grade pad that would be designed to allow unimpeded surface water flow through the undercrossing. The water conveyance pipeline to the CRA is currently being planned primarily for the south side of the railroad track. If site conditions require the pipeline to cross under the railroad tracks, the undercrossing would be still be placed below grade and thus not susceptible to erosion or siltation issues.

Mitigation Measure **HYDRO-4** ensures that above ground structures are not placed within any visible stream drainage or wash in a manner that could result in the restriction of surface water flow. In addition, because the drainage patterns of the intermittent streams in desert areas can change annually, if not with each individual rain event, the infrastructure elements shall be constructed to be protected from future changes to drainage patterns by routing water away and

around the structures in such a manner so as to not concentrate the flow and increase the potential for erosion. Implementation of Mitigation Measure **HYDRO-4** would ensure that the Project would reduce the potential impacts to less than significant levels.

Mitigation Measures

HYDRO-4: Construction plans shall be prepared that use standard best management practices (BMPs) to control drainage around the Project infrastructure. The BMPs shall include placing well pads and above-ground appurtenant facilities outside of visible drainages; and grading well pads to disperse runoff from the site in a manner that minimizes scour potential of storm water. Additional BMPs include the use of physical barriers to prevent erosion and siltation straw wattles, hay bales, setbacks and buffers, and other similar methods that reduce the energy in surface water flow.

Significance Conclusion

Less than significant with mitigation.

Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow

Significance Threshold

Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?

Impact Analysis

The Project does not include the construction of permanent housing. Almost all structures would be placed underground with the exception of some well pads, surface piping, and control structures. None of the Project area is located within the 100-year flood zone maps prepared by FEMA. The area is not subject to seiches, tsunamis, or mudflows. Temporary worker housing may be constructed in the Cadiz area or possibly in the southern area of the Project where the water conveyance pipeline would connect to the CRA or possibly other staging areas. These worker accommodations would be temporary in nature and would be purposely placed away from washes or other visible drainages.

Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. The seasonal flooding could damage above-ground structures such as well heads and supporting power equipment. Implementation of Mitigation Measure **HYDRO-4**, described above, would ensure that the Project would not adversely affect the floodplain.

Mitigation Measures

Implement Mitigation Measure **HYDRO-4**.

Significance Conclusion

Less than significant with mitigation.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Impacts to Water Quality Standards or Waste Discharge Requirements

Significance Threshold

Would the proposed Project result in a significant impact if the recharge of groundwater to the aquifer were to degrade water quality or violate waste discharge requirements?

Impact Analysis

The Imported Water Storage Component allows participating water providers to send surplus surface water supplies, when available, to the Project area to be recharged into the groundwater aquifer system via spreading basins and held in storage until needed in future years. When needed, the stored surface water would be pumped out of the aquifer system and returned to the appropriate participating provider. The maximum capacity of the Project's Imported Water Storage Component is 1 MAF at any given time. A maximum of 75,000 afy to 105,000 afy would be recharged or extracted from the Basin based on the maximum capacity of the 43-mile pipeline and the natural gas pipeline. The facilities proposed for this Component of the Project include an additional 10 to 15 wells in the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply, and distribution facilities; and a CRA diversion structure and pump station.

Importation of CRA or SWP water to the Fenner Watershed could introduce a foreign water source into the aquifer that could alter groundwater chemistry. Influences to groundwater quality could occur from any of the following:

- Percolating CRA or SWP water could transport salts from the unsaturated zones to the aquifer
- CRA or SWP water recharged into the ground would have a slightly higher TDS concentration (about 500 to 600 mg/l) than the indigenous groundwater (about 300 to 400 mg/l) and would therefore increase salt loading in the aquifer
- CRA or SWP water recharged into the ground may contain low levels of contaminants such as perchlorate, nitrates, or other chemical constituents that would be percolated into the aquifer

Table 4.9-8 above summarizes water quality parameters for water sampled from the alluvium, carbonate, and bedrock units in Fenner Gap and from the Colorado River just below Parker Dam, which represent the CRA water quality. As previously discussed, both the CRA water and the Fenner Gap water currently meet the drinking water standards before treatment. After treatment by the water purveyors, the concentrations would be expected to be even lower.

For the Imported Water Storage Component of the Project, CRA (and possibly SWP) water would be pumped to the spreading basins in the Fenner Gap area where the CRA water would infiltrate down into the alluvial aquifer for later recovery when needed. The water would then be pumped back through the water conveyance pipeline from the wellfield to the CRA, where the

water would be returned to the CRA and then sent on to the water purveyors. The CRA water would have higher TDS concentrations than the CRA water, whereas the sodium and chloride (salt) concentrations of the CRA water would be slightly lower than the current concentrations in the groundwater in the alluvium in the Fenner Gap area. However, as listed in Table 4.9-8 above, all of the parameter concentrations for both waters are below MCLs, meaning that both waters are currently acceptable for use as drinking water as is and all of the water would be further treated at the water purveyor's treatment facilities. In addition, the maximum volume of CRA water that could be stored in the alluvial aquifer, at any given time, would be 1,000,000 AF. The volume of water in the Fenner Watershed and the northern portion of the Bristol Watershed to which the CRA water would be added is estimated at 17 to 34 MAF. Consequently, the maximum percentage of CRA water that would be added relative to the volume of water in the aquifer would be only 3 to 6 percent. This represents a substantial dilution. Based on this overall evaluation, the potential impact would be considered less than significant.

Nonetheless, the FVMWC would implement monitoring features that includes sampling the existing Well CI-3, located within Fenner Gap to monitor the effects of imported water to groundwater. Well CI-3 would be sampled on a set schedule and analyzed for TDS, and general mineral and physical parameters, as described in the GMMMP.[224] The results of the analyses would be evaluated to verify that the water quality of the aquifer remains acceptable as a drinking water supply and that the impact would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Impacts to Groundwater Supplies or Groundwater Recharge

Significance Threshold

Would the proposed Project result in a significant impact if the recharge of groundwater were to substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

Impact Analysis

The Imported Water Storage Component would operate under the provision that only the amount of previously recharged water could be extracted from the groundwater basin, thereby resulting in a neutral effect to water volumes in storage in the aquifer. The introduction of up to 105,000 AFY and up to a total of 1,000,000 AF of water at any given time, into the groundwater basin would offset some of the drawdown associated with the Groundwater Conservation and Recovery

[224] CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, Appendices C and D.

Component. In addition, the current depths to groundwater in the proposed recharge area are in excess of 180 bgs, providing room for the storage of additional water.[225] Note that if the imported water were introduced prior to the establishment of the hydraulic barrier or in absence of ongoing managed groundwater production, evaporative losses to the Dry-Lakes could be accelerated and increased. Consequently, the Imported Water component is proposed to be implemented after the Conservation and Recovery Project. Therefore, the Imported Water Storage Component would not adversely affect groundwater supplies or impede naturally occurring groundwater recharge. Therefore, there would be no impact.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Impacts to Drainage Patterns

Significance Threshold

Would the proposed Project result in a significant impact if the existing drainage patterns of the area and the courses of streams would be altered in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

Impact Analysis

The Imported Water Storage Component of the Project would include expansion of the wellfield, construction of a recharge basin, extension of the conveyance pipeline, and the upgrading of the existing natural gas pipeline. The extension of the conveyance pipeline would follow existing access roads where possible and would be jack and bored under the BNSF railroad tracks. Given the size of the recharge basin, surface runoff patterns may change because it is unlikely that all existing drainage patterns could be avoided. Placing the recharge basin within well-defined washes could alter downstream floodways, including those that flow to railroad undercrossings. In addition, the access road to the spreading basin may utilize existing underscrossings which could alter drainage patterns. Implementation of Mitigation Measure **HYDRO-5** would ensure that the recharge basin and access road does not affect downstream drainages or floodways.

Mitigation Measures

> **HYDRO-5: Imported Water Storage Component.** Project operators shall prepare a drainage analysis of the recharge basin and access road locations to ensure that diverted stormwater runoff does not affect downstream railroad crossings, roads, or other infrastructure. Recharge basins shall be located outside of major drainages, such as Schulyer Wash. The recharge basins shall be designed using BMPs to divert sheet flow

[225] Cadiz Inc., *13th Annual Groundwater Monitoring Report, January – December 2010, Cadiz Valley Agricultural Development*, June 2011.

storm water around the basins and redistribute the flow downstream without increasing velocity or scour potential.

Significance Conclusion

Less than significant with mitigation.

Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow

Significance Threshold

Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?

Impact Analysis

The Imported Water Storage Component of the Project does not include any construction of permanent housing. Temporary worker housing would use the existing Cadiz-owned worker housing.

The spreading basins and associated additional wells would be at ground level. None of the Project area is located within the 100-year flood zone maps prepared by FEMA. The area is not subject to seiches, tsunamis, or mudflows.

Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. The seasonal flooding could damage above-ground structures such as well heads and supporting power equipment. Implementation of Mitigation Measure **HYDRO-4**, described above, would ensure that the Project would not adversely affect the floodplain.

Similarly, the existing natural gas pipeline is also not located within a 100-year flood zone. Nor would the natural gas pipeline element expose workers or structures to seiches, tsunamis, or mudflows. Thus, no impacts would occur.

Mitigation Measures

Implement Mitigation Measure **HYDRO-4**.

Significance Conclusion

Less than significant with mitigation.

Mitigation Measure Summary Table

Table 4.9-12 on the following page presents the impacts and mitigation summary for Hydrology and Water Quality.

TABLE 4.9-12
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	**HYDRO-1, HYDRO-2**, and **HYDRO-3**	Less than significant with mitigation
Impacts to Groundwater Supplies or Groundwater Recharge	**HYDRO-3**	Less than significant with mitigation
Impacts to Drainage Patterns	**HYDRO-4**	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	**HYDRO-4**	Less than significant with mitigation
Imported Water Storage Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	None required	Less than significant
Impacts to Groundwater Supplies or Groundwater Recharge	None required	No impact
Impacts to Drainage Patterns	**HYDRO-5**	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	**HYDRO-4**	Less than significant with mitigation

4.10 Land Use and Planning

The purpose of this Section is to identify existing land use within the Project area, analyze potential impacts to land use associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce any significant impacts identified. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

In addition, this Section also addresses socioeconomics and environmental justice issues. While analysis of these two issue topics is not required under CEQA, it is required as part of the federal environmental review process under NEPA. As a result, these issue topics have been addressed in this EIR in the event of federal agency(s) involvement in the Project during the permit approval process and potential funding process.

For socioeconomics, the purpose of this Section is to describe the existing socioeconomic conditions in the Project area related to employment and income, analyze potential impacts to these factors associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce any significant impacts identified.

For environmental justice, the purpose of this Section is to describe the existing occurrence, distribution, and status of minority or disadvantaged communities in the Project area; analyze potential impacts to these communities and determine whether, in light of all the facts and circumstances, a disproportionately high and adverse human health or environmental impact on minority populations or low-income populations is likely to result; and identify mitigation measures that would avoid or reduce any significant impacts identified.

The thresholds of significance for the socioeconomics impact analysis are based on guidance from the 2011 *CEQA Guidelines* (Section 15131) and on NEPA provisions (Title 40, Code of Federal Regulations, Sections 1508.8[b], 1508.14). The thresholds of significance for environmental justice are based on *Executive Order 12898*[1]and federal guidance.

4.10.1 Environmental Setting

Regional Land Use Setting

The Project area is located in a remote, unincorporated part of the Mojave Desert in eastern San Bernardino County. San Bernardino County is the largest county in the contiguous 48 United States with a land mass of more than 20,000 square miles. Approximately 90 percent of the County consists of desert and mountains.

The cities and communities closest to the Project include Barstow, Needles, Twentynine Palms, Amboy, and Chambless. Two military installations are also located in the region. The U.S.

[1] Council on Environmental Quality, *Environmental Justice Guidance Under the National Environmental Policy Act*, December 1997, pages 3-17.

Marine Corps Air Ground Combat Center in Twentynine Palms is located approximately 40 miles southwest of the Project site and occupies approximately 930 square miles, including an airfield. Fort Irwin, an Army installation, is located approximately 80 miles northwest of the Project site and occupies approximately 995 square miles.

BLM manages lands in the region for multiple uses that include recreation, mining and grazing, open space, wilderness, natural resources, and cultural resources. There are 11 BLM Wilderness Areas in the southeastern portion of San Bernardino County. **Figure 4.10-1** identifies land ownership in the region.

The National Park Service manages three national parks within the County including the Mojave National Preserve, Death Valley National Park, and Joshua Tree National Park (See Figure 1-1). The nearest of these, the Mojave National Preserve, is located approximately 20 miles north of the Project site on 1.6 million acres. The Mojave National Preserve provides hiking opportunities along with four-wheel drive routes, seasonal hunting, and camping.

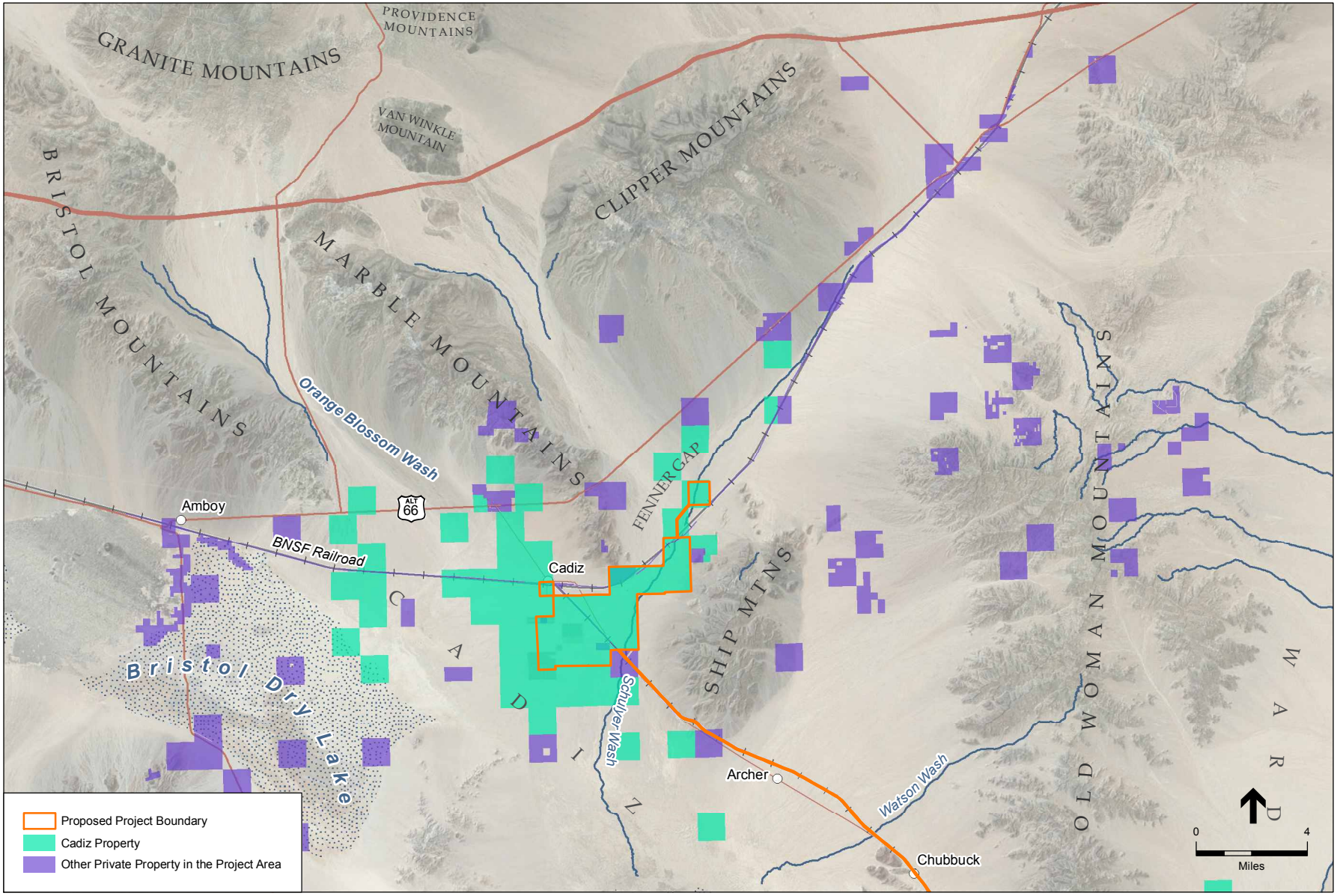
Local Land Use Setting

The Project area is located entirely within the Cadiz and Fenner Valleys of eastern San Bernardino County. The Cadiz Valley extends from Historic SR 66 south to SR 62, near the San Bernardino County-Riverside County boundary. Land uses in the Cadiz Valley include desert conservation, open space, recreation, agriculture, military facilities, mining, salt extraction, and transportation, water, electrical, gas, and oil utility corridors. The land surrounding the Project site is owned and managed by BLM, the State of California, Metropolitan, additional public land owners, and numerous private landowners, as illustrated in Figure 4.10-1.

Cadiz is the largest private landowner in the area with over 34,000 acres of landholdings in the Project's vicinity, including approximately 25,000 contiguous acres at the northern end of the Project area. Of this total, 9,600 acres of land are zoned for agriculture (AG) (see Figure 4.2-1). In 2011, 1,600 acres are in production including 240 acres within the Project wellfield boundary. (For more information on agricultural resources, refer to Section 4.2, Agriculture and Forestry Resources.)

Metropolitan's consolidated lands cover the Iron Mountain Pumping Plant and the land associated with and occupied by the CRA, as well as an electrical power easement. The Project intersects with Metropolitan's CRA corridor at the southern end of the pipeline route.

The Project site is traversed by numerous transportation, water, and utility corridors. The BNSF rail line crosses the northern portion of the Project area, south of the Ship Mountains. The ARZC railroad line branches from the BNSF rail line within the Project site and then travels southeastward



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.10-1

Private Property in the Project Area

toward Parker, Arizona. Six natural gas pipelines traverse the Project site near the wellfield area, and an overhead high voltage transmission line traverses Danby Dry Lake to Iron Mountain Pump Station on the CRA. Section 4.13, Public Services and Utilities, describes these facilities in more detail.

Land uses north of the Project wellfield include BLM open space, private properties, the BNSF railroad, SR 66, I-40, and the Mojave National Preserve. To the west of the proposed wellfield area, land uses include salt mining operations on the Bristol and Cadiz Dry Lakes, the community of Amboy approximately 15 miles west, and the U.S. Marine Corps Air Ground Combat Center at Twentynine Palms approximately 40 miles west. Sheephole Valley and Cadiz Dunes Wilderness Areas are west of the conveyance pipeline route, south of Bristol Dry Lake. South of the pipeline route, the CRA and SR 62 traverse the desert from east to west. East of the pipeline route, the Old Woman Mountains and Turtle Mountain Wilderness Areas dominate the land uses.

Socioeconomics and Environmental Justice

Data presented in this Section were obtained from the Southern California Association of Governments (SCAG) Local Profiles Report 2011[2] for unincorporated areas of San Bernardino County that refers to the latest U.S. Census Bureau's 2010 Census Files, and from *The Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report*[3] which can be found in Appendix I of this Draft EIR.

Demographic Characteristics

The proposed Project (facilities and operations) is locally situated within the Cadiz and Fenner Valleys of eastern San Bernardino County. The Cadiz Valley extends south from Historic State Route (SR) 66 to SR 62, near the San Bernardino County-Riverside County boundary. San Bernardino County is the largest county in both the United States and California with a land mass of over 20,000 square miles, of which 90 percent consists of deserts and mountains. The Project is located regionally within the SCAG service area and locally in the unincorporated part of San Bernardino County, within Census Tract 104.09.

Within SCAG, the Project area is a part of the San Bernardino Associated Governments (SANBAG) subregion, which consists of the cities of Adelanto, Apple Valley, Barstow, Big Bear Lake, Chino, Chino Hills, Colton, Fontana, Grand Terrace, Hesperia, Highland, Loma Linda, Montclair, Needles, Ontario, Rancho Cucamonga, Redlands, Rialto, San Bernardino, Twentynine Palms, Upland, Victorville, Yucaipa, Yucca Valley, and many unincorporated communities. The cities in closest proximity to the Project area are Barstow, Ludlow, and Twentynine Palms to the west; Needles to the east; Desert Center to the south; and the small community of Chambless to the north. The nearest residential communities include Chambless, five miles to the north;

2 Southern California Association of Governments, *Local Profiles Report 2011 for Unincorporated Areas of San Bernardino County*, May 2011.
3 Economic & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report*, April 2011.

Amboy, 15 miles to the west; and Twentynine Palms, 40 miles to the southwest of the Project site. There is no existing permanent residential population residing in the proposed Project area.

Population

Table 4.10-1 shows the total population, housing units, and employment for the local, subregional and regional areas for the year 2010. As shown in Table 4.10-1, Census Tract 104.09, where the proposed Project is located, has an estimated total population of 3,018 residents. The Unincorporated San Bernardino County area has a population of 291,776 residents, approximately 94,085 households, and 42,481 workers.[4] The SANBAG subregional area has a population of 2,035,210 residents, 611,618 households, and 640,497 workers. The SCAG regional area has a total population of 18,051,534 residents, 5,847,909 households, and 7,224,670 workers.

TABLE 4.10-1
TOTAL 2010 POPULATION, HOUSING, AND EMPLOYMENT

	Total Population	Total Households[a]	Total Employment
Local Area			
Unincorporated San Bernardino County	291,776	94,085	42,481
Subregional Area			
SANBAG	2,035,210	611,618	640,497
Regional Area			
SCAG	18,051,534	5,847,909	7,224,670

a Households were used instead of housing units to remain consistent with SCAG projected categories. Housing units generally represented a higher number of housing versus occupied households.

SOURCE: Southern California Association of Governments, *Profile of the Unincorporated Area of San Bernardino County, May 2011, page 2.*

According to the 2008 SCAG regional forecast, the population is expected to increase in all geographic areas. As shown in **Table 4.10-2**, the population in Unincorporated San Bernardino County is expected to increase approximately 67.1 percent between the year 2010 and 2035. The SANBAG subregion's forecasted population growth is 54.0 percent over the same period, while the SCAG regional area population is forecasted to increase 33.3 percent. Most recently, San Bernardino County's population grew 0.9 percent from January 2010 to January 2011.[5]

In unincorporated San Bernardino County, the largest category of race/ethnicity is White (49 percent), followed by Black/African American (3.6 percent). Census Tract 104.09 has a greater percentage of people categorized as White (79 percent). **Table 4.10-3** outlines the race/ethnic groups within unincorporated San Bernardino County and Census Tract 104.09 by percent of total population.

4 U.S. Census Bureau, *2010 Census Demographic Profiles, Census Tract 104.09,* http://2010.census.gov/2010census/popmap/, accessed December 2010.
5 San Bernardino County, *San Bernardino County 2011 Community Indicators Report, May 2011, page 2.*

TABLE 4.10-2
SCAG POPULATION, HOUSING, AND EMPLOYMENT PROJECTIONS

	Current	Projected			2010-2035[a]	
Geographic Zone	**2010**	**2020**	**2030**	**2035**	**Growth**	**Percentage Change (%)**
Population						
Local Area	291,776	408,654	462,447	487,697	195,921	+67.1
Subregional Area	2,035,210	2,582,765	2,957,753	3,133,801	1,098,591	+54.0
Regional Area	18,051,534	21,468,934	23,255,378	24,057,292	6,005,758	+33.3
Housing[b]						
Local Area	94,085	131,080	153,669	163,941	69,856	+74.2
Subregional Area	611,618	787,142	914,577	972,561	360,943	+59.0
Regional Area	5,847,909	6,840,331	7,449,484	7,710,716	1,862,807	+32.5
Employment						
Local Area	42,481	108,464	120,988	128,679	86,198	+203
Subregional Area	640,497	965,778	1,134,960	1,254,749	614,252	+96.0
Regional Area	7,224,670	9,183,026	9,913,372	10,287,122	3,062,452	+42.4

[a] 2010-2035 Growth was calculated by taking the difference between the Projected Year 2035 and Current Year 2010; Percentage Change was derived by dividing the 2010-205 Growth by the Current Year 2010
[b] Housing reflects the number of households and not housing units

SOURCE: Southern California Association of Governments, *Profile of the Unincorporated Area of San Bernardino County, May 2011, page 2;* Southern California Association of Governments, *Integrated Growth Forecast,* http://www.scag.ca.gov/forecast/index.htmk, accessed October 2010.

TABLE 4.10-3
2010 RACE/ETHNICITY WITHIN UNINCORPORATED SAN BERNARDINO COUNTY
(Percent of Total Population)

Local Area	White	Black or African American	Asian	American Indian	Other
Unincorporated San Bernardino County	49%	3.6%	2.2%	0.7%	2.5%
Census Tract 104.09	79%	4.5%	1.7%	1.8%	6.0%

SOURCE: Southern California Association of Governments, *Local Profiles Report 2011 for Unincorporated Areas of San Bernardino* County, May 2011; U.S. Census Bureau, 2010 Census Demographic Profiles, Census Tract 104.09, http://2010.census.gov/2010census/popmap/, accessed December 2010.

Income

As shown in **Table 4.10-4**, data compiled from 2005-2009 of unincorporated San Bernardino County revealed that the moderate income of households is $15,972. Approximately 87,922 residents resided in the unincorporated area during this period and approximately 18 percent of

TABLE 4.10-4
HOUSEHOLD INCOME AND STATUS

Local Area	Population	Median Household Income	Low-income (percent of total population)
Unincorporated San Bernardino County (2005-2009)	87,922	$15,972	18%
Census Tract 104.09 (1999)	2,206	$27,243	18.2%

SOURCE: Southern California Association of Governments, *Local Profiles Report 2011 for Unincorporated Areas of San Bernardino County*, May 2011; U.S. Census Bureau, *2010 Census Demographic Profiles*, *Census Tract 104.09*, http://2010.census.gov/2010census/popmap/, accessed December 2010.

the population fell under low-income households.[6] The most recent household income and status data for Census Tract 104.09 was compiled in 1999, and summarized in the 2000 Census Summary Files the following year. The median household income of the population for Census Tract 104.09 was approximately $26,243 during this period. Approximately 18.2 percent of the total households fell within the low-income category ($15,000 to $24,999).

Housing

As shown in Table 4.10-2, the SCAG housing forecasts show a 74.2 percent increase between years 2010 to 2035 for households in the local area of Unincorporated San Bernardino County. Households are projected to also increase 59.0 percent in the SANBAG subregional area and 32.5 percent in the SCAG regional area. The increase of forecasted housing is a result of projected population growth and employment within the areas. However, this forecasted growth does not take into account the recent economic downturn and the affected housing market. In addition, no residents currently live on the proposed Project area and are not projected to permanently live there in the future.

Employment and Economy

As shown in Table 4.10-2, SCAG has forecasted a large growth in employment for Unincorporated San Bernardino County with a percentage growth of approximately 203 percent between the years of 2010 and 2035 based on current and projected employment numbers. Employment in the subregional area of SANBAG and regional area of SCAG has a forecasted percentage growth of 96 percent and 42.4 percent, respectively. The forecasted employment growth for the regions does not take into account the recent economic downturn that has resulted in a high unemployment rate and a decrease in the local and regional economy.

Currently, there is no full-time, long-term employment within the proposed Project area, except for short-term employment opportunities associated with the Cadiz Inc. agricultural operations

6 Southern California Association of Governments, *Draft Statistics for Existing Housing Need: The 5th Cycle of Regional Housing Needs Assessment (RHNA) for SCAG Region*., *Attachment 2 Household Distribution by RHNA Income Category Based on County Median Income (MHI) from American Community Survey 2005-09 5-year average – unincorporated San Bernardino County*, July 2011, page 5.

and Metropolitan's Iron Mountain Pumping Plant located approximately 15 miles west of Rice, California, where the Project conveyance pipeline would access the CRA .

Labor Force and Unemployment

The labor force in San Bernardino County has consistently grown since the year 2000. In addition to the growing labor force, the unemployment rate has also steadily increased, reaching as high as 14.6 percent in January 2010 and averaging 14.2 percent for the year. Between 2008 and 2010, the unemployment rate has nearly doubled with the 2008 annual average at 7.9 percent. Currently, the labor force in San Bernardino County is at approximately 836,000 workers with an unemployment rate of 13.6 percent.[7]

Job-to-Housing Ratio

Job-to-housing ratio is defined as the balance between the distribution of employment relative to the distribution of workers within a given geographic area. A balanced job-to-housing ratio of 1:1 indicates that there is a job for every household. Areas with a job-to-housing ratio below 1.0 are considered "housing-rich" with a job deficit and housing surplus. Areas with a job-to-housing ratio above 1.0 are considered "job-rich," and have a job surplus and a housing deficit. SCAG has identified the average job-to-housing ratio at 1.25 and a "healthy" job-to-housing ratio at 1.5.[8] As shown in **Table 4.10-5,** currently the San Bernardino job-to-housing ratio is 0.37 as a result of too many approved housing permits to meet the once growing demand for housing prior to the economic downturn, and the increase in unemployment and loss of employment.[9] Therefore, the calculated job-to-housing ratio would actually be even lower in light of the current economic situation.

TABLE 4.10-5
JOB-TO-HOUSING RATIO PROJECTIONS[a,b]

	Current	Projected		
Geographic Zone	**2010**	**2020**	**2030**	**2035**
Local Area	0.58	1.06	1.02	1.01
Subregional Area	0.37[c]	1.38	1.40	1.45
Regional Area	1.25	1.36	1.35	1.35

a Job-to-Housing Ratio was calculated by dividing the employment and housing number.
b To account for vacant homes, the average vacancy rate of 1.5 percent as identified by the Regional Housing Needs Assessment was used for the Subregional Area. The vacancy rate of 12.58 percent and 29.22 percent was applied for the subregional area and the local area, respectively, according to the CA Department of Finance E-5 Population and Housing Estimates, May 2011.
c Representing the existing 0.37 job-to-housing ratio as identified by the San Bernardino County Communities Indicator Report, May 2011, page 2.

SOURCE: California Department of Finance, *E-5 Population and Housing Estimates for Cities, Counties and the State, 2010-11, with 2010 Census Benchmark,* May 2011; San Bernardino County, *San Bernardino County 2011 Community Indicators Report,* May 2011, page 2.

7 California Department of Employment Development Department, *Labor Market Info for San Bernardino County, California*, September 2011.
8 San Bernardino County, *San Bernardino County 2011 Community Indicators Report*, May 2011, page 21.
9 San Bernardino County, *San Bernardino County 2011 Community Indicators Report*, May 2011, page 21.

4.10.2 Regulatory Framework

Federal

U.S. Bureau of Land Management

BLM manages approximately 6 million acres of public land in San Bernardino County. BLM adopted the CDCA Plan in 1980. The CDCA was amended by the Northern and Eastern Colorado Desert Plan (NECO) in 2002.

California Desert Conservation Area (CDCA) Plan and Northern and Eastern Colorado Desert Plan (NECO)

The CDCA Plan (as amended in 2002 by the NECO Plan) area encompasses more than 5 million acres of the Mojave and Sonoran Deserts. The CDCA and NECO Plans establish a series of land-use designations to accommodate expected beneficial uses while protecting natural resources.[10] These land-use designations, or "Multiple-Use Classes," are further explained in Section 4.14, Recreation, but briefly, these classes are defined as follows:

- Multiple-Use Class C (Controlled) for the management of potential wilderness areas;
- Multiple-Use Class L (Limited Use) for sensitive, natural, scenic, ecological, and cultural resource values and lower-intensity uses;
- Multiple-Use Class M (Moderate Use) for controlled balance between higher-intensity use and protection of public lands; and
- Multiple-Use Class I (Intensive Use) to provide for concentrated use of lands and resources to meet human needs.

Federal lands in the Project area have been designated as Class M (Moderate Use). Allowable uses within Class M lands are discussed in detail in Section 4.14, Recreation.

An important component of the CDCA Plan is the designation of Areas of Critical Environmental Concern (ACEC). These areas are unique or special and have features that set them apart from other areas in the desert. These features could be an unusual diversity of plant or animal life, unique geologic features, or rare concentrations of remains of historic or prehistoric use and occupation. These areas are also identified by BLM as areas that require special management attention.

In the vicinity of the Project area there are two ACECs: Patton's Iron Mountain Divisional Camp, which is significant as a historic military camp site, and the Marble Mountain Fossil Bed which is significant for its paleontological values.

Of the CDCA and NECO Plans, the Wilderness, Recreation Management, and Energy Production/Utility Corridor Plan Elements are the sections relevant to the Project. These Elements are summarized below.

[10] County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, page VI-3.

Wilderness Plan Element

Under the Wilderness Plan Element, public lands administered by the BLM are inventoried and evaluated for wilderness potential in accordance with the Federal Land Policy and Management Act of 1976 (FLPMA). In the CDCA, 137 areas covering 5.7 million acres were determined to have wilderness characteristics; these areas were designated Wilderness Study Areas (WSAs) in May 1978.

Under the 1994 California Desert Protection Act (CDPA), the NECO Plan imposes the following allowances within wilderness areas: the grazing of livestock, where established prior to the date of enactment of the CDPA, shall be permitted to continue subject to such reasonable regulations, policies, and practices as deemed necessary, as long as such regulations, policies, and practices fully conform with and implement the intent of Congress in accordance with the Wilderness Act and Public Law 101-628, Section 101(f). Additionally, Congress does not intend for the designation of wilderness areas to lead to the creation of protective perimeters of buffer zones around any wilderness area. The fact that non-wilderness activities or uses can be seen or heard from areas within a wilderness area shall not, of itself, preclude such activities or uses up to the boundary of the wilderness area.[11]

In the Project vicinity, four Wilderness Areas are designated: the Trilobite, Cadiz Dunes, Old Woman Mountains and Sheephole Valley Wilderness Areas (see Figure 4.14-1). In the Livestock Grazing Element, the majority of the Project site and the surrounding area are listed as suitable for grazing with a small part of the area listed as unsuitable for grazing. The Project is not located in any BLM Wilderness Areas.

Recreation Management Plan Element

The Recreation Plan Element allows for the management of various recreational activities which are categorized as follows: High Importance (trail hiking, camping, nature study), Moderate Importance (horseback riding, picnicking, driving), and Low Importance (mountain biking, hunting, motorcycle/dirt bike/ATV use). Recreational activities such as hiking, camping, rock climbing, and wind sailing are allowed on BLM land near the proposed Project.

Energy Production and Utility Corridor Plan Element

The goal of the Energy Production and Utility Corridor Plan Element is to provide a network of joint-use planning corridors capable of meeting future utility, communications, and energy needs. The NECO Plan states that "probably the most significant use of the California Desert is for linear transmission facilities for electrical power, oil and gas products, water, and coaxial and fiber-optic cables. These facilities serve a critical need for infrastructure for people living in Southern California and the Southwest in general. On federal lands, rights-of-way for these facilities are granted under various land laws. To some extent all the federal agencies have rights-of-way crossing their lands…The predominant orientation of the designated corridors is east-west, with a number of entry points to the planning area along the Nevada-Arizona border."[12]

---

11 101st Congress, *Tax Relief and Health Care Act of 2006 – Public Law 101-628*. November 1990, Section 101(d).
12 Bureau of Land Management, *Proposed Northern & Eastern Colorado Desert Coordinated Management Plant and Final Environmental Impact Report*, July 2002, page 3-79.

There are 16 separate designated planning corridors in the CDCA, and one traverses a portion of the Project area near the CRA. (See Section 4.13 Public Services and Utilities.)

Local

The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. The following discussion on local zoning is provided for context to assess the Project's consistency with the County policies.

Zoning

The lands traversed by the Project facilities are zoned either AG or RC (see **Figure 4.10-2)**. Within the Project site, approximately 2,295 acres are zoned AG and 5,954 acres are zoned RC. The San Bernardino County Development Code describes these classifications as the following:

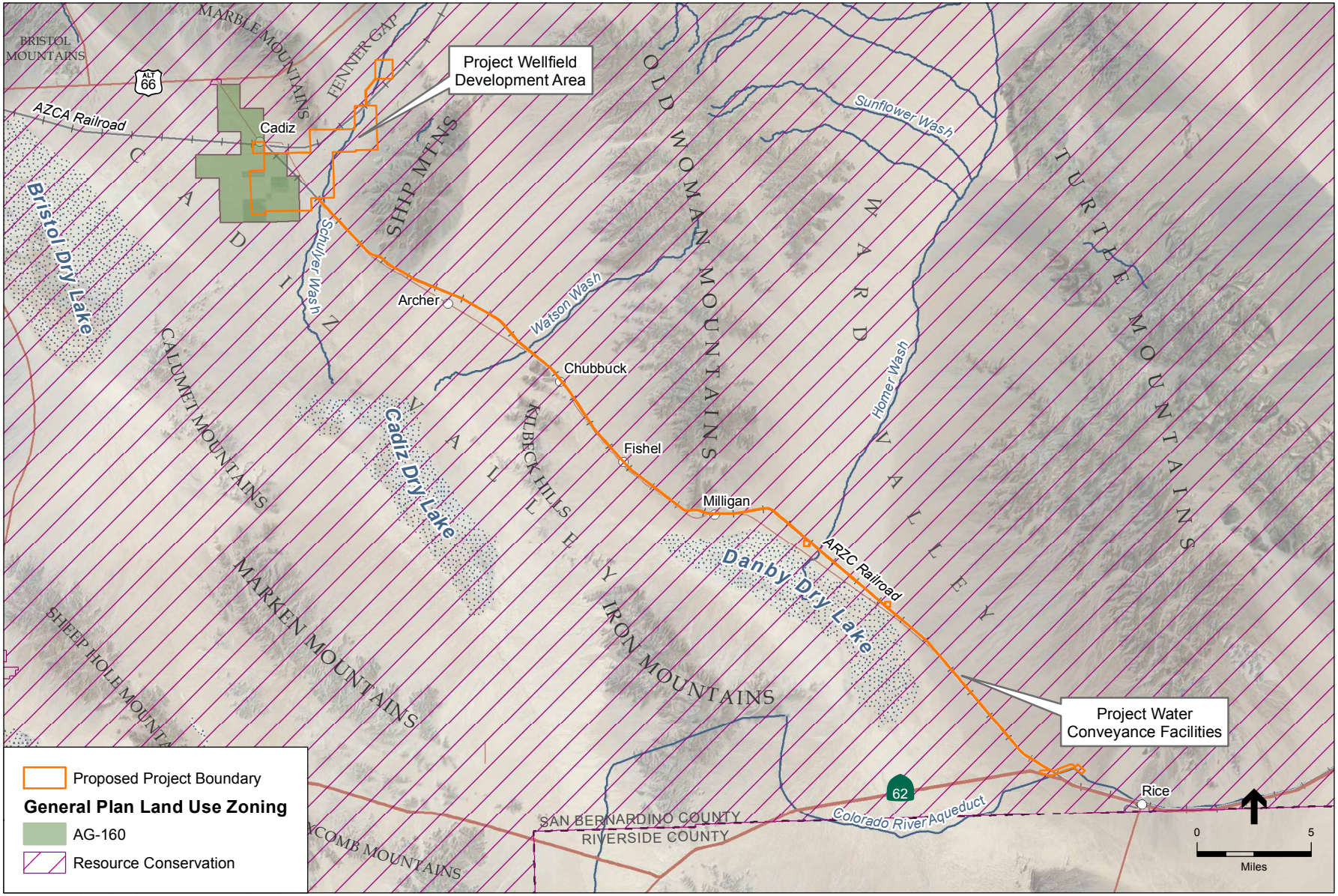
> **AG (Agriculture).** The AG land use zoning district provides sites for commercial agricultural operations, agriculture support services, rural residential uses, and similar and compatible uses. Open space and recreation uses may occur on non-farmed lands within the AG district.
>
> **RC (Resource Conservation).** The RC land use zoning district provides sites for open space and recreational activities, single family homes on very large parcels, and similar and compatible uses.

According to the Development Code, the following uses are allowed within AG and RC designated areas without a permit: crop production, horticulture, single dwelling residences, second dwelling units, accessory residential uses, guest housing, and social care facilities of six or fewer clients. Normally the County has discretionary approval authority for issuing various types of land-use and development permits to allow for specific types of facilities and land uses within AG and RC designated lands. For example, under a CUP, the following types of land uses can be approved: natural resources development (mining), hazardous waste facilities, composting operations, conference facilities, utility facilities, recreational vehicle parks, or cemeteries.[13] Under a Specific Use Regulations permit, Special Use Permit (SUP), Minor Use Permit (M/C), or site Plan Permit, allowable uses could include development of recreation, education, residential, and business service facilities.[14]

---

13 In this regard, in the early 1990's, the County approved a 2,100-acre landfill project which would receive up to 21,000 tons of garbage per day, on land located approximately one mile from the Cadiz property, adjacent to Bristol Dry Lake and the rail line between the towns of Amboy and Cadiz. While the County designated the site as "Resource Conservation," it approved a finding that the landfill was "consistent with the Open Space policies of the General Plan which recognize that landfills are uses which require undeveloped land and open space as a resource or buffer." (Cadiz Land Co., Inc. v. Rail Cycle, L.P. (2000) 83 Cal.App.4th 74, 81-82, 113-15.)

14 County of San Bernardino, *County of San Bernardino 2007 Development Code, As Amended,* September 2010, pages 2-18, 2-56.



SOURCE: Bing Maps, 2010; ESRI, 2010; Cadiz Inc., 2010; San Bernardino Co., 2010; and ESA, 2010

Cadiz Groundwater Conservation and Storage Project

Figure 4.10-2

General Plan Land Use / Zoning

San Bernardino County General Plan and Development Code

Adopted in 2007, the San Bernardino County General Plan includes goals and policies that guide land uses and planning in the County. The General Plan includes seven Elements with the goal of guiding future development; facilitating economic development; enhancing neighborhoods and commercial areas; and ensuring adequate infrastructure services and community facilities to support projected growth in the County. The following goals and policies are relevant to the proposed Project:

Land Use Element

Goal LU 1: The County will have a compatible and harmonious arrangement of land uses by providing a type and mix of functionally well-integrated land uses that are fiscally viable and meet general social and economic needs of the residents.

Goal LU 9: Development will be in a contiguous manner as much as possible to minimize environmental impacts, minimize public infrastructure and service costs, and further countywide economic development goals.

Goal LU 11. Promote mutually beneficial uses of land to address regional problems through coordination and cooperation among the County, the incorporated cities, SCAG, SANBAG, the various special districts and other local, state, and federal agencies.

Conservation Element

Goal CO 1: The County will maintain to the greatest extent possible natural resources that contribute to the quality of life within the County.

Open Space Element

Goal D/OS 1: Preserve open space lands to ensure that the rural desert character of the region is maintained.

Development Code

Section 810.01.230 (e) of the County Development Code defines a "utility facility" as a "fixed base structure or facility serving as a junction point for transferring electric utility services from one transmission voltage to another or to local distribution and service voltages, and similar facilities for water supply and natural gas distribution." These uses include any of the following facilities:

- Electrical substations and switching stations.
- Natural gas regulating and distribution facilities.
- Public water system wells, treatment plants and storage, water tanks.
- Pumping plants.
- Reservoirs.
- Telephone switching facilities.
- Utility corporation and maintenance yards.

Socioeconomics

Federal

National Environmental Policy Act

According to the provisions of the National Environmental Policy Act (Title 40, Code of Federal Regulations, Section 1508.14):

> "…economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment."

State

California Environmental Quality Act

Under *CEQA Guidelines* (Section 15358[b]), the impacts analyzed in an Environmental Impact Report (EIR) must be "related to physical changes" in the environment. The *CEQA Guidelines* (Section 15131) state, "Economic or social effects of a project shall not be treated as significant effects on the environment." In some cases, however, economic effects can result in physical effects. Therefore guidelines also state:

> An EIR may trace a chain of cause and effect from a proposed decision on a project through anticipated economic or social changes resulting from the project to physical changes caused in turn by the economic or social changes. The intermediate economic or social changes caused need not be analyzed in any detail greater than necessary to trace the chain of cause and effect. The focus of the analysis shall be on the physical changes.

Local

County of San Bernardino General Plan – Economic Development Element

The County of San Bernardino General Plan – Economic Development Element sets goals and policies necessary to ensure economic growth within the County. The Economic Development Element is intended to guide the County's goals in expanding the local economy, providing jobs, attracting and retaining businesses, support diverse and vibrant commercial areas, and bringing in sufficient revenue to support local programs and services. The County of San Bernardino General Plan was adopted in March 2007.

Environmental Justice

Federal

Executive Order 12898

Executive Order 12898 on Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, issued in 1994, requires federal agencies (and state agencies receiving federal funds) implementing NEPA to address environmental justice

concerns.[15] The order was designed to focus attention on environmental and human health conditions in areas of high minority populations and low-income communities, and to promote nondiscrimination in programs and projects substantially affecting human health and the environment.

Environmental Justice Implementation Plan

In 1997, the U.S. EPA's Office of Environmental Justice released the *Environmental Justice Implementation Plan*, supplementing the U.S. EPA's environmental justice strategy and providing a framework for developing specific plans and guidance for implementing Executive Order 12898. In 1998, federal agencies received a framework for the assessment of environmental justice in the U.S. EPA's *Guidance for Incorporating Environmental Justice Concerns in the EPA's National Environmental Policy Act Compliance Analysis*. This framework emphasizes the importance of selecting an analytical process appropriate to the unique circumstances of the potentially affected community.

State

While several California state agencies have used the U.S. EPA's *Environmental Justice Implementation Plan* as a basis for the development of their own environmental justice strategies and policies, the majority of these agencies do not yet have guidance for incorporating environmental justice impact assessment into the *CEQA* process. However, the State of California has a number of legislative and agency actions associated with environmental justice, as described below.

California Government Code

Section 65040.12 of the California Government Code states that:

> "[E]nvironmental justice" means the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

Under Assembly Bill 1553, signed into law in October 2001, the Governor's Office of Planning and Research (OPR) is required to adopt guidelines for addressing environmental justice issues in local agencies' general plans. California Code Section 65040.12 also established the OPR as the "coordinating agency in state government for environmental justice programs;" it also directs the agency to coordinate its efforts and to share information regarding environmental justice programs with federal agencies, and to review and evaluate any information obtained as a result of their respective regulatory activities. To this end, the OPR prepared the *Environmental Justice in California State Government*; this policy report gives a brief history of environmental justice, reports on the status of the OPR's efforts, and provides for future environmental justice efforts within State government. OPR also provides general environmental justice guidelines in its most recent *2003 General Plan Guidelines*. OPR is currently in the process of updating these Guidelines (Litchney, 2008).

[15] Federal Register, *Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* Vol. 59, No. 32, February 1994.

Although the OPR policy report (the California State Lands Commission (CSLC) Environmental Justice Policy, discussed below) and State legislation provide useful background information and guidance on the equitable treatment of environmental justice populations, no specific guidelines have been adopted at the State level to guide environmental justice in CEQA environmental documents. As such, most state agencies have been using federal guidance to assess the environmental justice impacts of the projects under their review.

California State Lands Commission Environmental Justice Policy

The CSLC developed an Environmental Justice Policy to ensure equity and fairness in its own processes and procedures and in October 2002 adopted an amended policy. The policy ensures that "environmental justice is an essential consideration in its processes, decisions and programs and that all people who live in California have a meaningful way to participate in these activities".[16] The CSLC implements the policy, in part, by identifying and communicating with relevant populations that could be adversely and disproportionately affected by CSLC projects or programs and by ensuring that a range of reasonable alternatives is identified to minimize or eliminate environmental impacts affecting such populations. This discussion is provided in this EIR consistent with and in furtherance of the CSLC's Environmental Justice Policy. Under the agency's adopted environmental justice policy, CSLC's staff is required to report back to the Commission on how environmental justice is integrated into its programs, processes, and activities.[17]

Local

County of San Bernardino does not identify specific goals, policies or implementation measures related to environmental justice.

4.10.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to land use and planning if it would:

- Physically divides an established community;
- Conflicts with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the General Plan, Specific Plan, Local Coastal Program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect; or
- Conflicts with any applicable habitat conservation plan or natural community conservation plan.

16 California State Lands Commission, *Environmental Justice Policy*, http://www.slc.ca.gov/Policy_Statements/Environmental_Justice_Home_Page.html, accessed October 2011.
17 California State Lands Commission, *Environmental Justice Policy*, http://www.slc.ca.gov/Policy_Statements/Environmental_Justice_Home_Page.html, accessed October 2011.

Socioeconomics

CEQA Guidelines do not currently require a discussion of socioeconomic effects as they are not considered direct effects on the physical environment and no significance criteria has been established. However, *CEQA Guidelines* state that "…economic or social effects of a project shall not be treated as significant effects on the environment. An EIR may trace a chain of cause and effect from anticipated economic or social changes resulting from the project to physical change caused in turn by the economic or social changes."[18] Therefore, if socioeconomic factors, such as employment, income, land cost, or tax base or city/county revenue, create a secondary physical impact to the environment (such as urban decay), socioeconomic analysis may be warranted.

In addition, socioeconomic effects may be used to determine the significance of physical changes caused by the project. (*CEQA Guidelines* Section 15131(b)). For example, if the construction of a new freeway or rail line divides an existing community, the construction would be the physical change, but the social effect on the community would be the basis for determining that the effect would be significant. As an additional example, if the construction of a road and the resulting increase in noise in an area disturbed existing religious practices in the area, the disturbance of the religious practices could be used to determine that the construction and use of the road and the resulting noise would be significant effects on the environment. The religious practices would need to be analyzed only to the extent to show that the increase in traffic and noise would conflict with the religious practices.

For purposes of this Draft EIR, a project is considered to have a significant impact on the environment in relation to socioeconomics if it would:

- Cause an adverse effect on economic or socioeconomic conditions to an extent that would result in substantial physical environmental effects to the project area (e.g. urban decay) or cause physical changes that are determined to be significant due to economic or social effects (e.g. divide a community).

Environmental Justice

For purposes of this Draft EIR, a project is considered to have a significant impact on environmental justice if it would:

- Cause a disproportionately high and adverse human health or environmental impact on minority or low-income populations.

Methodology

Land Use and Planning

The Project was evaluated for consistency with local planning documents including the County General Plan and federal land management plans. The Project was also evaluated for consistency with surrounding land uses. The potential for a conflict with an applicable habitat conservation

18 CEQA Guidelines, California Code of Regulations Title 14, Chapter 3, §15131.

plan or natural community conservation plan is also discussed in Section 4.4, Biological Resources.

Socioeconomics

The socioeconomic analysis of the proposed Project evaluates potential economic changes resulting from Project construction activities. The analysis focused on the potential construction-related socioeconomic effects since this aspect of the Project involves the greatest opportunity for mobilization and re-allocation of money, such that Project construction is expected to financially affect individuals and businesses within the local economy. As compared to Project construction, operation would have relatively little effect on the local economy and community. Analysis of the economic and employment impacts of the Project is based on data derived from the *Economic Impact of the Propsed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report* (Economic Report) prepared by Economic & Politics, Inc. The Economic Report uses the IMPLAN model to determine the economic impact of the Project on San Bernardino County's economy. The model uses three broad sectors (construction of other non-residential structures; fabricated pipe and pipe fitting manufacturing; and management, scientific, and technical consulting) to represent the construction economic impacts. The model assumes the economy is not operating at full capacity and utilizes the February 2011 unemployment rate of 13 percent.

Economic growth in the County can be created through direct, indirect, and induced effects. Direct effects impact the local economy by bringing in money to the market from the outside world directly from the Project. Indirect effects are made up of activities in local sectors that receive expenditures resulting from the Project. Induced effects are made up of activities in the local economy that occur simply because money is flowing through the community and County.

Environmental Justice

Demographic information was reviewed and summarized for the Project area to identify any minority or low-income communities, and potential Project impacts to such communities are evaluated.

Groundwater Conservation and Recovery Component

Divide an Established Community

Significance Threshold

Would the proposed Project physically divide an established community?

Impact Analysis

Land uses in the Project area consist largely of open space, mining, utility corridors, water conveyance, and military installations. The nearest residential and commercial communities are in Chambless (5 miles to the north), Amboy (15 miles to the west) and Twentynine Palms (40 miles to the southwest).

Construction and operation of the Project would not interrupt the existing roadways, open space areas, residential communities, and large military installations that are located in the Project vicinity. The proposed wellfield would be located on Cadiz Property. The water conveyance pipeline would be installed underground within a portion of the existing ARZC ROW parallel to the railroad tracks between the wellfield on Cadiz Property and the CRA. Cadiz has acquired an easement to construct the water conveyance facilities within a portion of the ARZC ROW that runs between mile post 189.0 at Cadiz, California, and mile post 144.0 at Freda, California. The easement provides for the installation and maintenance of a water conveyance pipeline parallel to the railroad tracks within the ARZC ROW.

The Project area is sparsely populated and the BLM is the dominant land owner. Figure 4.10-1 identifies privately held parcels in the Project area as recorded by the County. The small community of Chambless with approximately 10 residences is located on Route 66 at the Cadiz Ranch Road turn off. The community of Amboy is located approximately 10 miles west of Chambless on Route 66. Sporadic private properties with private dwellings are widely spread out in the desert region. The Project would not construct any facilities that would divide or separate any of the residential areas in the region.

Construction and operation of the necessary facilities within the ARZC ROW would occur without affecting the existing, ongoing operation of the railroad or BLM lands adjacent to the easement or ROW and would not physically divide an established community. Therefore, impacts related to the Groundwater Conservation and Recovery Component are considered less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Consistency with Land Use Plans

Significance Threshold

Would the proposed Project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the General Plan, Specific Plan, Local Coastal Program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

Impact Analysis

San Bernardino General Plan and Development Code

The Project is located within unincorporated portions of San Bernardino County zoned for resource conservation (RC) and agriculture (AG). The Project would not conflict with goals and

policies of the San Bernardino County General Plan because the pipeline would be constructed entirely within the railroad easement that allows for water conveyance facilities, and the wellfield would be a low intensity development. The RC zone allows for installation of utilities subject to a CUP unless exempted under Government Code §§ 53091(e). Construction and operation of the proposed Project would not conflict with the goals and policies of the County General Plan's Land Use Element, Conservation Element or Open Space Element since the facilities would be utilities conditionally allowed by the Development Code or exempted, and the development would be low intensity and would not conflict with or substantially reduce the open space value in the Cadiz Valley region.

The County has jurisdiction over development that is not exempt, pursuant to its General Plan policies and Development Code. The County would need to approve a CUP for the Project facilities unless the Project is exempted from local jurisdiction pursuant to Gov. Code §§ 53091(e). The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. Because the Project is exempt from the County's zoning ordinances, no CUP for these facilities is required from San Bernardino County.

In contrast, facilities "related" to water (i.e., those that are integral to the operation of water storage and transmission, such as storage yards and buildings containing equipment and materials needed for the water system, and office buildings and parking areas for field crews and support personnel) receive qualified immunity, which is required to be confirmed by SMWD at a public hearing. (Gov. Code § 53096(b)). Project components that are not sufficiently water-related would still be required to comply with building and zoning ordinances.

As discussed previously in Section 4.2, Agriculture and Forest Resources, the Project would convert a small portion of active agricultural lands to non-production uses including access roads, a wellfield and manifold pipeline, and power distribution facilities. These non-production uses are consistent with the County Development Code and the AG land designation since they are water utilities. Moreover, operation of Project facilities would not preclude continued surface agricultural production or prevent agricultural operations from expanding into adjacent AG-zoned lands located west of the Project site. Therefore impacts related to agricultural land uses and zoning are less than significant.

U.S. Bureau of Land Management (CDCA and NECO Plans)

BLM lands in the vicinity of the Project area are predominantly designated as Class M (Moderate Use) in the CDCA and NECO Plans. The Class M designation provides for a wide range of uses such as agriculture, roads, airport landing strips, installation of a variety of new utility facilities, and livestock grazing and support facilities. The Project would be constructed on lands owned by Metropolitan, Cadiz, and ARZC and would not utilize or encroach onto any BLM lands. The Project would not be located on federal property or conflict with surrounding land uses

designated by BLM in the CDCA and NECO Plans. As a result, impacts to federal land and land use plans would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Habitat Conservation Plans or Natural Community Conservation Plans

Significance Threshold

Would the proposed Project conflict with any applicable habitat conservation plan or natural community conservation plan?

Impact Analysis

No HCP or NCCP has been established in the Project area. Therefore, the Project would not conflict with an HCP or NCCP.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Socioeconomics

Significance Threshold

Would the proposed Project cause an adverse affect on economic or socioeconomic conditions to an extent that would result in substantial physical environmental effects to the Project area (e.g. urban decay) or cause physical changes that are determined to be significant due to economic or social effects (e.g. divide a community)?

Employment and Economy

The Groundwater Conservation and Recovery Component would construct new water conveyance infrastructure that would require the need for an extensive labor supply from a variety of construction-related trades. The Project would be built in San Bernardino County and would positively impact the local economy with new job creation and increased economic

activity.[19] Approximately 240 workers from the San Bernardino County labor force would be directly employed and working on-site, at any given time during the construction of this component. The construction employment would be short-term, for approximately 18 months.

However, as shown in **Table 4.10-6**, a total of 3,101 full-time equivalent employment opportunities for the San Bernardino County labor force would also be created as a result of the Project according to the Economic Report. These employment opportunities would be created in San Bernardino County through direct effects (i.e. off-site workers, consulting, management, engineering, planning), indirect effects (i.e. suppliers, manufacturing), and induced effects (i.e. new business opportunities in the subregion). Of these generated jobs, the Economic Report states that 1,790 would work directly on the Project, 468 jobs would be indirectly created in firms assisting those operations, and 843 jobs would be created due to monies flowing generally through the economy. A total of approximately $169 million of income is expected to be earned directly, indirectly, and induced by the Project. A total of approximately $455 million in economic activity would be added into the County's economy. In addition, a total of $19.7 million in tax revenues would be created.[20]

TABLE 4.10-6
ECONOMIC IMPACTS DURING CONSTRUCTION OF THE GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Type of Impact	Employment	Labor Income	Economic Activity Generated
Direct Effect	1,790	$ 108,158,760	$ 277,750,000
Indirect Effect	468	$ 24,819,009	$ 69, 436, 260
Induced Effect	843	$ 36,266,441	$ 107,582,177
TOTAL	**3,101**	**$ 169,204,210**	**$ 454,768,437**

SOURCE: Economics & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011, pages 5, 7.

The Groundwater Conservation and Recovery Component of the Project would create new full-time employment opportunities for the labor force in San Bernardino County. The increase of employment to the County would be beneficial for the job market and would benefit the labor force living in San Bernardino County. In addition, income and economic activity generated by the Project would also benefit the County in terms of tax revenue generation. The increase of employment would be within the SCAG forecasted growth and would also lower the high unemployment rate in San Bernardino County.

Housing

It is estimated that approximately 240 workers from the San Bernardino County labor force would be directly employed and working on-site, at any given time during the construction of the

[19] Economic & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011, pages 3, 10.
[20] Economic & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011, pages 6-8.

Groundwater Conservation and Recovery Component. They would reside within the existing worker housing located on the Cadiz Property during the workweek and commute back home on the weekends. These existing worker housing areas support the seasonal agricultural activities during the peak harvest season and can accommodate over 300 workers. The housing areas are expandable if necessary within the footprint of the existing areas. Thus, no new residential housing units would be required as a result of Project construction.

As described above, a total of 3,101 employment opportunities for San Bernardino County would be created directly, indirectly, and through induced effects as a result of the Project. These employment opportunities do not represent the total number of on-site employees/construction workers (expected to be approximately 240 workers) to be working at any given time, but instead represents employment opportunities in San Bernardino County created through direct, indirect, and induced effects. Since San Bernardino County is currently "housing-rich" with a job-to-housing ratio of 0.58 in the Unincorporated areas of San Bernardino County and 0.37 in the subregion of San Bernardino County, no new additional housing would be required to accommodate employment opportunities generated by the Project.

The proposed Project would be constructed mainly on unoccupied private property and within an existing ROW easement. No residential communities would be impacted by construction or operation of the proposed Project. The nearest residential and commercial developments are located in Chambless (5 miles to the north), Amboy (15 miles to the west), and Twentynine Palms (40 miles to the southwest). Construction activities and Project implementation have no potential to adversely impact any communities within these areas during construction or in the long term during operation. Therefore, Project effects would not be significant based on social or economic effects.

Mitigation Measures

None required.

Significance Conclusion

Beneficial.

Environmental Justice

Significance Threshold

Would the proposed Project cause a disproportionately high and adverse human health or environmental impact on minority populations or low-income populations?

Impact Analysis

There are no disadvantaged communities within or in the vicinity of the areas proposed for construction. The proposed Project would be constructed mainly on unoccupied private property and within an existing ROW easement. No residential communities would be impacted by

construction of the proposed Project. The nearest residential and commercial communities are located in Chambless (5 miles to the North), Amboy (15 miles to the west) and Twentynine Palms (40 miles to the southwest). Construction activities and Project implementation have no potential to adversely impact any minority or low income communities within these areas during construction or in the long term during operation. Relatively few people would be affected by the Project, and demographic groups within the Cadiz Valley would equally be subject to the potential impacts of the Project – no one community would specifically be subject to more impacts than would another. Based on the Census data presented, the Groundwater Conservation and Recovery Component would not have any disproportionate effect on minority or low income populations. There would be no impact.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Divide an Established Community

Significance Threshold

Would the proposed Project physically divide an established community?

Impact Analysis

The construction of additional wells under the Imported Water Storage Component would increase the network of power and water distribution facilities in the wellfield. The new spreading basins, CRA diversion structure, and pump station would also be constructed in undeveloped desert areas on privately owned property. No communities would be divided or access roads impeded by the Imported Water Storage Component of the proposed Project, and established communities in the area would not be divided or affected.

Construction activities at existing natural gas pipeline include converting the pipeline from natural gas to be used for water conveyance and the construction of pump stations and air valves along the pipeline. The pipeline alignment currently exists and does not divide an established community. Therefore, the existing natural gas pipeline element would not physically divide an established community and no impacts would occur.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Consistency with Land Use Plans

Significance Threshold

Would the proposed Project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the Project (including, but not limited to the General Plan, Specific Plan, Local Coastal Program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

Impact Analysis

The spreading basins would be constructed on Cadiz Property that is currently undeveloped, open space zoned as RC. The Project would covert approximately 300 acres from open space to spreading basins which constitutes less than two percent of the 25,000 acres of the Cadiz Property in the wellfield area. The spreading basins would be part of a water supply management and distribution system that would contribute to the beneficial management of the groundwater basin. The spreading basins would be conditionally consistent with the RC zone since they would be part of a water supply utility system. The construction of the spreading basins would be subject to a CUP unless exempted pursuant to Government Code Section 53091(e).

The development of the expanded wellfield, CRA diversion, and pump station associated with the Imported Water Storage Component would be conditionally allowable within the RC designation and would therefore be consistent with local land use plans. The Project would be constructed entirely within Cadiz Property, Metropolitan property, or within the ARZC ROW and would therefore not impact federal land uses or land use designations of adjacent BLM lands. The Imported Water Storage Component of the Project would have a less than significant impact on designated land uses and would be consistent with applicable land use plans.

The existing natural gas pipeline traverses through different land uses including utility lands, rangelands, and BLM lands. Construction and upgrading activities on the pipeline would not conflict with existing planning goals and policies as the activities would be primarily be conducted within the pipeline right-of-way. The addition of appurtenant structures including air relief valves and pump stations would be exempt from local zoning ordinances under the State of California Government Code (Gov. Code §§ 53091(d), (e)). Since the appurtenances would be consistent with utility infrastructure within the existing easement, impacts to land uses would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Habitat Conservation Plans or Natural Community Conservation Plans

Significance Threshold

Would the proposed Project conflict with any applicable habitat conservation plan or natural community conservation plan?

Impact Analysis

No HCP or NCCP has been established in the Project area. The Project would not be located within the wilderness areas established in the NECO Plan. The proposed Project would not conflict with an HCP or NCCP.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Socioeconomics

Significance Threshold

Would the proposed Project cause an adverse affect on economic or socioeconomic conditions to an extent that would result in substantial physical environmental effects to the Project area (e.g. urban decay) or cause physical changes that are determined to be significant due to economic or social effects (e.g. divide a community)?

Impact Analysis

Employment and Economy

Construction of the Imported Water Storage Component would create employment and generate income and economic activity. Approximately 240 workers from the San Bernardino County labor force would be directly employed and working on-site, at any given time during the construction of this Component. The construction employment would be short-term, for approximately 18 months. As shown in **Table 4.10-7**, a total of 2,885 full-time equivalent jobs would be created in San Bernardino County as a result of the Imported Water Storage Component of the Project according to the Economic Report. Of the jobs described within the Economic Report, 1,666 would work directly on the Project in construction, construction material production or planning, and engineering. A total of 435 jobs would be indirectly created in firms

assisting those operations, and 785 jobs would be created due to monies flowing generally through the economy. A total of approximately $157 million of income is expected to be earned directly, indirectly, and induced by the Project. A total of approximately $423 million in economic activity would be added into the County's economy. In addition, a total of $18.3 million in tax revenues would be created. [21]

TABLE 4.10-7
ECONOMIC IMPACTS DURING THE IMPORTED WATER STORAGE COMPONENT

Type of Impact	Employment	Labor Income	Economic Activity Generated
Direct Effect	1,666	$ 100,662,607	$ 258,500,000
Indirect Effect	435	$ 23,098,880	$ 64,623,846
Induced Effect	785	$ 33,715,696	$ 100,125,984
Total	**2,885**	$ **157,477,183**	$ **423,249,830**

SOURCE: Economic & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011, pages 11, 13.

The Imported Water Storage Component of the Project would create new full-time employment opportunities for the labor force in San Bernardino County for the approximately 18-month duration of the construction phase. The increase of employment to the County would be beneficial for the job market and would benefit the labor force living in San Bernardino County. In addition, income and economic activity generated by the Project would also benefit the County.

Housing

Approximately 240 workers per Project component would work on-site, at any given time during construction of the Imported Water Storage Component and would live in the existing worker housing located on the Cadiz Property. The housing can accommodate over 300 workers and can be expanded within the Property footprint if necessary. According to the Economic Report, a total of 2,885 employment opportunities for the San Bernardino County would also be created directly, indirectly, and through induced effects as a result of this component of the Project. Since San Bernardino County is currently "housing-rich" with a job-to-housing ratio of 0.58 in the Unincorporated areas of San Bernardino County and 0.37 in the subregion of San Bernardino County, no new additional housing would need to be built as there is a housing surplus that would support a Project-related construction phase employment.

The Project would not generate long-term employment on-site that would result in direct residential growth and housing needs.

The proposed Project would be constructed mainly on unoccupied private property and within an existing ROW easement. No residential communities would be impacted by construction or

[21] Economic & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report*, April 2011, pages 11-13.

operation of the proposed Project. The nearest residential and commercial developments are located in Chambless (5 miles to the north), Amboy (15 miles to the west) and Twentynine Palms (40 miles to the southwest). Construction activities and Project implementation have no potential to adversely impact any communities within these areas during construction or in the long term during operation. Therefore, Project effects would not be significant based on social or economic effects.

Construction at the existing natural gas pipeline would not create long-term employment that would result in direct residential growth and housing needs. In addition, construction activities would be located within existing ROW easements along the pipeline and would not impact residential communities. Thus, impacts to housing would not be significant.

Overall Socioeconomic Impact for Groundwater Conservation and Recovery Component and Imported Water Storage Component

The County would benefit from the direct, indirect, and induced employment opportunities as a result of the construction of the Project. The County would also benefit from an increase in the local and regional economic activity as shown in **Table 4.10-8**. The Project would not result in adverse socioeconomic effects that would, in turn, result in adverse physical environmental effects. The Project would have a beneficial economic impact on the local and regional area and would not disrupt an establish community.

TABLE 4.10-8
SUMMARY OF TOTAL ECONOMIC IMPACTS

Type of Impact	Conservation and Recovery Component	Imported Water Storage Component	Project Total
Employment	3,101	2,855	5,986
Labor Income	$ 169,204,210	$ 157,477,183	$ 326,681,393
Economic Activity Generated	$ 454,7686,437	$ 423,249,830	$ 878,018,267
State and Local Taxes Generated	$19,651,006	$ 18,289,057	$ 37,940,063

SOURCE: Economics & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011, pages 3, 10.

Mitigation Measures

None required.

Significance Conclusion

Beneficial.

Environmental Justice

Significance Threshold

Would the proposed Project cause a disproportionately high and adverse human health or environmental impact on minority populations or low-income populations?

Impact Analysis

The construction of additional wells under the Imported Water Storage Component, new spreading basins, CRA diversion structure, and pump station would also be constructed in undeveloped desert areas on privately-owned property. No disadvantaged communities exist in the Project area where proposed construction activities would occur; therefore, there is no potential to adversely impact any minority or low-income communities during construction or in the long term. No impacts would occur with implementation of the Imported Water Storage Component.

No communities or residential areas, in particular, disadvantaged communities would be affected by the exiting natural gas pipeline alignment and associated facilities. Therefore, no impacts would occur.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.10-9 on the following page presents the impacts and mitigation summary for Land Use and Planning.

TABLE 4.10-9
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Divide an Established Community	None required	Less than significant
Consistency with Land Use Plans	None required	Less than significant
Habitat Conservation Plans or Natural Community Conservation Plans	None required	No impact
Socioeconomics	None required	Beneficial
Environmental Justice	None required	No impact
Imported Water Storage Component		
Divide an Established Community	None required	No impact
Consistency with Land Use Plans	None required	Less than significant
Habitat Conservation Plans or Natural Community Conservation Plans	None required	No impact
Socioeconomics	None required	Beneficial
Environmental Justice	None required	No impact

4.11 Mineral Resources

The purpose of this Section is to identify existing mineral resources within the Project area, analyze potential impacts to mineral resources associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Mineral resources of concern include salts, metals, industrial minerals (e.g. aggregate, sand and gravel) oil and gas, and geothermal resources that would be of value to the region and residents of the State. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

The operation of the Project would be managed under a plan which incorporates additional safeguards and action criteria when adverse conditions occur attributable to the Project.

4.11.1 Environmental Setting

Regional Setting

The Project is located within the Eastern Mojave Desert, which is characterized by broad interior desert valleys and playas intersected by isolated mountain ranges. The geologic history of the region has resulted in the deposition of economically-valuable deposits of metals and evaporite minerals. The metals include gold, silver, copper, lead, and others. These metals are typically emplaced into a variety of host rocks through the injection of hydrothermal fluids, primarily by replacement (i.e., by solution and re-precipitation), or by open-space filling (e.g., veins, breccias, pore spaces). The evaporite minerals include salts such as sodium chloride (halite, rock salt, or table salt), calcium chloride, and calcium sulfate (gypsum), along with other less common evaporite minerals. The evaporites are typically derived from the evaporation of previously saline lakes or seas, or as salts dissolved out of sediments and rocks into surface water or groundwater and are transported to lower-elevation basins, where the salts accumulate. Lower elevation areas of playas or dry lakes[1] within closed basins commonly have high evaporite mineral concentrations in the soil and groundwater.

Local Setting

Playas in the local area have historically and are currently producing evaporite minerals. Tetra Technologies produces salts at Bristol and Cadiz Dry Lakes; National Chloride produces salts at Bristol Dry Lake. The Salt Products Company produces salt at Danby Dry Lake. The salt producing operations at Bristol and Cadiz Dry Lakes recover sodium chloride (also called halite, rock salt, or table salt) and calcium chloride (commonly used for brine for refrigeration plants, ice and dust control on roads, and desiccation) by pumping saline water from wells into trenches, where evaporation removes more water from the solution. Halite precipitates out as a solid, leaving the remaining solution concentrated calcium chloride. The operations at Danby Dry Lake produce only halite. **Figure 4.11-1** shows the extent of the salt mining operations within the

[1] The terms playas and dry lakes are generally synonymous, with the specific dry lake areas generally considered to be the innermost center areas of the playas.

Project area dry lakes as of February 16, 2003 (Bristol and Cadiz) and December 6, 2005 (Danby).[2]

California's Surface Mining and Reclamation Act of 1975 (SMARA) requires the State Geologist to classify land into mineral resource zones (MRZs) based on the known or inferred mineral resource potential of that land. The California Division of Mines and Geology has not yet identified nor is it currently working on identifying MRZs within the Project area.[3]

The USGS website for tracking active mining operations identified no active metals mining operations as of 2003 [4] within the view of the area represented in Figure 4.11-1. Although the Project area does not have any other active mining operations, the region, including the Project area, does have a history of mining for mineral resources dating back to the 1800's. **Figure 4.11-1** includes the locations of various historical inactive mining locations within and near the Project area, along with the salt producing operations. Most of these historical mining operations extracted metals, such as gold, silver, copper, and lead.

4.11.2 Regulatory Framework

The following summarizes the regulatory requirements applicable to mineral resources in the Project area.

Federal

The following federal laws and acts are implemented and enforced by the BLM. The BLM provides the mineral resource evaluations for federally-owned and managed lands.

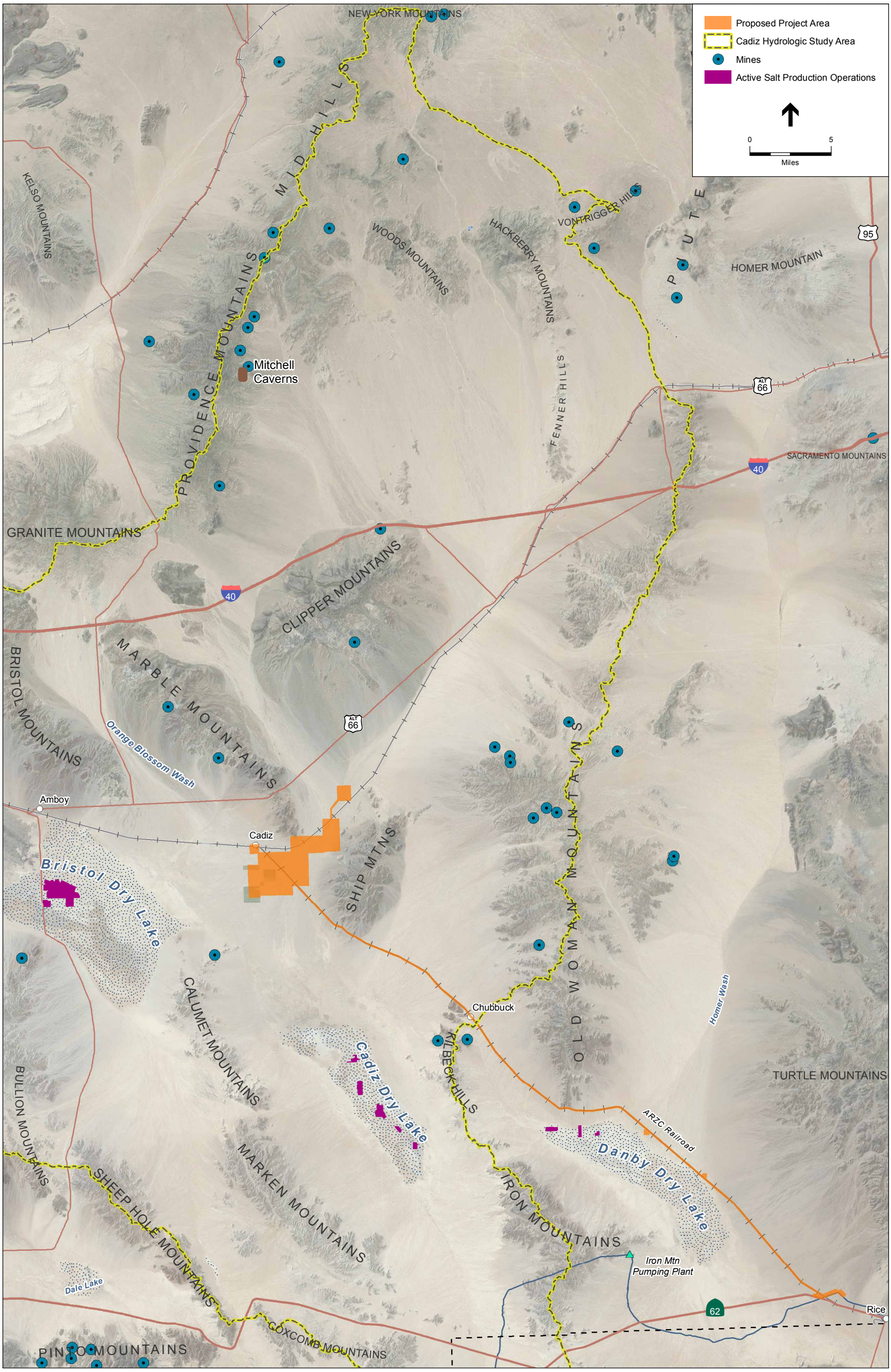
General Mining Law of 1872

Under the General Mining Law of 1872 (30 USC 29 and 43 CFR 3860, as amended), U.S. citizens are given the opportunity to explore for, discover, and purchase certain valuable mineral deposits on unreserved public domain land. Locatable deposits are those mineral deposits that are authorized to be claimed under the General Mining Law of 1872 (as amended).

Mineral Leasing Act of 1920

Leasable minerals are those commodities that may be acquired on federal public lands under the Mineral Leasing Act of 1920 (30 USC 181, as amended). Leasable minerals are subject to exploration and development through leases, permits, or licenses issued by the BLM.

2 Google Earth, accessed June 2011.
3 State Mining and Geology Board, *A Report of Mineral Land Classification and Designation Under the Surface Mining and Reclamation Act of 1975*, State Mining and Geology Board Information Report 2008-05, July 2008.
4 U.S. Geological Survey, *Active Mines and Mineral Plants in the U.S. 2003*, http://mrdata.usgs.gov/mineral-resources/active-mines.html, accessed April 2011.



SOURCE: Bing Maps, 2011; USDA, 2009; CA Natural Resource Agency, 2009; ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.11-1

Current Salt Production and Historical Mining Locations

This page left intentionally blank

Materials Act 1947

Salable minerals include common varieties of sand, stone, crushed rock and gravel, pumice, pumicite, cinders, and ordinary clay. These commodities have relatively low unit value, but may have high bulk commercial or industrial value and importance depending on their proximity to markets. Salables are used chiefly for roadways and other construction. These minerals may be obtained under the Materials Act of 1947 (30 U.S.C. 601 et seq., as amended) and are disposed of at the discretion of the BLM by contract or permit.

State

The California Department of Conservation is the primary agency charged with mineral resource protection. The Department's main responsibility is conserving the earth's mineral resources through five program divisions: the State Mining and Geology Board (SMGB); the Division of Oil, Gas and Geothermal Resources (DOGGR); the Division of Land Resource Protection; the California Geological Survey; and the Office of Mine Reclamation. The SMGB operates within the Department of Conservation and serves as a regulatory, policy, and appeals body representing the State's interest in geology, geologic and seismologic hazards, conservation of mineral resources, and reclamation following surface mining activities.

The Department of Conservation is the primary state entity that evaluates and regulates mineral resources, including the SMARA discussed below.

State Surface Mining and Reclamation Act

The State SMARA, as amended, is the primary State law governing the conservation and development of mineral resources in California (Health and Safety Code, Division 2, Chapter 9, Section 2710, et seq.).[5] Specifically, it mandates the development of mineral land classifications to help identify and protect mineral resources in areas within the State that are subject to urban expansion or other irreversible land uses that would preclude mineral extraction. After classification of mineral resource areas, SMARA provides for the designation of lands containing mineral deposits of regional or statewide significance. In addition, SMARA was designed to provide guidelines for the proper reclamation of mineral lands.

In compliance with SMARA, the SMGB is responsible for establishing MRZs to classify lands that contain mineral deposits. According to the latest status report on the SMGB website, the SMGB has not yet completed MRZs and does not have any MRZ studies in progress for the Project area.[6]

[5] Mining also may be regulated by local government, which has the authority to prohibit mining pursuant to its general plan and local zoning laws.

[6] State Mining and Geology Board, *A Report of Mineral Land Classification and Designation Under the Surface Mining and Reclamation Act of 1975*, State Mining and Geology Board Information Report 2008-05, July 2008.

Local

San Bernardino County General Plan

The San Bernardino County General Plan addresses the conservation of mineral resources in Section V, Conservation Element, Part 6 – Minerals. The goal of the Conservation Element is to prevent the wasteful exploitation, destruction, and neglect of resources. Because the State has not yet prepared an MRZ map for the area where the Project is located, the County is unable to presently implement the State MRZ program. For discussion of the applicability of the County General Plan and Development Code policies to the Project, please see Section 4.10.3 (*Consistency with Land Use Plans*) of the Land Use and Planning Chapter.

4.11.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to mineral resources if it would:

- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State; or
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.

Methodology and Assumptions

Mineral resource impacts are based upon the project's proximity to nearby mineral resources that are identified as being of importance on a local, regional, state, or federal level. Specifically, this Section addresses the potential environmental impacts related to the loss of existing or potential mineral resources. Mineral resource maps and known and potential locations of mineral resources and mining operations were identified to evaluate whether the proposed Project would impede access to these resources or disrupt on-going mining operations.

As described in Section 4.9, Hydrology and Water Quality, using data collected to date, Geoscience prepared a groundwater model to simulate the aquifer system in the Project area, including Fenner Valley, Fenner Gap, and the Cadiz Valley area that includes most of the Bristol Playa and the northern portion of the Cadiz Playa.[7] The groundwater model was used to simulate the potential response of the aquifer system to Project operations using two variations of the wellfield configuration and three variations of potential annual recharge volumes over a period of 50 years of groundwater production at 50,000 AFY, followed by 50 years of recovery (no groundwater production). The output of the simulations include the modeled drawdown of groundwater levels, the potential movement of the freshwater-saline water interface, and the amount of potential subsidence.

[7] GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project Phase I – Conservation Scenarios,* August 2011, Figure 1.

The modeled scenarios vary by recharge amounts. The Project scenario assumes an annual recharge of approximately 32,000 AFY in the Fenner Watershed and Orange Blossom Wash based on CH2M Hill's updated evaluation of recharge. This recharge volume estimate is derived from the USGS INFIL3.0 Model, is based on long-term precipitation records and represents the long-term average annual recharge within the Fenner Watershed that ultimately evaporates off of Bristol and Cadiz Playas.[8] Because earlier evaluations of available recharge predicted a lower potential range for recharge, two sensitivity scenarios were applied to model conservative, worst-case aquifer responses where the average annual recharge over a 100-year time period is reduced to 16,000 and 5,000 AFY respectively.[9] The modeling did not include recharge that occurs west, south, and east of the Bristol and Cadiz Dry Lakes. Consequently, the groundwater model provides the most conservative aquifer responses as the inclusion of recharge from other watersheds would reduce the predicted groundwater level drawdown and freshwater saline water interface movement.

Groundwater Management, Monitoring, and Mitigation Plan

The GMMMP prepared for the Project to provide for the adaptive management of the basin includes measures to monitor Project operations and potential effects on critical resources. The project design feature that is in regard to mineral resources is listed below:

- GMMMP Project Design Feature 6.5 – Brine Resources Underlying Bristol and Cadiz Dry Lakes (See this Section and Section 4. 9, Hydrology)

Groundwater Conservation and Recovery Component

Loss of Availability of Known Mineral Resources

Significance Threshold

Would the proposed Project result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State?

Impact Analysis

Most of the Project elements would be located outside of existing or potential mineral resource areas. Some portions of the 43-mile water conveyance pipeline cross areas of potential mineral resources (gypsum, metals and non-metals, sodium (salt), oil and gas, uranium and/or thorium) that are on public lands managed by the BLM. However, the BLM evaluation, largely based on limited data such as aerial surveys, determined these mineral resources are not in active use.[10] In addition, no impacts would occur from the water conveyance pipeline, which is to be located within ARZC ROW where potential future mineral resource exploration and use would not be permitted due to safety concerns for the rail line. Similarly, the wellfield facilities are located on private land that would not be required to provide access for mineral resource mining activities

8 CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-8.
9 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project Phase I – Conservation Scenarios,* August 2011, page 4.
10 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume I,* September 2001, page 5-187, 5-188.

without permission from the land owner. Therefore, the Project would not affect availability of mineral resources other than salt, as discussed below, and the impact is considered less than significant.

With respect to Project facility impacts on salt production operations, all of the Project infrastructure would be constructed outside of the playas and far from the existing salt production operations. The Project wellfield is to be located within and just northeast of Fenner Gap, at least five miles from the edge of Bristol Playa, the closest playa. The water conveyance pipeline would pass just northeast of Danby Playa, but would have no impact on the playa because it consists solely of a shallowly buried pipeline that would not encounter groundwater, and therefore, would not require dewatering.

As described in Section 4.9, Hydrology and Water Quality, water levels beneath the playas are maintained by the inflow of groundwater from the entire Watershed (the combined recharge from Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds) and surface water from direct precipitation and overland flow, when present. The depth to groundwater measured on May 5, 2011 in two wells (Wells HAL 1 and MW-5) located at the northeast margin of the Bristol Playa approximately ½-mile northeast of the playa edge where vegetation begins to occur were 93.40 and 85.05 feet below ground surface, respectively.[11] Trenches dug in central portions of Bristol Playa for salt production show water levels ranging from 8 to 12 feet deep.[12]

As noted above, Section 4.9, Hydrology and Water Quality describes the groundwater model prepared to simulate the aquifer system in the Project area under Project operations, including the potential drawdown of groundwater beneath the salt production operations on the Dry Lakes. **Table 4.11-1** below summarizes the model-predicted drawdown at the edge of Bristol and Cadiz Dry Lakes and the center of Bristol Dry Lake for both the end of the 50-year Project operation period and the subsequent 50-year recovery period.[13]

As shown on the table above, water levels would begin to recover once the 50-year pumping period has been completed. As described in the Geoscience report, complete recovery of water levels to pre-Project levels would occur in all scenarios.[14]

The salt production at the Dry Lakes begins with the excavation of trenches that expose saline groundwater. If the Project drawdown results in water levels too deep to initiate the salt concentration process by simple excavation, this impact would be considered significant because the salt production operators would have to initially fill the trenches with pumped saline groundwater, thus incurring an added operational cost. As shown in Table 4.11-1, lowering

11 Cadiz Inc., *Communication with ESA based on field measurements collected on* August 4, 2011.
12 HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Play, San Bernardino, California,* January 2011, page 7.
13 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1,* September 2011, pages 51-52.
14 GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis*, Volume 1, September 2011, page 53.

TABLE 4.11-1
SUMMARY OF MODEL-PREDICTED DRAWDOWN UNDER OPERATION OF THE GROUNDWATER CONSERVATION AND RECOVERY ELEMENT OF THE PROJECT

		Depth to Groundwater (feet)			
Location	**Time**	**Modeled Existing**	**Project Scenario (32,000 AFY Natural Recharge)**	**Sensitivity Scenario 1 (16,000 AFY Natural Recharge)**	**Sensitivity Scenario 2 (5,000 AFY Natural Recharge)**
Edge of Bristol Dry Lake	End of 50 Years	33	68	95	118
	End of 100 Years		42	74	108
Center of Bristol Dry Lake	End of 50 Years	18	50	63	54
	End of 100 Years		33	62	79
Edge of Cadiz Dry Lake	End of 50 Years	7	21	59	72
	End of 100 Years		10	17	68

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 51-52.

groundwater levels from the existing depth of 18 feet at the center of the Bristol Dry Lake to 50 feet or greater would result in levels too deep to continue current excavation practices used by operators to initiate the salt concentration process.

The salt concentration process continues by adding saline water pumped from wells tapping saline groundwater from beneath the Dry Lakes. If the Project drawdown results in water levels decreasing to below the top of the well screens for the saline water supply wells, this impact would be considered significant because the pumps would have to be lowered to below the decreased water level.

While Project operation would not result in loss of availability of the salt resource, it could make it more difficult or costly to mine and require a change in mining operations and/or well facilities. In this way, the Project could have a significant impact on existing salt mining operations, however, with mitigation it could be reduced to less than significant.

The GMMMP includes the project design features to verify model-predicted effects and confirm protection of critical resources. The project design feature relative to subsidence is GMMMP Project Design Feature 6.5 – Brine Resources Underlying Bristol and Cadiz Dry Lakes.[15] The Action Criteria and Corrective measures are summarized in **Table 4.11-2**.

[15] CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, pages 81-82.

TABLE 4.11-2
GMMMP PROJECT DESIGN FEATURE 6.5 –
BRINE RESOURCES UNDERLYING BRISTOL AND CADIZ DRY LAKES

Action Criteria	Corrective Measures
For effects to brine resources beneath Bristol or Cadiz Dry Lake, the action criteria shall be: 1. changes in groundwater levels larger than projected by the groundwater model simulations, or 2. changes in groundwater or brine water levels of greater than 50 percent of the water column above the intake of any of the salt mining companies' wells in comparison to pre-operational static levels in cluster wells at the margins of the dry lakes.	Corrective measures that would be implemented would be modification of Project operations to address impacts to the brine resources beneath Bristol or Cadiz Dry Lake would include one or more of the following actions: • Reduction in pumping from Project wells; or • Revision of pumping locations within the Project wellfield; or • Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or • Installation of an injection wells to mitigate the impact, or • Compensation to mining operators for the additional costs of pumping.

SOURCE: CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011, pages 81-82.

Implementation of the project design features in Chapter 6.5 of the GMMMP would reduce the potential impacts to infrastructure to less than significant. Therefore, for purposes of this CEQA analysis of the Project, the project design features in Chapter 6.5 of the GMMMP are incorporated into this EIR as Mitigation Measure **MIN-1**. Implementation of Mitigation Measure **MIN-1** would ensure that the potential impacts for brines resources beneath Bristol and Cadiz Dry Lakes are mitigated to less than significant for the existing salt production operations.

Mitigation Measures

MIN-1: PDF 6.5 shall be implemented to address the potential impact for groundwater level drawdown on existing salt production operations. If changes in groundwater levels occur that are larger than projected by the groundwater model simulations or if changes occur in groundwater or brine water levels that are greater than 50 percent of the water column above the intake of any of salt mining companies' wells in comparison to pre-operational static levels in wells at the margins of the dry lakes, one or more of the following actions shall be implemented:

- Reduction in pumping from Project wells; or
- Revision of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or
- Installation of injection wells to mitigate the impact, or
- Compensation to mining operators for the additional costs of pumping.

Significance Conclusion

Less than significant with mitigation.

Loss of Availability of Locally Important Mineral Resources

Significance Threshold

Would the proposed Project result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?

Impact Analysis

As noted in the Regulatory Framework Section above, neither the State nor the County have developed MRZ maps or designated mineral resource sites in the Project area. Therefore, there are no known designated mineral resource sites in the Project area in a local planning document. Based on existing mining operations as shown on Figure 4.11-1, and because the State has not yet prepared an MRZ map for the area and the County's inability to implement the State MRZ program in the Project area, the Project would not result in an impact to locally important mineral resources identified by local planning documents nor conflict with any plans.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Loss of Availability of Known Mineral Resources

Significance Threshold

Would the proposed Project result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State?

Impact Analysis

As with the Groundwater Conservation and Recovery Component, all Imported Water Storage Project infrastructure would be constructed outside of the playas and the associated salt production operations. The wellfield expansion and spreading basins are to be located within and just northeast of Fenner Gap, at least five miles from the nearest playa and all on privately-owned land that would not be accessible for mining activities without permission from the owner. The Imported Water Storage component would require that imported water be recharged into the ground and stored for future extraction. The expanded wellfield of the Imported Water Storage Component could allow for greater extraction of water than would be occurring as part of the Groundwater Conservation and Recovery Component during certain periods. However, more importantly, the recharge of water back into the aquifer would reduce the potential impacts discussed above by increasing water levels in the basin. As such, the action of recharging water

back into the aquifer would have no impact to the existing salt production operations. Consequently, the Imported Water Storage component of the Project would not affect availability of saline water to the salt production companies and therefore, would have no impact**.**

Mitigation Measure

None required**.**

Significance Conclusion

No impact.

Loss of Availability of Locally Important Mineral Resources

Significance Threshold

Would the proposed Project result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan*?*

Impact Analysis

Neither the State nor the County have developed MRZ maps or designated mineral resource sites in the Project area. Therefore, there are no known designated mineral resource sites in the Project area. Therefore, the Project would not conflict with local mineral planning documents. Based on existing mining operations as shown on Figure 4.11-1, no locally important mineral resources would be affected by the Project.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.11-3 on the following page presents the impacts and mitigation summary for Mineral Resources.

TABLE 4.11-3
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Loss of Availability of Known Mineral Resources	**MIN-1**	Less than significant with mitigation
Loss of Availability of Locally Important Mineral Resources	None required	No impact
Imported Water Storage Component		
Loss of Availability of Known Mineral Resources	None required	No impact
Loss of Availability of Locally Important Mineral Resources	None required	No impact

4.12 Noise

The purpose of this Section is to identify existing noise environment within the Project area, analyze potential noise impacts associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.12.1 Environmental Setting

Environmental Noise Fundamentals

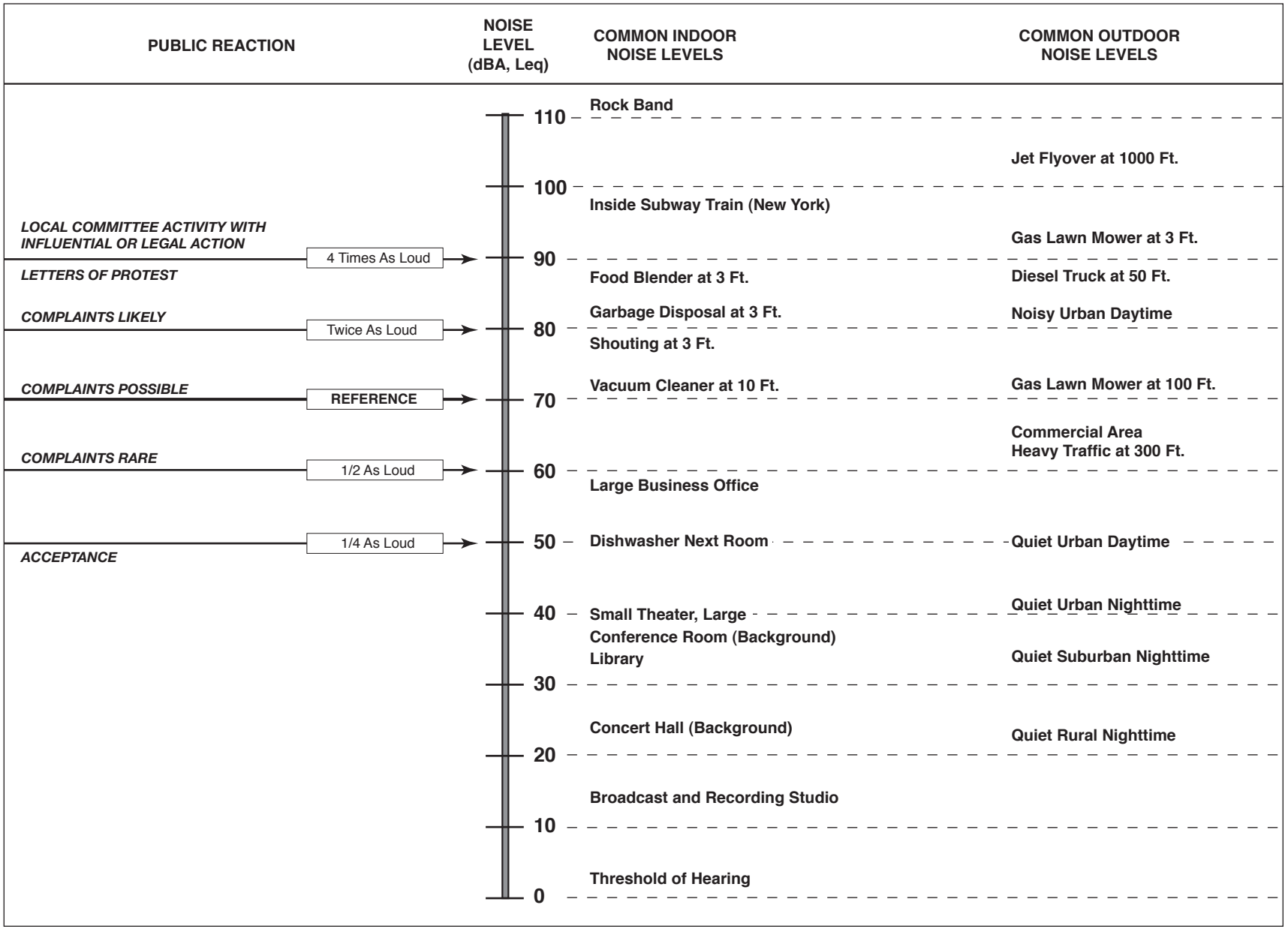
Sound is mechanical energy transmitted by pressure waves through a medium such as air. Noise is defined as unwanted sound. Sound, traveling in the form of waves from a source, exerts a sound pressure level (referred to as sound level) which is measured in decibels (dB), with zero dB corresponding roughly to the threshold of human hearing, and 120 to 140 dB corresponding to the threshold of pain. Pressure waves traveling through air exert a force registered by the human ear as sound.

Sound pressure fluctuations can be measured in units of hertz (Hz), which correspond to the frequency of a particular sound. Typically, sound does not consist of a single frequency, but rather a broad band of frequencies varying in levels of magnitude (sound power). When all the audible frequencies of a sound are measured, a sound spectrum is plotted consisting of a range of frequencies spanning 20 to 20,000 Hz. The sound pressure level, therefore, constitutes the additive force exerted by a sound corresponding to the sound frequency/sound power level spectrum.

The typical human ear is not equally sensitive to all frequencies of the audible sound spectrum. As a consequence, when assessing potential noise impacts, sound is measured using an electronic filter that de-emphasizes the frequencies below 1,000 Hz and above 5,000 Hz in a manner corresponding to the human ear's decreased sensitivity to extremely low and extremely high frequencies. This method of frequency weighting is referred to as A-weighting and is expressed in units of A-weighted decibels (dBA). Frequency A-weighting follows an international standard methodology of frequency de-emphasis and is typically applied to community noise measurements. Some representative noise sources and their corresponding A-weighted noise levels are shown in **Figure 4.12-1**.

Noise Exposure and Community Noise

An individual's noise exposure is a measure of noise over a period of time. A noise level is a measure of noise at a given instant in time. The noise levels presented in Figure 4.12-1 are representative of measured noise at a given instant in time, however, they rarely persist consistently over a long period of time. Rather, community noise varies continuously over a period of time with respect to the contributing sound sources of the community noise environment. Community noise is primarily the product of many distant noise sources, which constitute a relatively stable background noise exposure, with the individual contributors unidentifiable.



SOURCE: Caltrans Transportation Laboratory Noise Manual, 1982; and modification by ESA.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.12-1

Effects of Noise on People

The background noise level changes throughout a typical day, but does so gradually, corresponding with the addition and subtraction of distant noise sources such as traffic and atmospheric conditions. What makes community noise constantly variable throughout a day, besides the slowly changing background noise, is the addition of short duration single event noise sources (e.g., aircraft flyovers, motor vehicles, sirens), which are readily identifiable to the individual.

These successive additions of sound to the community noise environment vary from instant to instant requiring the measurement of noise exposure over a period of time in order to legitimately characterize a community noise environment and evaluate cumulative noise impacts. This time-varying characteristic of environmental noise is described using statistical noise descriptors. The most frequently used noise descriptors are summarized below:

Leq — The equivalent sound level is used to describe noise over a specified period of time, typically one hour, in terms of a single numerical value. The Leq is the constant sound level which would contain the same acoustic energy as the varying sound level during the same time period (i.e., the average noise exposure level for the given time period).

Lmax — The instantaneous maximum noise level for a specified period of time.

L50 — The noise level that is equaled or exceeded 50 percent of the specified time period. The L50 represents the median sound level.

L90 — The noise level that is equaled or exceeded 90 percent of the specified time period. The L90 is sometimes used to represent the background sound level.

Ldn — 24-hour day and night A-weighted noise exposure level which accounts for the greater sensitivity of most people to nighttime noise by weighting noise levels at night ("penalizing" nighttime noises). Noise between 10:00 PM and 7:00 AM is weighted (penalized) by adding 10 dBA to take into account the greater annoyance of nighttime noises.

CNEL — Community Noise Equivalent Level (CNEL) is similar to the Ldn, which adds a 5-dBA penalty during the evening hours between 7:00 PM and 10:00 PM in addition to a 10-dBA penalty between the hours of 10:00 PM and 7:00 AM

As a general rule, in areas where the noise environment is dominated by traffic, the Leq during the peak-hour is generally equivalent to the Ldn at that location (within +/- 2 dBA).[1]

Effects of Noise on People

The effects of noise on people can be placed into three categories:

- Subjective effects of annoyance, nuisance, dissatisfaction;
- Interference with activities such as speech, sleep, learning; and
- Physiological effects such as hearing loss or sudden startling.

Environmental noise typically produces effects in the first two categories. Workers in industrial plants can experience noise in the last category. There is no completely satisfactory way to measure

[1] California Department of Transportation, *Technical Noise Supplement*, October 1998, page 52.

the subjective effects of noise, or the corresponding reactions of annoyance and dissatisfaction. A wide variation in individual thresholds of annoyance exists, and different tolerances to noise tend to develop based on an individual's past experiences with noise.

Thus, an important way of predicting a human reaction to a new noise environment is the way it compares to the existing environment to which one has adapted: the so called "ambient noise" level. In general, the more a new noise exceeds the previously existing ambient noise level, the less acceptable the new noise will be judged by those hearing it. With regard to increases in A-weighted noise level, the following relationships occur:

- Except in carefully controlled laboratory experiments, a change of 1 dBA cannot be perceived;
- Outside of the laboratory, a 3 dBA change is considered a just-perceivable difference;
- A change in level of at least 5 dBA is required before any noticeable change in human response would be expected; and
- A 10 dBA change is subjectively heard as approximately a doubling in loudness, and can cause adverse response.

These relationships occur in part because of the logarithmic nature of sound and the decibel system. The human ear perceives sound in a non-linear fashion; hence the decibel scale was developed. Because the decibel scale is based on logarithms, two noise sources do not combine in a simple additive fashion, rather logarithmically. For example, if two identical noise sources produce noise levels of 50 dBA the combined sound level would be 53 dBA, not 100 dBA.

Noise Attenuation

Stationary point sources of noise, including stationary mobile sources such as idling vehicles, attenuate (lessen) at a rate between 6 dBA for hard sites and 7.5 dBA for soft sites for each doubling of distance from the reference measurement. Hard sites are those with a reflective surface between the source and the receiver such as parking lots or smooth bodies of water. No excess ground attenuation is assumed for hard sites and the changes in noise levels with distance (drop-off rate) is simply the geometric spreading of the noise from the source. Soft sites have an absorptive ground surface such as soft dirt, grass, or scattered bushes and trees. In addition to geometric spreading, an excess ground attenuation value of 1.5 dBA (per doubling distance) is normally assumed for soft sites. Line sources (such as traffic noise from vehicles) attenuate at a rate between 3 dBA for hard sites and 4.5 dBA for soft sites for each doubling of distance from the reference measurement.[2]

Sensitive Receptors

Some land uses are considered more sensitive to ambient noise levels than others because of the amount of noise exposure (in terms of both exposure duration and insulation from noise) and the types of activities typically involved. Residences, hotels, schools, rest homes, and hospitals are generally more sensitive to noise than commercial and industrial land uses. The Project facilities proposed would be located in the Cadiz Valley in eastern San Bernardino County. The water conveyance pipeline, which would connect Cadiz Property with the CRA near Rice, CA, would be buried within the ARZC ROW along the railroad tracks. The nearest sensitive receptors are

[2] California Department of Transportation, *Technical Noise Supplement*, October 1998, page 15.

residences located approximately 3.3 miles north of the Project site near the corner of Cadiz Road and National Trails Highway. Wildlife in the area may be sensitive to loud or persistent noises as well. Refer to Section 4.4, Biological Resources for further discussion on noise impacts to wildlife.

Existing Noise Environment

The noise surrounding the Project site would be expected to be typical of open space and agricultural areas. The predominant sources of noise include railroad noise, roadway traffic, and equipment noise from existing agricultural operations. Military operations including explosions and low-flying aircraft also generate noise in the valley. Average noise levels in these types of environments typically are in the range of 35-55 dBA.[3] In this naturally quiet environment, trains traversing the valley (10 to 20 per day on the BNSF and 2 or 3 on the ARZC) are the primary source of non-wildlife noises.

4.12.2 Regulatory Framework

Federal

Federal Code of Regulations, Part 205(B)

Federal regulations establish noise limits for medium and heavy trucks (more than 4.5 tons, gross vehicle weight rating) under 40 CFR, Part 205, Subpart B. The federal truck pass-by noise standard is 80 dBA at 15 meters from the vehicle pathway centerline. These controls are implemented through regulatory controls on truck manufacturers.

The National Park Service has established internal orders, Director's Order #47: Soundscape Preservation and Noise Management, that outline operating procedures for assessing noise effects from Park management actions. The Order establishes internal operating and management protocols but do not apply to neighboring land uses.

State

California Government Code Section 65302(f)

California Government Code Section 65302(f) mandates that the legislative body of each county and city adopt a noise element as part of their comprehensive general plan. The local noise element must recognize the land use compatibility guidelines established by the State Department of Health Services.

State of California OPR Noise Element Guidelines

The State of California Office of Planning and Research (OPR) Noise Element Guidelines include recommended interior and exterior standards for local jurisdictions to identify and prevent the creation of incompatible land uses due to noise. The OPR Guidelines describe the compatibility of various land uses with a range of environmental noise levels in terms of dBA CNEL.

In California, most cities and counties have adopted noise ordinances, which serve as enforcement mechanisms for controlling noise, and general plan noise elements, which are used

[3] Cunniff, P.F., *Environmental Noise Pollution*, 1977, page 131.

as planning guidelines to ensure that long-term noise generated by a source is compatible with adjacent land uses. The California Department of Health Services' Office of Noise Control studied the correlation of noise levels and their effects on various land uses and published land use compatibility guidelines for the noise elements of local general plans. The guidelines are the basis for most noise element land use compatibility guidelines in California.

The land use compatibility for a community noise environment chart identifies the normally acceptable range for several different land uses, as shown in **Figure 4.12-2** below. Persons in low-density residential settings are most sensitive to noise intrusion, with noise levels of 60 dBA CNEL and below considered "acceptable." For land uses such as schools, libraries, churches, hospitals, and parks, acceptable noise levels go up to 70 dBA CNEL.

The State of California also establishes noise limits for vehicles licensed to operate on public roads. For heavy trucks, the State pass-by standard is consistent with the federal limit of 80 dB at 15 meters. The State pass-by standard for light trucks and passenger cars (less than 4.5 tons, gross vehicle rating) is also 80 dBA at 15 meters from the centerline. These standards are implemented through controls on vehicle manufacturers and by legal sanction of vehicle operators by State and local law enforcement officials.

Local

San Bernardino County Municipal Code

The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. The following discussion on the County Municipal Code is provided for context to assess the Project's consistency with the County policies.

Table 4.12-1 describes the noise standard for emanations from a stationary noise source, as it affects adjacent properties.

TABLE 4.12-1
SAN BERNARDINO COUNTY STATIONARY NOISE STANDARDS

Affected Land Uses Receiving Noise	7:00 am – 10:00 pm dBA Leq	10:00 pm – 7:00 am dBA Leq
Residential	55	45
Professional Services	55	55
Other Commercial	60	60
Industrial	70	70

SOURCE: County of San Bernardino, *County of San Bernardino 2007 Development Code*, *As Amended,* September 2010, page 3-12.

	Normally Acceptable	Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements
	Conditionally Acceptable	New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features are included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.
	Normally Unacceptable	New construction or development should be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirement must be made and needed noise insulation features included in the design.
	Clearly Unacceptable	New construction or development generally should not be undertaken.

SOURCE: State of California, Governor's Office of Planning and Research, *General Plan Guidelines*, 2003.

Cadiz Water Conservation, Recovery, and Storage Project 210324

Figure 4.12-2
Land Use Compatibility For Community Noise Environment

Exemptions to noise and vibration thresholds include temporary construction, maintenance, repair, or demolition activities between 7:00 am and 7:00 pm, except Sundays and Federal holidays. For discussion of the applicability of the County General Plan and Development Code policies to the Project, please see Section 4.10.3 (*Consistency with Land Use Plans*) of the Land Use and Planning Chapter.

4.12.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to noise if it would:

- Expose persons to or generated noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies;
- Expose persons to or generated excessive ground-borne vibration or ground-borne noise levels;
- Create a substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project;
- Create a substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project;
- Expose people residing or working in the Project area to excessive noise levels for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport; or
- Expose people residing or working in the Project area to excessive noise levels for a project located in the vicinity of a private airstrip.

Methodology

The methodology for determining a significant impact related to noise is the same whether applied to the proposed Project on a programmatic or a project level. Noise impacts are assessed based on a comparative analysis of the noise levels resulting from the Project and the noise levels under existing conditions. The primary short-term sources of noise associated with the proposed Project would be temporary construction noise effects and are based on typical construction phases, equipment noise levels, attenuation of those noise levels due to distances, and any barriers between the construction activity and the sensitive receptors near the sources of construction noise.

Groundwater Conservation and Recovery Component

Sensitive Receptors

Significance Threshold

Would the proposed Project expose persons, or sensitive receptors, to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

Impact Analysis

Construction of Wellfield and Conveyance Facilities

Noise levels associated with the installation of pipelines and construction of the wellfield would fluctuate depending on the particular type, number, and duration of uses of various pieces of construction equipment. **Tables 4.12-2** and **4.12-3** show typical noise levels during different construction stages and those produced by various types of construction equipment. Noise would be generated within the wellfield during the drilling of each new well. Multiple construction zones along the pipeline corridor would generate noise along the railroad alignment.

TABLE 4.12-2
TYPICAL NOISE LEVELS FROM CONSTRUCTION ACTIVITIES

Construction Phase	Noise Level[a] (dBA, Leq)
Ground clearing	84
Excavation	89
Foundations	78
Erection	85
Finishing	89
Rock Blasting	111-115

a Average noise levels correspond to a distance of 50 feet from the noisiest piece of equipment associated with a given phase of construction and 200 feet from the rest of the equipment associated with that phase.

SOURCE: U.S. Environmental Protection Agency, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, December 1971, page 26, Table I-A; Cunniff, P.F., *Environmental Noise Pollution*, 1977, page 131.

TABLE 4.12-3
TYPICAL NOISE LEVELS FROM CONSTRUCTION EQUIPMENT

Construction Equipment	Noise Level[a] (dBA, Leq at 50 Feet)
Dump truck	88
Portable air compressor	81
Concrete mixer (truck)	85
Scraper	88
Jackhammer	88
Dozer	87
Paver	89
Generator	76
Backhoe	85
Rock Drilling	98

a Average noise levels correspond to a distance of 50 feet from the noisiest piece of equipment associated with a given phase of construction and 200 feet from the rest of the equipment associated with that phase.

SOURCE: U.S. Environmental Protection Agency, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, December 1971, page 26, Table I-A; Cunniff, P.F., *Environmental Noise Pollution*, 1977, page 131.

The loudest portion of typical construction would be during excavation of the pipeline trenches and when blasting or drilling through rock. As shown in Table 4.12-2, excavation noise levels are 89 dBA at 50 feet and blasting can generate noise levels of 115 dBA at 50 feet. The nearest sensitive receptors to construction activities are approximately 3.3 miles (17,424 feet) to the north. Wildlife in the immediate vicinity would be much closer. (The effect of noise on wildlife is addressed in Section 4.4.) Assuming an attenuation rate of 7.5 dBA per doubling of distance, a receptor at 3.3 miles would experience noise levels of approximately 25 dBA Leq during excavation. If drilling were to be used at this distance during construction, then the sensitive receptor would be exposed to noise levels of approximately 34 dBA Leq. If blasting is needed, then the sensitive receptor would be exposed to noise levels of approximately 52 dBA. Other sensitive receptors located further away from construction would be exposed to construction noise at incrementally lower levels. Basting would occur only once or twice per day for up to three days at a time and would be similar to the military exercises conducted on the western edge of the valley.

Noise would also increase during construction near the worker housing areas. The nearest residences to the worker housing areas are approximately one mile to the north. At this distance, worker housing area noise would attenuate to less than significant levels.

San Bernardino County Municipal Code has exemptions to noise and vibration thresholds for construction activities between 7:00 am and 7:00 pm, except Sundays and federal holidays. However, wellfield drilling would occur 24 hours a day. Nevertheless, the loudest construction activities would not exceed San Bernardino County nighttime noise ordinance levels of 45 dBA at the nearest sensitive receptor. Therefore, construction noise would be less than significant.

Operations

Noise during Project operations would be generated by the well pump motors and from maintenance vehicles. The well pumps would be housed in acoustical covers to minimize noise generation. The noise would attenuate to imperceptible levels at the nearest residences due to the remoteness of the wellfield. The dominant noise in the valley is from the frequent trains and the vehicle traffic on Route 66. Maintenance vehicle trips would be infrequent and would not substantially alter the existing condition in the valley from dirt-road traffic. Wildlife in the immediate vicinity of the wellfield may experience audible noise from the pumps. (The effect of noise on wildlife is discussed in Section 4.4). Operation of the proposed Project would not result in significant noise impacts to sensitive receptors.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Ground-Borne Vibrations and Ground-Borne Noise

Significance Threshold

Would the proposed Project expose persons to or generate excessive ground-borne vibration or ground-borne noise levels?

Impact Analysis

Construction of Wellfield and Conveyance Facilities

Ground borne vibration (GBV) created by construction activity, notably grading and excavation utilizing large bulldozers, would fall within the range of readily perceivable vibration at 25 feet from source but would not exceed the threshold at which continuous vibration would begin to annoy people. Ground borne vibration would attenuate at a rate of approximately 6 VdB per doubling of distance. The ground-borne vibration generated during construction activities would therefore primarily impact sensitive uses that are located adjacent to or within 25 feet of specific Project-related activity.

Vibration that takes the form of oscillatory motion, can be described in terms of acceleration, velocity, and displacement. There are several different methods that are used to quantify vibration. The PPV is defined as the maximum instantaneous peak of the vibration signal. The PPV is most frequently used to describe vibration impacts to buildings. The RMS amplitude is most frequently used to describe the affect of vibration on the human body. The RMS amplitude is defined as the average of the squared amplitude of the signal. The FTA's threshold of architectural damage for conventional sensitive structures is 0.2 in/sec PPV, and the FTA threshold of human annoyance to ground-borne vibration is 80 RMS.[4]

The Project would result in a significant impact if buildings would be exposed to the Federal Transit Administration (FTA) building damage ground-borne vibration threshold level of 0.2 Peak Particle Velocity (PPV) or if sensitive individuals would be exposed to the FTA human annoyance response ground-borne vibration threshold of 80 Root Mean Square (RMS) velocity level.

Construction of the Project would require drilling during well and pipeline installation. As shown in **Table 4.12-4** below, caisson drilling generates vibration levels of up to 0.089 PPV or 87 RMS at a distance of 25 feet. The nearest sensitive receptors to construction activities in the wellfield are approximately 3.3 miles (17,424 feet) to the north of the wellfield. (Project effects on wildlife are discussed in Section 4.4 Biological Resources.) At this distance, the nearest sensitive receptor would be exposed to vibration levels of approximately 0.000005 PPV and 1.7 RMS. These levels would not exceed FTA standards. Similarly, construction activities to install the pipeline could generate minimal vibration along the railroad that would be well below any damage threshold as shown in Table 4.12-5. Therefore vibration impacts from construction would be less than significant.

4 Federal Transit Administration, *Transit Noise and Vibration Impact Assessment,* May 2006, page 8-2.

TABLE 4.12-4
VIBRATION FROM CONSTRUCTION EQUIPMENT

Construction Equipment	PPV at 25 feet (inches/second)[a]	RMS at 25 feet (VDB)[b]
Loaded Trucks	0.076	86
Caisson Drilling	0.089	87
Large Bulldozer	0.089	87
Jackhammer	0.035	79

a. Buildings can be exposed to ground-borne vibration levels of 0.2 PPV without experiencing structural damage.
b. The human annoyance response level is 80 RMS.

SOURCE: Federal Transit Administration, *Transit Noise and Vibration Impact Assessment*, May 2006, page 12-12, Table 12-2.

Operations

Operation of the Project would not result in substantial vibration. Localized vibration may be experienced near well pump motors and along access roads used by maintenance vehicles, but vibration would attenuate and would not damage structures or reach annoyance levels of significance. Operation would result in less than significant vibration effects.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Ambient Noise Levels

Significance Threshold

Would the proposed Project create a substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project?

Would the proposed Project create a substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?

Impact Analysis

Construction of Wellfield and Conveyance Facilities

Ambient noise levels in the desert are low, typically near 40-45 dBA. Noise levels associated with the installation of pipelines and construction of the wellfield would fluctuate depending on the particular type, number, and duration of uses of various pieces of construction equipment. Tables 4.12-3 and 4.12-4 show typical noise levels during different construction stages and those produced by various types of construction equipment. Noise would be generated within the wellfield during the drilling of each new well. Multiple construction zones along the pipeline corridor would generate noise along the railroad alignment. If blasting is needed in certain locations along the pipeline alignment, noise from blasting would be audible in the valley.

Nighttime and daytime construction would increase the ambient noise levels in the local construction area.

Since the construction zone is in a remote area, the temporary noise would not be audible to many receptors. Some visitors in the wilderness areas and wildlife may hear construction and the noise may alter the ambient quietness, however, the existing condition includes train noises and traffic. Airplane noises are also audible. The temporary construction noise would modify the ambient noise levels in the immediate vicinity of the construction, but once construction is complete, the site would return to existing conditions. Blasting noise would be similar to the military exercises that occur periodically in the valley. Blasting may be required once or twice per day over a three day period. This would be a less than significant impact.

Operations

Project operations that would generate noise include maintenance vehicle trips and the operation of certain mechanical equipment such as stationary pumps, fans, and generators. Maintenance inspection of the wellfield, pipelines, and pump stations would occur infrequently, less than one per day. Therefore operational vehicle trip increases would be minimal and would not generate a substantial increase in noise along local roadways.

The loudest stationary noise at the Project site would be from the power generators and pump stations. As shown in Table 4.12-4 above, generator noise levels are 76 dBA at 50 feet. The nearest sensitive receptors to potential generator activity are approximately 3.3 miles (17,424 feet) to the north. Assuming an attenuation rate of 7.5 dBA per doubling of distance, a receptor at 3.3 miles would experience noise levels of approximately 12 dBA Leq from generator operation. These noise levels would not exceed San Bernardino County nighttime noise ordinance levels of 45 dBA at the nearest sensitive receptor. Effects to ambient noise levels on wildlife are evaluated in Section 4.3 Biological Resources. Therefore, due to the remote nature of the Project area and the moderate noise generation, operational noise would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Exposure to Excessive Noise Levels

Significance Threshold

Would the proposed Project expose people residing or working in the Project area to excessive noise levels for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport?

Would the proposed Project expose people residing or working in the Project area to excessive noise levels if the Project is located in the vicinity of a private airstrip?

Impact Analysis

Construction of Wellfield and Conveyance Facilities

The Project site would be located in close proximity to the private airstrip owned and maintained by Cadiz Inc. This airstrip is used approximately five times a month and is not available to the public. During construction, there may be a minor increase in the number of flights into and out of the airstrip associated with various contractor personnel visiting the Project area as needed (less than five per week). But it is expected that the increase would amount to less than five visits per week and would be temporary, only lasting throughout construction. As a result, impacts would be considered less than significant and no mitigation is required.

Operations

Ongoing travel to and from the Project site for ongoing maintenance of the new wellfield facilities and pump stations would occur infrequently and should be on par with current airstrip operations. Therefore, future employees on the Project site would not be subjected to excessive noise levels from airstrip activity, and exposure to airport noise would be a less than significant impact. Similarly, since the Project would not create noise-sensitive land uses in the area,. No other potential excessive noise sources exist in the vicinity.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Sensitive Receptors

Significance Threshold

Would the proposed Project expose persons, or sensitive receptors, to or generate noise levels in excess of standards established by any applicable plan, noise ordinance, or applicable standards of other agencies?

Impact Analysis

Construction activities required for the Imported Water Storage Component would emit noise at levels similar to the Groundwater Conservation and Recovery Component. Construction of the spreading basins would be temporary and would not result in significant amounts of noise experienced by sensitive receptors. Operations would increase the number of extraction well pumps, but would not significantly increase noise levels at sensitive receptors due to the low level of noise generated and the long distance from the well sites to the sensitive receptors.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Ground-borne Vibrations and Ground-borne Noise

Significance Threshold

Would the proposed Project expose persons to or generate excessive ground-borne vibration or ground-borne noise levels?

Impact Analysis

The Project would result in a significant impact if buildings would be exposed to the FTA building damage ground-borne vibration threshold level of 0.2 PPV or if sensitive individuals would be exposed to the FTA human annoyance response ground-borne vibration threshold of 80 RMS velocity level. Similar to the Groundwater Conservation and Recovery Component, construction of the spreading basins, existing natural gas pipeline appurtenances, and expanded wellfield would not result in vibration that could affect neighboring structures. The impact would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Ambient Noise Levels

Significance Threshold

Would the proposed Project create a substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project?

Would the proposed Project create a substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?

Impact Analysis

Similar to the Groundwater Conservation and Recovery Component, Project operations that would generate noise include maintenance vehicle trips and the operation of certain mechanical equipment such as stationary pumps, fans, and generators. Maintenance inspection of the wellfield, pipelines, pump stations, and existing natural gas pipeline appurtenances would occur infrequently. Therefore, operational vehicle trip increases would be minimal and would not

generate a substantial increase in noise along local roadways. Noise levels would not exceed San Bernardino County nighttime noise ordinance levels of 45 dBA at the nearest sensitive receptor. Therefore, operational noise would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Exposure to Excessive Noise Levels

Significance Threshold

Would the proposed Project expose people residing or working in the Project area to excessive noise levels for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport?

Would the proposed Project expose people residing or working in the Project area to excessive noise levels if the Project is located in the vicinity of a private airstrip?

Impact Analysis

Similar to the Groundwater Conservation and Recovery Component, the Imported Water Storage Component would not locate people near excessive noise sources. The closest neighboring noise sources include the airstrip, trains, and highway. Since the Project would not create noise-sensitive land uses in the area, impacts from existing and Project-related noise sources would be less than significant during construction and operations.

The existing natural gas pipeline alignment is not located within an airport land use plan. However, the pipeline alignment is located in proximity to the Barstow-Daggett Airport which is a county-owned public-use airport, located between the community of Daggett and City of Bartow. The airport consists of two paved runways. The pipeline currently exists and construction would be conducted within the existing right-of-way. The Project would not place noise-sensitive land uses in the area. Thus, impacts from existing and Project-related noise sources would be less than significant during construction and operations.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Mitigation Measure Summary Table

Table 4.12-5 presents the impacts and mitigation summary for Noise.

TABLE 4.12-5
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Sensitive Receptors	None required	Less than significant
Ground-borne Vibrations and Ground-borne Noise	None required	Less than significant
Ambient Noise Levels	None required	Less than significant
Exposure to Excessive Noise Levels	None required	Less than significant
Imported Water Storage Component		
Sensitive Receptors	None required	Less than significant
Ground-borne Vibrations and Ground-borne Noise	None required	Less than significant
Ambient Noise Levels	None required	Less than significant
Exposure to Excessive Noise Levels	None required	Less than significant

4.13 Public Services and Utilities

The purpose of this Section is to identify existing public services and utilities within the Project area, analyze potential impacts to public services and utilities associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analyses are from Appendix G of the 2011 *CEQA Guidelines*. Impacts to Parks and Recreation are analyzed in Section 4.14, Recreation.

4.13.1 Environmental Setting

Public Services

Fire Protection

Fire protection and paramedic services are provided to the proposed Project area by the San Bernardino County Fire Department (SBCFD). The SBCFD works with other agencies such as the California Department of Forestry and Fire Protection, the National Park Service Fire Crews, the City of Twentynine Palms Fire Department, the U.S. Marine Corps Fire Department, the Morongo Valley Fire Department, and the Morongo Basin Ambulance Service.[1]

The SBCFD is headquartered at 157 West Fifth Street in San Bernardino, approximately 105 miles southwest of the Project site. The nearest fire station to the proposed Project area is the Wonder Valley Fire Station No. 45 in Twentynine Palms, which is approximately 33 miles west of the Cadiz Property. Fire Station No. 31, which is located in Needles, would provide additional support, depending on the severity of the emergency. This station is located approximately 56 miles east of the Cadiz Property.[2] These stations would provide first responder paramedic and ambulance services to the Project area.

The average response time to the Cadiz Property from the Wonder Valley Fire Station is approximately 35 minutes to an hour. The average response time to the Cadiz Property from Fire Station No. 31 is approximately 45 minutes.

To address the remoteness of the site from fire protection services, Cadiz maintains fire suppression equipment, trained personnel, and an emergency evacuation plan for its agricultural operations.[3] Fire extinguishers are present in the office, dormitory, kitchen, equipment storage and maintenance buildings, and all company vehicles. All fire extinguishers are checked on a six or twelve month schedule by licensed professionals. The dormitory has a sprinkler system. The office trailer park and worker housing facilities have sets of fire hoses in water supply boxes. Selected personnel are trained by professional fire personnel in fire suppression techniques.

1 San Bernardino County Fire Department website, http://www.sbcfire.org/fire rescue/southd1.asp, accessed October 2010.
2 Star Javier, District Coordinator, San Bernardino County Fire Department, *Phone conversation with ESA,* October 20, 2010.
3 Cadiz Inc., *Communication with ESA,* October 19, 2011.

Police Protection

Police protection services are provided in the Project area by the San Bernardino County Sheriff-Coroner's Department (SBCSD). The SBCSD is headquartered at 655 East 3rd Street in San Bernardino, approximately 105 miles southwest of the Project site. The nearest police station to the Project site is SBCSD's Morongo Basin Station, located at 6527 White Feather Road, approximately 78 miles west of the Cadiz Property. This station has 82 assigned staff, including 60 sworn personnel and 22 civilian employees. There are a minimum of two to four patrol officers per shift assigned to the 3,000 square miles of the unincorporated Morongo Basin jurisdiction. The proposed Project area is patrolled on a random basis, depending on the need for service. The estimated response time of a Sheriff's unit to the Cadiz Property for emergency calls is approximately 1 hour. Annually, an average of approximately 10 calls are made for police and law enforcement services in the Project vicinity.[4]

The proposed Project area is served by the Barstow office of the California Highway Patrol (CHP). The CHP does not regularly patrol the Project area. However, they provide assistance on an on-call basis for accidents, emergencies, and related incidences. The normal response time is approximately 1 to 1.5 hours.

A Sheriff's Department Citizen on Patrol volunteer group is also active in the Cadiz area. This unit consists of unarmed volunteers who patrol the proposed Project area in marked Citizen Patrol cars and report suspicious activities. This group does not take any law enforcement action, and there is no set schedule for this volunteer unit. The volunteers patrol when they have free time.[5]

In addition, the BLM Needles field office manages a force of approximately 200 Law Enforcement Rangers and 70 Special Agents who enforce a wide range of laws and regulations in the prevention, detection, and investigation of crimes affecting public lands resources. The Rangers provide a regular and recurring presence over the resource area and are responsible for conducting high visibility patrols; conducting public contacts; enforcing federal laws and regulations; assisting local county and city police departments, other federal and state land management agencies, and generally providing for the safety of public land users.

Public Schools

The proposed Project area is under the jurisdiction of the Needles Unified School District (NUSD), which provides elementary and secondary education. The nearest school to the Project site is the Parker Dam Elementary School at 1207 West 16th Street, approximately 46 miles east of the Cadiz Property. This school serves grades kindergarten through 8th grade. Currently, there are 88 students attending Parker Dam Elementary School. Needles High School, which serves grades 9 through 12, is located approximately 68 miles east of the Cadiz Property. This high school has approximately 275 regular students. Bus transportation is available to Needles High School from Amboy, approximately 13 miles west of the Cadiz Property.

---

4 Lieutenant Rich Boswell, San Bernardino County Sheriff's Department, *Phone conversation with ESA,* October 20, 2010.

5 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I,* September 2001, page 5-219.

Libraries

The San Bernardino County Public Library (SBCPL) provides library services to 18 cities and unincorporated areas in San Bernardino County. The closest branches of the SBCPL system are in Twentynine Palms, approximately 50 miles southwest of the Cadiz Property, and in Needles, approximately 60 miles east of the Cadiz Property. The Twentynine Palms Library occupies 5,000 square feet and has 37,000 volumes. This library is open 48 hours a week.[6]

The Needles Library is staffed by two full-time librarians, two library assistants, and page help and is open 43 hours a week. It occupies 5,568 square feet and has approximately 20,000 volumes.[7]

A bookmobile, which services the proposed Project area, is headquartered at the Needles Library. This bookmobile visits the proposed Project area on a weekly basis and is staffed by two people.

Health Care Services

The nearest medical facility to the proposed Project site is the Colorado River Medical Center (CRMC) located in Needles, approximately 55 miles to the east. Other hospitals in the Project vicinity include the Valley View Medical Center, which is located 61 miles to the east, the Western Arizona Regional Medical center, located approximately 68 miles to the east, and the Hi Desert Medical Center, located approximately 72 miles to the west of the Cadiz Property.

Medical aid and ambulance services to the proposed Project area are provided from Twentynine Palms or Needles, when needed. The Sheriff's Department helicopter, the CHP air ambulance or Mercy Air Service can provide assistance in the case of emergencies for transporting patients to the nearest medical facilities. Response time varies from 15 minutes to 1 hour, depending on the type of transportation to the site.[8] The Cadiz airstrip by the Project office can be used for air rescue. The Cadiz agricultural operations have first aid materials onsite, and the site manager has been trained as a first responder.[9]

Public Utilities

Regional Water Supply

Section 2.4, Overview of Southern California Water Supply and Section 3.6, Project Facilities provide descriptions of the SWP and the CRA, the public water supply elements that the Project would be connected to for water conveyance. The Groundwater Conservation and Recovery Component of the Project would pipe water to the CRA to be added to the public water supply of Southern California. The Imported Water Storage Component of the Project would pipe water from the CRA to spreading basins in the Fenner Gap area to be recharged into the aquifer and stored for later use. **Figure 4.13-1** shows the location of the CRA south of Danby Dry Lake where the Project water conveyance pipeline would tie in. A currently unused natural gas pipeline

6 San Bernardino CountyPublic Library website, http://www.sbcounty.gov/library/home/, accessed October 2010.
7 Kristen Mouton, Branch Manager of Needles Library, *Phone Conversation with ESA*, October 20, 2010.
8 Gary Faulkner, San Bernardino County Fire Department, *Phone conversation with ESA*, October 20, 2010.
9 Cadiz Inc., *Communication with ESA*, October 21, 2011.

is also under consideration for piping water from the SWP. **Figure 4.13-2** shows the location of the inactive gas pipeline that could be converted for water conveyance use.

Local Water Supply

Residents and businesses located in the neighboring communities of Amboy, Chambless, and Essex, among others, obtain water using private wells or have water delivered by truck. Cadiz meets their own domestic and agricultural (irrigation) water supply needs through their existing groundwater wells. Cadiz maintains three domestic wells near the office area and worker housing facilities, and seven agricultural wells. Refer to Figure 3-14 for the location of the seven existing agricultural wells.

The primary groundwater uses in the region are Cadiz agricultural operations, BNSF, the three salt production companies operating on Bristol, Cadiz, and Danby Dry Lakes, and the few residents within the Watersheds. Between 1901 and 1947, an average of 50 acre-feet per year (AFY) was produced from Fenner Valley.[10] Between 1948 and 1962, approximately 4 AFY were pumped from Fenner Valley. The drop in production was attributed to a switch from steam to diesel-powered engines on the railroad. Between 1954 and 1981, groundwater pumping in Fenner Valley remained constant at approximately 7 to 8 AFY.[11]

Average annual groundwater production for the Cadiz agricultural operations during the 5-year period from 1998-2002 was approximately 5,600 AFY.[12] This decreased to approximately 4,340 AFY for the period 2003 - 2007. Average annual groundwater production decreased to approximately 1,969.54 AF during 2008, 1,882.26 AF during 2009, and 1,867.06 in 2010 due to changes in crop cultivation and increased irrigation efficiency. [13]

Sewer

Sewage disposal is handled locally using septic tanks and leach lines, including at the Cadiz agricultural operations. There are no public sewage treatment plants serving the proposed Project area.

Storm Water

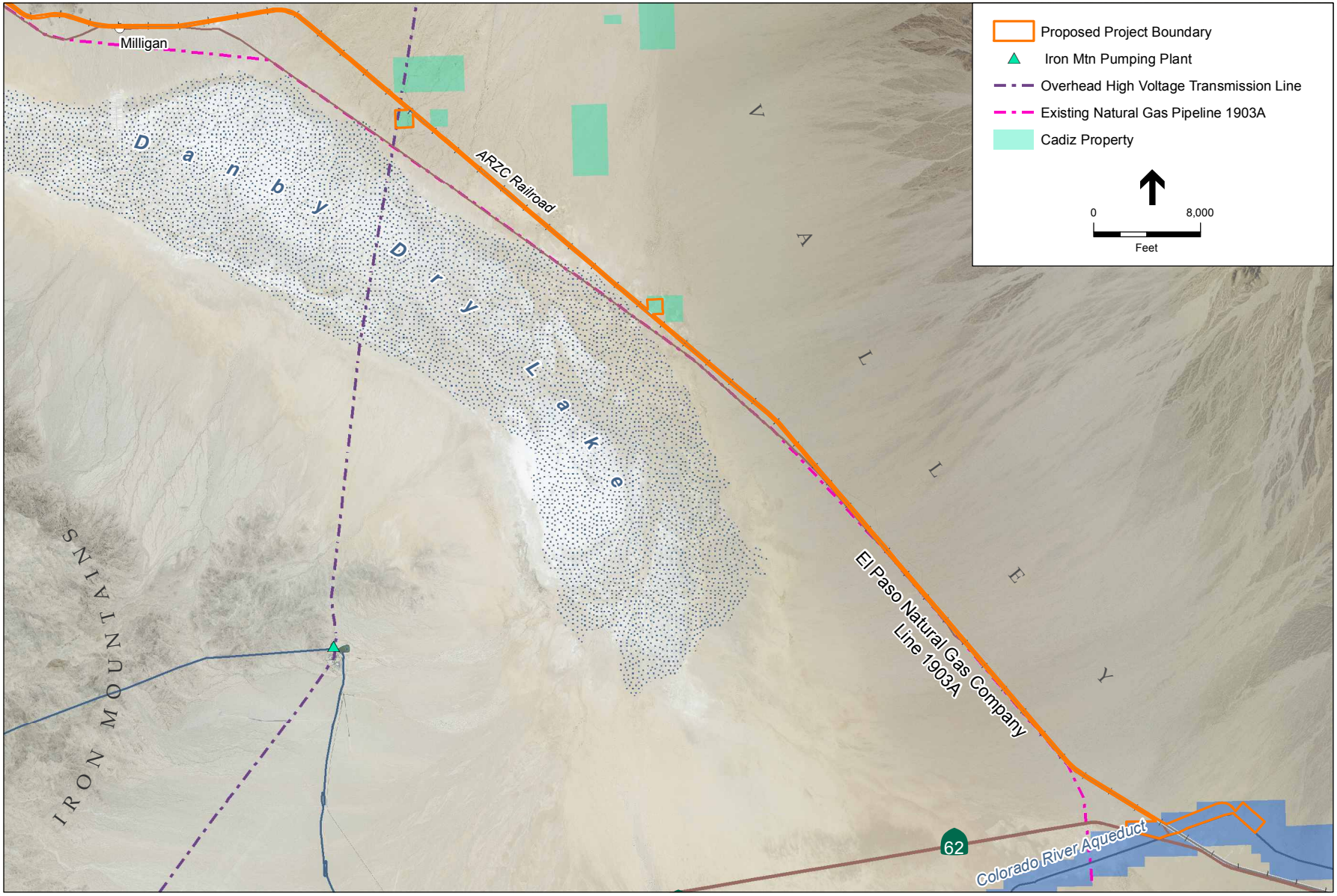
The proposed Project vicinity consists of scattered mountain ranges traversed by low-lying valley areas. Runoff becomes concentrated as it passes through constricted mountain ravines, and as a result, flash floods occur in the valleys periodically. Due to the lack of development, storm drain systems operated by a public agency do not exist in the area. However, individual entities have taken precautions to protect their facilities. ARZC and BNSF have constructed and maintain

10 Metropolitan Water District of Southern California and US Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I* September 2001, pages 5-80.

11 Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*, USGS Water Resources Investigation Report 83-4082, July 1984, Page 11.

12 Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 15, 2009, Page 13.

13 Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 30, 2011, Page 12.

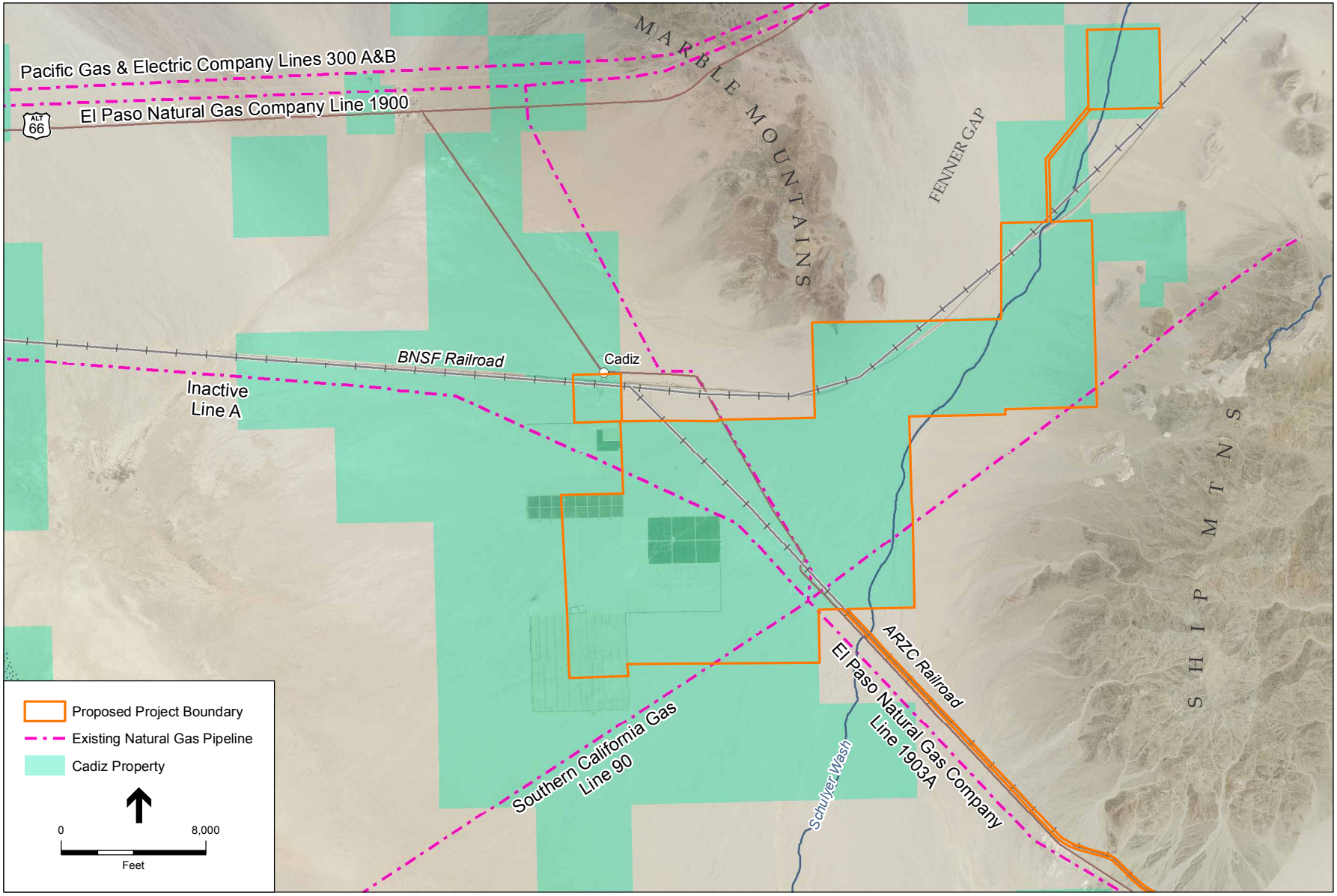


SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 4-13.1

Utilities Corridors Near the Pipeline Alignment



SOURCE: USDA, 2009; Bing Maps, 2011; ESRI, 2010; Tetra Tech, 2008; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery and Storage Project

Figure 4-13.2

Existing Pipelines Near the Project Area

levees along their respective rail line alignments to divert runoff to undercrossings to protect the rail lines and other facilities.[14] The existing Cadiz agricultural facilities do not currently have or require storm water diversion facilities.

Solid Waste Management

Solid waste currently generated by the Cadiz agricultural operations is collected by Sierra Environmental and is transported to the Twentynine Palms Landfill. This landfill has a Permitted Maximum Disposal of 100 tons per day and has a Remaining Estimate Capacity of 10,821,000 cubic yards (98.9 percent). This landfill has sufficient capacity to dispose of additional amounts of solid waste into the foreseeable future.[15] Private residences located in the area individually dispose of their solid waste at the Twentynine Palms Landfill or other permitted facilities.

Electricity

Overhead electrical lines in the area serve the limited domestic and commercial uses along National Trails Highway and the railroad lines. SCE provides electrical service to Amboy, Cadiz and other communities near the proposed Project area through standard overhead power lines on wooden poles located mostly along the railroad track alignment. Figure 4.13-1 shows one high voltage transmission line crossing the ARZC ROW across Danby Dry Lake about 15 miles south of the agricultural operations.

Natural Gas

Six interstate natural gas pipelines and appurtenant facilities are located in the Project vicinity. Figures 4.13-1 and 4.13-2 show the locations of the pipelines. Two parallel pipelines owned and operated by Pacific Gas & Electric Company (PG&E) traverse east to west near National Trails Highway, north of the Project site. A third pipeline, located approximately 200 feet to the north of the National Trails Highway, is operated by the Mojave Pipeline Operating Company, which is a subsidiary of El Paso Natural Gas (EPNG). A fourth pipeline traversing the Cadiz Valley north to south is owned by EPNG. This line runs parallel to the ARZC ROW and the proposed conveyance pipeline alignment and crosses the northern portion of the Cadiz Property where it connects to the Mojave Pipeline.[16] A fifth pipeline originates in Cadiz beneath the proposed wellfield area and parallels the BNSF rail line west to Wheeler Ridge, California. This pipeline is currently inactive. A sixth pipeline owned and operated by Southern California Gas Company (SGC) crosses Cadiz Property in the proposed wellfield area and south of Cadiz agricultural operations (Line 90). The EPNG or the PG&E lines could supply power to the Project facilities.

---

14 Metropolitan Water District of Southern California and US Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I*, September 2001, pages 5-219.

15 California Department of Resources Recycling and Recovery website, *Active Landfills Profile for USMC - 29 Palms Disposal Facility (36-AA-0067)*, http://www.calrecycle.ca.gov/profiles/Facility/Landfill/LFProfile1.asp?COID=36&FACID=36-AA-0067, accessed October 2010.

16 PCR Services Corporation, *Technical Memorandum: Assessment for CEQA Compliance – Cadiz Valley Aquifer Storage Project*, October 2006, page 85.

Communications

AirTouch Cellular and AT&T Wireless provide service in the Cadiz Valley through booster stations, both of which are located in the proposed Project area.[17] AT&T provides services to the communities of Amboy and Cadiz through microwave transmissions and underground local telecommunication lines. Local lines are limited to the communities north of the proposed Project site that are located along National Trails Highway. Each of the railroad companies that traverse the Project area, BNSF and ARZC, have their own telephone lines located adjacent to and within the rights-of-way of their respective rail lines.

4.13.2 Regulatory Framework

State

California Fire Code

San Bernardino County has adopted the 2010 California Fire Code (2010 CFC; Title 24, Part 9), which includes fire codes for construction activities in Chapter 14. Requirements include the following:

- Designation of a person as the fire prevention program superintendent responsible for and with the authority to implement the fire prevention program and spill response plan.
- Requirements for the handling, storage, and disposal of flammable and combustible materials.
- Requirements for minimum 100 foot access to water supplies fire suppression.
- Requirements for portable fire extinguishers when flammable and combustible materials are used.
- Requirements that motorized vehicles are not located such that exhaust is discharged onto combustible materials and that the vehicles are not refueled while in operation.

California Department of Public Health

The California Department of Public Health, Division of Drinking Water and Environmental Management regulates public water systems. Regulatory responsibilities include the enforcement of the federal and State Safe Drinking Water Acts, the regulatory oversight of public water systems, issuance of water treatment permits, and certification of drinking water treatment and distribution operators. State regulations for potable water are contained primarily within Titles 22 and 17, Chapter 5 of the California Code of Regulations.

2005 California Energy Action Plan II and 2008 Update

The California Energy Action Plan II is the State's principal energy planning and policy document (California Energy Commission, 2005 updated 2008). The plan identifies state-wide energy goals, describes a coordinated implementation plan for State energy policies, and identifies specific action areas to ensure that California's energy is adequate, affordable,

[17] Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I,* September 2001, pages 5-224.

technologically advanced, and environmentally sound. In accordance with this plan, the first priority actions to address California's increasing energy demands are energy efficiency and demand response (i.e., reduction of customer energy usage during peak periods in order to address system reliability and support the best use of energy infrastructure). Additional priorities include the use of renewable sources of power and distributed generation (i.e., the use of relatively small power plants near or at centers of high demand). To the extent that these actions are unable to satisfy the increasing energy and capacity needs, clean, and efficient fossil-fired generation is supported.

Protection of Underground Infrastructure

California Government Code Section 4216-4216.9 "Protection of Underground Infrastructure" requires an excavator to contact a regional notification center (e.g., Underground Services Alert or Dig Alert) at least two days prior to excavation of any subsurface installations. Anyone seeking to begin a project that could damage underground infrastructure can call Underground Service Alert, the regional notification center for Southern California. Underground Service Alert will notify the utilities that may have buried lines within 1,000 feet of the Project. Representatives of the utilities are then notified and are required to mark the specific location of their facilities within the work area prior to the start of Project activities in the area.

California Integrated Waste Management Act of 1989

Assembly Bill (AB) 939 was signed into law on September 29, 1989. AB 939 created the California Integrated Waste Management Board (CIWMB) and requires that all cities and counties have Integrated Waste Management Plans. (Public Resources Code, § 42920.) Essentially, it requires all California cities and counties to achieve a 50% diversion rate by 2000. The Act requires every city and county to prepare a Source Reduction and Recycling Element (SRRE) with its Solids Waste Management Plan. (Pub. Resources Code, § 41780.) The purpose of AB 939 is to facilitate reduction, recycling, and re-use of solid waste to the greatest extent possible.

The California Solid Waste Reuse and Recycling Access Act of 1991 (as amended) requires each development project to provide an adequate storage area for collection and removal of recyclable materials.

County and Local

The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project by SMWD would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. The following discussion is provided for context to assess the Project's consistency with the County policies.

San Bernardino County Septic System Requirements

The San Bernardino County Code contains the locally adopted standards and requirements for onsite sewage disposal systems developed to implement the RWQCB's water quality requirements. The County reviews specifications, location, and design of proposed wastewater disposal systems; however, the final approval of septic systems rests with the RWQCB. Permits are obtained through the San Bernardino County Building and Safety Division.

4.13.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to public services and utilities if it would:

- Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:
  - Fire protection;
  - Police protection;
  - Schools;
  - Parks; or
  - Other public facilities.
- Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board;
- Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects;
- Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects;
- Require new or expanded water supply resources or entitlements;
- Result in a determination by the wastewater treatment provider which serves or may serve the Project that it has inadequate capacity to serve the Project's projected demand in addition to the provider's existing commitments;
- Be served by a landfill with insufficient permitted capacity to accommodate the Project's solid waste disposal needs; or
- Not comply with federal, State, and local statutes and regulations related to solid waste.

The following significance threshold criteria are applicable in the evaluation of project impacts related to utility lines and energy use, and therefore have also been included herein:

- Disrupt local or regional utility lines; or
- Require a substantial increase in energy usage.

Methodology

Public service providers were contacted to confirm jurisdiction, capacity, and response times. Regional utilities that traverse the Project area were identified relative to Project components. Cadiz provided information on their agricultural operations relative to this section's significance criteria.

Groundwater Conservation and Recovery Component

Public Services

Significance Threshold

Would the proposed Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services listed below?

- Fire protection;
- Police protection;
- Schools;
- Parks; or
- Other public facilities.

Impact Analysis

Fire Protection, Police and Emergency Services

The Groundwater Conservation and Recovery Component would construct new water conveyance infrastructure that would not significantly increase demand for fire protection, police, or medical services once constructed. During construction, approximately 240workers would be located in the Project area (see **Table 3-5**) intermittently on-site at any given time, for a period of up to two years. As discussed above, Cadiz maintains fire suppression equipment, trained personnel, and an emergency evacuation plan for its agricultural operations that include the existing construction worker housing facilities. The existing Cadiz wells provide water for the fire suppression systems. The construction contractor would prepare and implement a fire prevention program and spill response plan consistent with the requirements of the 2010 CFC requirements for temporary fire control and emergency response.

Emergency medical service demand could increase during the summer months, due to the potential for workers to experience heat exhaustion and/or sunstroke during periods of extreme heat. In addition, accidents can occur during construction, necessitating emergency response and/or fire protection service calls to the Project site. The construction contractor would provide safety training to all construction workers and would have sufficient on-site medical supplies to address heat-related illness and minor injuries. The Cadiz agricultural operations have first aid

materials onsite and the site manager has been trained as a first responder. In addition, the existing Wonder Valley Fire Station has confirmed that it has the capacity to meet the minor increase in demand for fire and emergency services that could occur during construction of the Groundwater Conservation and Recovery Component without compromising existing level of service to other communities in their service area.[18] The existing Cadiz airstrip can be used for emergency airlift to regional hospitals.

With respect to police services, according to Lieutenant Rich Boswell of the Morongo Basin Police Station, the Morongo Basin Police Station has the capacity to meet the minor increase in law enforcement service calls that could result during construction of the Groundwater Conservation and Recovery Component. The minor increase in emergency medical, police, and fire protection service calls during construction and operation would be short-term (1 to 2 years) and would not require the provision of new or the expansion of existing governmental facilities in order to maintain acceptable services to the Project area. This impact is therefore considered less than significant, and no mitigation measures would be required.

Schools and Libraries

The proposed Project would not construct or require the construction of permanent residential development, as operation of the proposed Project would not require a substantial number of new, full-time employees. Because the Project would not generate a long-term need for housing or school services, the Project would not result in the need to expand existing or construct new school or library facilities or affect school related services, and no mitigation measures would be required.

Hospitals

Similarly, because the proposed Project does not include residential development and would not bring a substantial number of new, full-time employees to the Project area, it would not result in substantial adverse physical impacts associated with the expansion of hospitals or other public facilities and no mitigation measures would be required.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements

Significance Threshold

Would the proposed Project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?

[18] Star Javier, District Coordinator, San Bernardino County Fire Department, *Phone conversation with ESA,* October 20, 2010.

Would the proposed Project require or result in the construction of new water or wastewater treatment facilities or the expansion of existing facilities, the construction of which could cause significant environmental effects?

Impact Analysis

Construction activities would involve approximately 240 workers intermittently on-site at any given time, for a period of up to two years. Currently, 40 to 100 workers are employed seasonally to harvest crops at the Cadiz agriculture operations. Wastewater service for the current seasonal work force is supplied through septic systems at the Cadiz Property and by portable sanitary units to serve a seasonal work force. Implementation of the Groundwater Conservation and Recovery Component would require increased use of portable sanitary units and septic disposal services. No new wastewater treatment systems including new septic systems would be constructed. The Groundwater Conservation and Recovery Component would not require that an existing publicly owned wastewater utility confirm that treatment capacity is available since no such facility exists in the area and since the Project would not permanently increase wastewater generation in the Project area. Therefore, the Groundwater Conservation and Recovery Component would have a less than significant impact on wastewater treatment.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Storm Water Drainage Facilities

Significance Threshold

Would the proposed Project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

Impact Analysis

The Groundwater Conservation and Recovery Component would not require the construction of new storm water drainage facilities or the expansion of existing facilities. Although the Groundwater Conservation and Recovery Component would create minor new impervious surfaces associated with the proposed wellfield, power distribution facilities, CRA tie-in, and pump station, the increase would not be substantially greater than existing conditions and would not substantially increase the volume of surface-water runoff. Currently, most storm water that falls in the Project area flows into natural drainage features and desert washes. Some precipitation infiltrates through the soils. The natural drainage systems in the area experience rare flood events that convey large amounts of runoff in short periods of time. Any additional runoff created by the minor amount of new impervious or hardened surfaces would be accommodated in these large natural wash systems.

Section 4.9, Hydrology and Water Quality discusses the BMPs that would be required as a part of the construction activities relative to the wellfield installation. This includes Mitigation Measures **HYDRO- 1** and **HYDRO-6**, copied below, that would reduce the construction impacts to less than significant with mitigation. The water conveyance pipeline would cross numerous drainages along the railroad easement. However, since the pipeline would be constructed 15 feet underground and more than 50 feet from the centerline of the railroad track, the pipeline would have no impact on existing surface water drainage. In addition, Mitigation Measure **UTIL-1** would require that the construction contractor restore the drainages to their original contours and flow capacity using the existing drainage diversion berms constructed by the railroads to convey surface runoff under the tressels built for this purpose. Impacts from the Groundwater Conservation and Recovery Component would therefore be reduced to less than significant with mitigation.

Mitigation Measures

> **UTIL-1**: Storm water drainages traversed by the water conveyance pipeline alignment shall be returned to pre-construction conditions. Existing structures such as storm flow diversion berms, railroad facilities including bridge supports, access roads, and utility poles shall be returned to pre-construction conditions and protected from scouring by storm water flows, subject to the approval of the railroad owner.

Implement Mitigation Measures **HYDRO-1** and **HYDRO-6**.

Significance Conclusion

Less than significant with mitigation.

Expansion of New Water Supply Facilities

Significance Threshold

Would the proposed Project require new or expanded water supply resources or entitlements?

Would the proposed Project result in a determination by the wastewater treatment provider which serves or may serve the project that it has inadequate capacity to serve the Project's projected demand in addition to the provider's existing commitments?

Impact Analysis

The Groundwater Conservation and Recovery Component of the proposed Project would result in the construction of a wellfield, power distribution facilities, and a water conveyance pipeline to the CRA, the effects of which are discussed throughout this EIR. The Project would not increase local water demands, nor would the Project construct a distribution system locally or increase local demands that would require a local water distribution system. Potential impacts to groundwater supplies that serve the local area are addressed in Section 4.9, Hydrology and Water Quality. Impacts to local water service would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Solid Waste

Significance Threshold

Would the proposed Project be served by a landfill with insufficient permitted capacity to accommodate the Project's solid waste disposal needs?

Would the proposed Project comply with federal, State, and local statutes and regulations related to solid waste?

Impact Analysis

The Project would comply with all federal, State, and local statutes and regulations related to solid waste. Solid waste would be disposed of at the Twentynine Palms Disposal Facility located at Landfill Road in the City of Twentynine Palms. As of March 2007, the landfill had a remaining capacity of 10,821,000 cubic yards, and an estimated closure date of 2076. Currently, the landfill is permitted to receive a maximum of 100 tons per day.[19]

Construction of the Groundwater Conservation and Recovery Component of the proposed Project would generate small quantities of waste associated with construction activities, worker meals, office record keeping, and related activities. Construction activities would not require the removal of soil from the Project area. Any excavated soils would be spread on site within the construction footprint. Waste material would be collected and periodically hauled off the site to be disposed of at the Twentynine Palms Disposal Facility.

Project operations would generate negligible quantities of solid waste associated with facilities operation and maintenance. Since sufficient capacity is available in the Twentynine Palms Landfill, the Groundwater Conservation and Recovery Component would result in a less than significant impact on solid waste disposal facility capacity.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

---

[19] California Department of Resources Recycling and Recovery website, *Active Landfills Profile for USMC - 29 Palms Disposal Facility (36-AA-0067)*, http://www.calrecycle.ca.gov/profiles/Facility/Landfill/LFProfile1.asp?COID=36&FACID=36-AA-0067, accessed October 2010.

Disruption of Local and Regional Utilities

Significance Threshold

Would the proposed Project disrupt local or regional utility lines?

Impact Analysis

As shown on Figures 4.13-1 and 4.13-2, several high-pressure natural gas pipelines traverse the Mojave Desert in the Project vicinity. Two El Paso Natural Gas natural gas pipelines and a Southern California Gas Company natural gas pipeline cross Cadiz Property within the wellfield area. The wellfield manifold system and the conveyance pipeline would traverse these pipelines. If construction near these pipelines damaged one of the natural gas pipelines, catastrophic failure or rupture of the natural gas pipelines could cause explosions, create severe hazards for workers, and disrupt delivery of natural gas for long periods.

To avoid this potential impact, construction near these facilities would be conducted under the supervision of the pipeline owners, in compliance with all applicable worker safety laws. For pipeline crossings, the water pipeline would be placed under the gas pipeline at sufficient depth to avoid damaging the gas pipeline during construction and to avoid any connection between the two pipelines once buried. Mitigation Measure **UTIL-2** would ensure that under-crossings are designed and implemented safely, in accordance with industry standards and owner requirements.

If natural gas from one of the high-pressure pipelines is used to power the wellfield, a connection facility would be constructed in the pipeline on Cadiz Property. The pipeline owner would stipulate connection requirements. The connection would be constructed under the direction of the pipeline owner in compliance with worker safety regulations. The disruption of service created by this construction activity would be coordinated with the pipeline owner to minimize impacts to service providers.

The implementation of Mitigation Measure **UTIL-2** would reduce the potential impact to less than significant.

Mitigation Measures

> **UTIL-2**: The owner of the natural gas pipelines traversing the Cadiz Property shall be notified in advance of construction activities near the pipelines sufficient to allow for supervision and approval by the owner of construction methods and pipeline under-crossing designs. The under-crossing designs shall require approval from the pipeline owner.

Significance Conclusion

Less than significant with mitigation.

Energy Usage

Significance Threshold

Would the proposed Project require a substantial increase in energy usage?

Impact Analysis

The Groundwater Conservation and Recovery Component would install new groundwater wells requiring approximately 50.7 million kilowatt hours (kWh) per year. The wells would be powered by natural gas motors. The Project would connect to the existing high-pressure gas lines traversing the site. If a forebay and pump station is required, an additional 22 million kWh/year would be required.

The Project would convey water to the CRA for distribution to the Southern California public water supply. According to studies published by the CEC and Metropolitan, the CRA utilizes approximately 6,138 kWh/million gallon (MG) at full capacity.[20] The Groundwater Conservation and Recovery Component would require 3,112 kWh/MG to convey water to the CRA. Once in the CRA the Project would not increase the CRA's overall energy usage.

Some of the Project participants would use the water to replace supplies that otherwise would be conveyed by the SWP from northern California. The net energy use for water delivery to these Project participants would decrease slightly since energy usage for the SWP is greater than that of the proposed Project. The CEC estimates that delivery of water via the SWP West Branch to northern Los Angeles County requires approximately 7,672 kWh/MG. The proposed Project would require the additional consumption of approximately 3,112 kWh/MG, which is less than half the energy required to convey the same amount of water through the SWP.[21] The Project would not result in wasteful use of electricity or substantially increase energy use compared to existing energy demands for importing water to Southern California. As a result, the impact would be less than significant.

To support the California Energy Action Plan II to reduce the State's overall energy usage, the Project would incorporate energy efficient pumps, lighting, and other equipment to minimize energy impacts.[22] Mitigation Measure **UTIL-3** would require the installation of energy efficient equipment consistent with County goals of reducing GHG emissions.

Refer to Section 4.4-3, Air Quality and 4.4-7, Greenhouse Gas Emissions for further discussion dealing with energy usage.

Mitigation Measures

> **UTIL-3:** Pumps installed as part of the Project shall be rated for high efficiency to minimize energy consumption.

Significance Conclusion

Less than significant with mitigation.

---

[20] California Energy Commission, *California's Water – Energy Relationship*, November 2005, Figure 2-2 and pg 23; Metropolitan Water District of Southern California, *2006 Revised Power Integrated Resource Plan for Metropolitans's Colorado Rive Aqueduct Power Operations*, October 2006, table 4.

[21] California Energy Commission, *California's Water – Energy Relationship*, November 2005, Figure 2-2 and page 23.

[22] California Energy Commission, *California Energy Action Plan*, 2005.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Public Services

Significance Threshold

Would the proposed Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services listed below?

- Fire protection;
- Police protection;
- Schools;
- Parks; or
- Other public facilities.

Impact Analysis

Fire Protection, Police and Emergency Services

The Imported Water Storage Component would construct new recharge basins, expand the wellfields on the existing Project site. Therefore, it would not significantly increase demand for fire protection, police, or medical services once constructed. During construction, additional construction workers would be located in the Project area, resulting in a temporary increase in demand for fire, police, and medical services. However, the number of construction workers would be less than needed for construction of the Groundwater Conservation and Recovery Component. Once constructed, operation of the facilities would not increase the need for these services. As discussed above, Cadiz maintains fire suppression equipment, trained personnel, and an emergency evacuation plan for its agricultural operations that include the existing construction worker housing facilities. The existing Cadiz wells provide water for the fire suppression systems. The construction contractor would prepare and implement a fire prevention program and spill response plan consistent with the requirements of the 2010 CFC requirements for temporary fire control and emergency response. Impacts to these local service providers would be less than significant.

Schools and Other Public Facilities

The proposed Project does not include permanent residential development, and operation of the Imported Water Storage Component would not require a substantial number of new, full-time employees. Because the proposed Project would not generate the need for local housing or school services, the Imported Water Storage Component would not result in the need to expand existing or construct new school facilities or affect school related services. Nor would the Imported Water Storage Component result in the expansion of hospitals, parks, or other public facilities.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements

Significance Threshold

Would the proposed Project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?

Would the proposed Project require or result in the construction of new water or wastewater treatment facilities or the expansion of existing facilities, the construction of which could cause significant environmental effects?

Impact Analysis

The Imported Water Storage Component would not conflict with wastewater treatment requirements of the Colorado River Basin RWQCB because it would not involve permanent expansion of wastewater treatment facilities. Temporary increase in wastewater generation from construction workers would be accommodated using the existing septic and mobile sanitary systems currently employed for seasonal farm workers, as discussed above.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Storm Water Drainage Facilities

Significance Threshold

Would the proposed Project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

Impact Analysis

The Imported Water Storage Component of the Project proposes to expand the wellfield and construct spreading basins that would create new impervious or hardened surfaces associated with the expansion of the wellfield. Currently, storm water in the Project area either infiltrates directly or flows into natural drainage features and desert washes. Surface water draining from the Fenner Watershed flows into the Schuyler Wash adjacent to the proposed spreading basins. This wash experiences intermittent flows during storm events. When large storm events occasionally occur

in the desert, flash flood events can occur resulting in substantial volumes of water flowing through the valley in a short period of time. Currently, the railroads are equipped to accommodate these large flow events with armored over-crossings and storm flow diversion berms. The construction of the spreading basins could alter the existing drainage such that surface water flow is concentrated resulting in increased erosion.

Section 4.9, Hydrology and Water Quality discusses the BMPs that would be required as a part of the construction activities relative to the wellfield installation. This includes Mitigation Measures **HYDRO- 1** and **HYDRO-6**, copied above, that would reduce the construction impacts to less than significant with mitigation. In addition, Mitigation Measure **UTIL-4** would require that the construction contractor include constructing drainage features for the spreading basins that convey surface water flow around the basins, minimize the concentration of flow, and reduce the energy of the flows. Impacts from the Imported Water Storage Component would therefore be reduced to less than significant with mitigation.

Impacts from the Imported Water Storage Component of the proposed Project would be less than significant with implementation of mitigation.

Mitigation Measures

> **UTIL-4: Imported Water Storage Component.** Spreading basins shall be designed to avoid or minimize encroachment into major surface drainages. The Project participants shall conduct a drainage study to evaluate the potential impact of the spreading basins to surface drainages and to develop design parameters to minimize storm flow detention, velocity, and scouring downstream from the new basins. These recommendations shall be included in final designs to ensure that downstream improvements, including railroad lines and the agricultural operations, are not adversely affected.

Implement Mitigation Measures **HYDRO-1** and **HYDRO-6**.

Significance Conclusion

Less than significant with mitigation.

Expansion of New Water Supply Facilities

Significance Threshold

Would the proposed Project require new or expanded water supply resources or entitlements?

Would the proposed Project result in a determination by the wastewater treatment provider which serves or may serve the project that it has inadequate capacity to serve the Project's projected demand in addition to the provider's existing commitments?

Impact Analysis

The Imported Water Storage Component of the Project proposes to expand the wellfield and construct spreading basins to serve the water supply infrastructure serving Project participants. No new local water demands would be generated by the Project. Potential impacts to groundwater

supplies serving local demands are discussed in Section 4.9, Hydrology and Water Quality of this EIR.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Solid Waste

Significance Threshold

Would the proposed Project be served by a landfill with insufficient permitted capacity to accommodate the Project's solid waste disposal needs?

Would the proposed Project comply with federal, State, and local statutes and regulations related to solid waste?

Impact Analysis

The Imported Water Storage Component of the Project proposes to expand the wellfield and construct spreading basins which would generate small quantities of construction waste associated with construction activities, worker meals, office record keeping, etc. This waste material would be collected and periodically hauled off the site to be disposed of at the Twentynine Palms Disposal Facility. Proposed Project operations would generate only negligible quantities of solid waste associated with permanent employee activities such as maintenance. Since sufficient capacity is available in the Twentynine Palms Landfill for these small quantities, the proposed Project would not adversely result in a significant impact regarding solid waste disposal facility capacities. Therefore, impacts from the Imported Water Storage Component of the proposed Project would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Disruption of Local and Regional Utilities

Significance Threshold

Would the proposed Project disrupt local or regional utility lines?

Impact Analysis

The Imported Water Storage Component of the Project proposes to expand the wellfield and construct spreading basins. As shown on Figures 4.13-1 and 4.13-2, several high-pressure natural

gas pipelines traverse the Mojave Desert in the Project vicinity. Two El Paso Natural Gas Company natural gas pipelines and a Southern California Gas Company natural gas pipeline cross Cadiz Property within the wellfield area. The wellfield manifold system and the conveyance pipeline would traverse these pipelines. The expanded wellfield may require additional crossings of the underground utilities. Mitigation Measure **UTIL-2** would ensure that existing utilities would not be adversely affected.

Mitigation Measures

Implement Mitigation Measure **UTIL-2**.

Significance Conclusion

Less than significant with mitigation.

Energy Usage

Significance Threshold

Would the proposed Project require a substantial increase in energy usage?

Impact Analysis

The Imported Water Storage Component of the Project proposes to expand the wellfield and construct spreading basins which would increase energy usage by increasing the flow of water in the pipeline in both directions. Conveying water from the CRA to the wellfield would require approximately twice as much energy as the Groundwater Conservation and Recovery Component. This additional energy would add to the overall energy requirements of the Imported Water Storage Component.

The Imported Water Storage Component would add 10-15 wells in order to return up to 105,000 150,000 AFY of previously stored water through the pipeline to the CRA and/or SWP. The additional wells would be powered by natural gas supplied from the natural gas pipeline traversing the Cadiz property. This would double the energy consumption to approximately 100 million kWh/year, but would not change the amount of energy needed per million gallons conveyed (3,112 kWh/MG). As discussed for the Groundwater Conservation and Recovery Component, the amount of energy per gallon required to convey water to the CRA is less than half of the consumption of the SWP systems to convey the same amount of water. The additional energy would not be wasteful since much of the water would be replacing supplies that otherwise would be imported longer distances requiring greater energy demand. As a result, the additional energy requirements would not be significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Mitigation Measure Summary Table

Table 4.13-1 presents the impacts and mitigation summary for Public Services and Utilities.

TABLE 4.13-1
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	Less than significant
Storm Water Drainage Facilities	**HYDRO-1, HYDRO-6**, and **UTIL-1**	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	**UTIL-2**	Less than significant with mitigation
Energy Usage	**UTIL-3**	Less than significant with mitigation
Imported Water Storage Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	No impact
Storm Water Drainage Facilities	**HYDRO-1, HYDRO-6**, and **UTIL-4**	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	**UTIL-2**	Less than significant with mitigation
Energy Usage	None required	Less than significant

4.14 Recreation

The purpose of this Section is to identify existing recreation opportunities within the Project area, analyze potential impacts to recreation associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.14.1 Environmental Setting

Regional Setting

The Project is located near Cadiz, California, an unincorporated community in the southeast Desert Region of San Bernardino County. The Desert Region includes a significant portion of the Mojave Desert and contains about 93 percent (18,735 square miles) of the land within San Bernardino County. The Desert Region is an assemblage of mountain ranges interspersed with long, broad valleys that often contain dry lakes.[1] The County has established numerous regional and community parks in the Desert Region, supporting recreational activities including hiking, camping, picnicking, and nature trails. **Table 4.14-1** lists the regional and community parks in the Desert Region.

TABLE 4.14-1
COUNTY REGIONAL PARKS AND COMMUNITY PARKS IN THE DESERT REGION

Parks		Acreage
County Regional Parks		
Big Morongo Regional Park		183
Calico Ghost Town Regional Park		480
Mojave Narrows Regional Park		1,100
Mojave River Forks Regional Park		840
Mojave River Forks Regional Park		2,393
	Subtotal:	4,996
Community Parks		
Big River Park and Recreation Site		14
Covington Park		3
Midway Park		16
Pioneer Park		12
Sugarloaf Park		6
Chet Hoffman		4
	Subtotal:	55
Total Regional and Community Park Acres		**5,051**

SOURCE: County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report*, February2007, page IV-146.

[1] County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, pages VI-1, VI-3, VI-5.

Local Setting

Public land in the Desert Region is managed by the BLM, the U.S. Forest Service (USFS), the National Park Service (NPS), California State Department of Parks and Recreation, County Regional Parks Department, and local city Parks Departments.[2] The majority of the surrounding land in the Project vicinity is managed by BLM.

BLM Multiple-Use Classes

The BLM has identified 4 Multiple-Use Classes (for BLM-administered lands only) in the Desert Region of which each identifies acceptable recreation uses. **Table 4.14-2** identifies the allowable recreational activities for each Multiple-Use Class. Because the Project is not on BLM land, these Multiple-Use Classes do not apply to the Project site. The lands immediately adjacent to the Project site are classified as Multiple-Use Class M, *Moderate Use*. Additionally, there are Class C (Wilderness), Class L (Limited), and Class I (Intensive) lands located near, but not on, the proposed Project. Each class of land is described in more detail below.

Class C (Controlled Use/Wilderness Areas)

The Project site is in the vicinity of several Class C wilderness areas managed by BLM. **Figure 4.14-1** shows the locations of the 6 wilderness areas and BLM Multiple-Use Classes in the Project vicinity. BLM does not have records or data making public the number of people that use the wilderness areas for recreational purposes or the times and locations of when and where people use the wilderness areas.[3]

The Trilobite Wilderness Area is located approximately 4 miles north of the Project site. The Trilobite Wilderness Area covers approximately 31,160 acres, including a large segment of the Marble Mountains and alluvial fans. Much of this Wilderness Area is shielded from the Project site by the southern part of the Marble Mountains, which lie outside the boundary of this Wilderness Area.

The northeastern boundary of the Cadiz Dunes Wilderness Area is located approximately 250 feet from a 5-mile segment of the proposed pipeline within the ARZC ROW (see Figure 4.14-1). The Cadiz Dunes Wilderness Area consists of approximately 39,740 acres of sand dunes formed by winds from the Cadiz Dry Lake, which is located west of the Cadiz Dunes Wilderness Area.

The Sheephole Valley Wilderness Area is located approximately 7 miles west of the Project site and covers approximately 174,800 acres. Within this wilderness area are the Calumet Mountains, the Sheephole Range, and the Sheephole Valley that separates them.

2 County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, page VI-5.
3 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I*, September 2001, page 5-272.

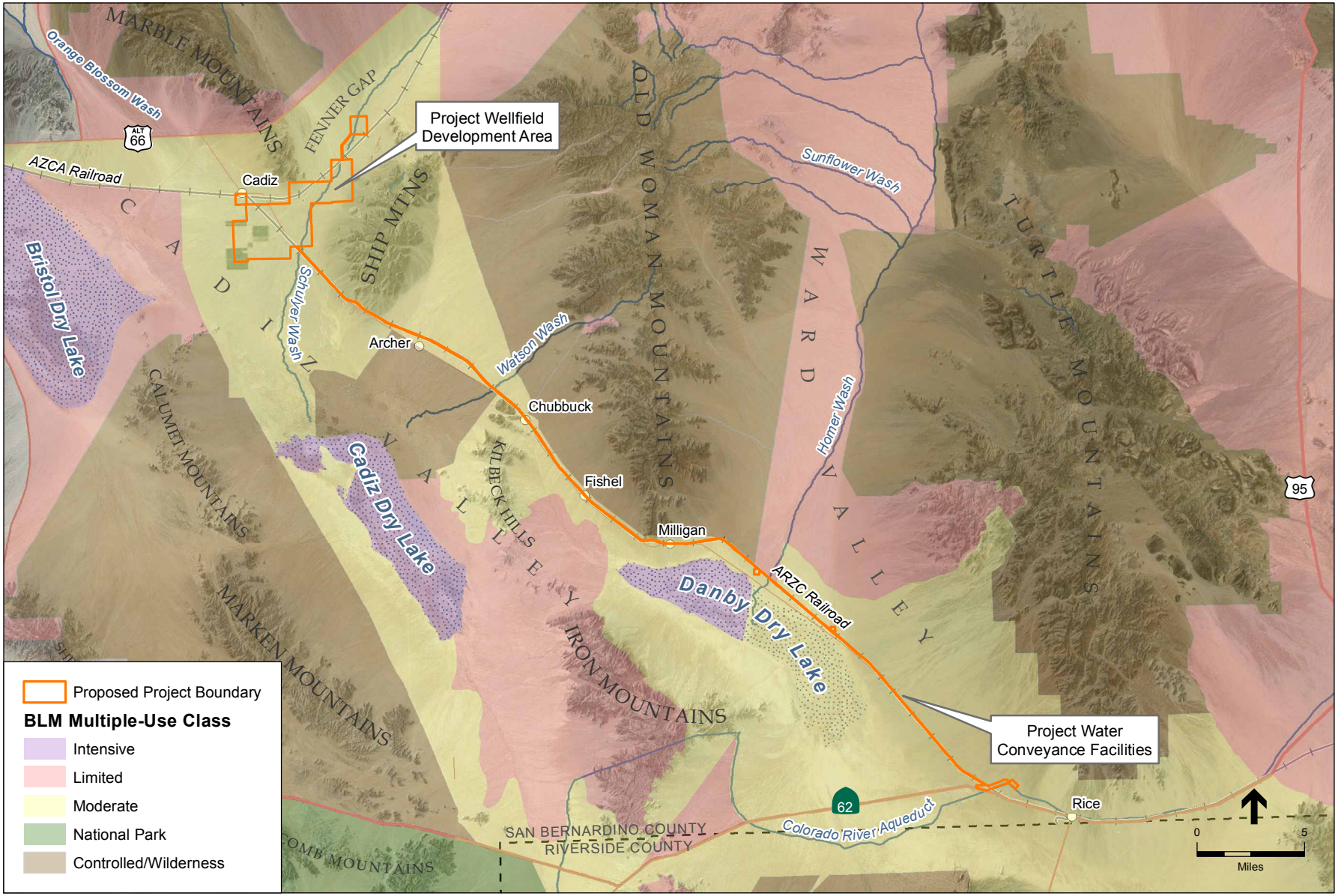
TABLE 4.14-2
CDCA GUIDELINES FOR RECREATIONAL ACTIVITIES ALLOWED IN EACH OF THE MULTIPLE-USE CLASSES (BLM-ADMINISTERED LANDS ONLY)

Multiple-Use Class C *Controlled Use (Wilderness Mgt.)*	**Multiple-Use Class L** *Limited Use*	**Multiple-Use Class M** *Moderate Use*	**Multiple-Use Class I** *Intensive Use*
This class is suitable for non-mechanical types of recreational experiences which generally involve low to very low user densities. Recreational opportunities provided include, but are not limited to, the following characteristic activities: • backpacking • primitive, unimproved site camping • hiking • horseback riding • rockhounding • nature study and observation • photography and painting • rockclimbing • spelunking • hunting	This class is suitable for recreation which generally involves low to moderate user densities. Recreation opportunities include those permitted in Class C plus: • landsailing on dry lakes • noncompetitive vehicle touring and events only on "approved" routes of travel All organized vehicle events, competitive or not, require a permit specifying the conditions of use; these conditions will include, but are not limited to: • approved routes • no pitting, start, finish, or spectator areas	This class is suitable for a wide range of recreation activities which may involve moderate to high user densities. Recreational opportunities include those permitted in Class L. Competitive motorized-vehicle events are limited to "existing" routes of travel and must be approved by the authorized officer. Pit, start, and finish areas must be designated by the authorized officer. All competitive events having 50 or more vehicles require permits.	This class is suitable for recreation activities which generally involve high user densities. A wide array of recreational opportunities will be found in this class. Offroad vehicle play will be allowed where approved and in open areas. Uses permitted are the same as Class M. In addition, motorized-vehicle play is allowed in areas designated "open." All aspects of competitive events will be permitted except where specific limitations are stipulated by the authorized officer.
Permanent or temporary facilities for resource protection and public health and safety may be allowed at the discretion of the authorized officer or in accordance with approved Wilderness Management Plans.	Permanent or temporary facilities for resource protection and public health and safety are allowed.		
Trails are open for non-vehicular use and new trails for non-motorized access may be allowed.			

SOURCE: Bureau of Land Management, *Proposed Northern & Eastern Colorado Desert Coordinated Management Plan and Final Environmental Impact Report*, July 2002, page 3-55.

The 146,020-acre Old Woman Mountains Wilderness Area is located approximately 6 miles east of the Project site. The southernmost boundary of the wilderness area is approximately 180 feet from a portion of the ARZC ROW (see Figure 4.14-1). Topography within this Wilderness Area ranges from 800 feet to 5,300 feet at the summit of Old Woman Peak.

The Turtle Mountains Wilderness Area is located approximately 3 miles to the east of the southern portion of the ARZC ROW and covers 182,626 acres of land.



SOURCE: Bing Maps, 2010; ESRI, 2010; Cadiz Inc., 2010; BLM-NECO Plan, 2002; and ESA, 2010

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.14-1

BLM Multiple-Use Classes and Wilderness Areas

The Stepladder Mountains Wilderness Area is located approximately 15 miles north of the Project site and covers approximately 84,370 acres. This Wilderness Area is located north of the Turtle Mountains Wilderness Area and east of the Sunflower Wash.

Class L (Limited Use)

Class L lands in the Project vicinity include areas of the Cadiz Valley and Ward Valley. Areas surrounding the Trilobite Wilderness Area, approximately 3 miles to the north, are Class L, as are areas bordering the Bristol Dry Lake (approximately 7 miles to the west), Cadiz Dry Lake (approximately 9 miles south), and areas to the north and east of the Old Woman Mountains (approximately 12 miles to the east).

Class M (Moderate Use)

The proposed Project wellfield and pipeline are entirely surrounded by Class M lands.

Class I (Intensive Use)

Class I lands in the Project vicinity include the Bristol Dry Lake (located approximately 7 miles to the west of the Project site), the Cadiz Dry Lake (located approximately 9 miles south), and the Danby Dry Lake (located approximately 20 miles southeast of the proposed wellfield area and 0.5 mile from the proposed water conveyance facilities that would be constructed within the ARZC ROW).

Competitive Recreation Route

Almost 30 years ago, the Johnson Valley to Parker, Arizona Corridor (JV-Parker) off-road motorcycle race route traversed a portion of the proposed water conveyance facilities in the southern portion of the Project site, near the CRA. Last held in 1983, the JV-Parker historically had been sponsored by the American Motorcyclist Association. Before further races can be held, a new BLM permit would need to be obtained, which would require the preparation of a NEPA Environmental Assessment.[4]

Popular Rockhounding Areas

Amateur geology, also known as rockhounding, is the recreational study and hobby of collecting rocks and mineral specimens from their natural environment. Rockhounding relies heavily on motorized-vehicle access, given the remoteness of many of the collection sites and the nature of the activity. Rockhounding areas near the Project site include parts of BLM's Trilobite Wilderness Area and Old Woman Mountains Wilderness Area.[5] This site is located north of SR 66 approximately 10 miles from the Project area. Construction and operation of the Project would not impede existing motorized-vehicle access to rockhounding collection areas.

---

4 Bureau of Land Management, *Proposed Northern & Eastern Colorado Desert Coordinated Management Plan,* September 2002, page 3-59.

5 California Desert.gov, *Places to Go Rockhounding in the Californa Desert, http://www.californiadesert.gov/actinfo.php?act=rh, accessed October 2011.*

Camping & Off Highway Vehicles

There are no designated camping or open areas designated for off-highway vehicles (OHV) in the vicinity of the Project site.

4.13.2 Regulatory Framework

Federal

U.S. Bureau of Land Management

BLM, a federal agency within the DOI, is responsible for the management of public lands and resources on behalf of the American people. The BLM administers approximately 15 percent (15,007,475 acres) of California's public lands, 40 percent (6,076,378 acres) of which are located in San Bernardino County. Comparatively, the County consists of approximately 20,105 square miles, or 12,870,080 acres, such that approximately 47 percent of lands within the County's landholdings are managed by BLM.[6] BLM special management areas subject to specific BLM Plans within the County include the NECO Plan; CDCA Plan; and the West Mojave Habitat Conservation Plan and California Desert Amendment. The CDCA and NECO Plan cover BLM lands surrounding the Project area.

California Desert Conservation Area Plan (CDCA) and Northern and Eastern Colorado Desert (NECO) Plan

BLM lands are managed for multiple uses identified in the CDCA and NECO Plan, including natural resources, recreational, scenic, and open space opportunities. Table 4.14-2, above, describes the allowable recreational uses within each of the 4 BLM Multiple-Use Classes. Wilderness and recreation management is described in greater detail below.

Wilderness Management

The Federal Land Policy and Management Act of 1976 (FLPMA) requires BLM to inventory and evaluate public lands for their wilderness potential. The BLM identified 137 areas covering 5.7 million acres which were determined to have wilderness characteristics; these areas were designated Wilderness Study Areas in May 1978. The CDCA and NECO Plan further refined the boundaries of these Wilderness Areas. **Table 4.14-3** lists the Wilderness Areas closest to the Project area.

6 County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, page VI-3.

TABLE 4.14-3
BLM WILDERNESS AREAS LOCATED IN THE PROJECT VICINITY

Wilderness	Acres[a]
Cadiz Dunes	21,298
Old Woman Mountains	183,524
Sheephole Valley	195,244[b]
Stepladder Mountains	84,370
Trilobite	39,693
Turtle Mountains	182,676

[a] Acres include federal, state, and private lands within wilderness area boundaries.
[b] Acres reported constitute the entire Sheephole Valley Wilderness, a portion of which occurs outside the NECO Planning Area.

SOURCE: Bureau of Land Management, *Proposed Northern & Eastern Colorado Desert Coordinated Management Plan and Final Environmental Impact Report*, July 2002.

The Project is adjacent to but not within any BLM Wilderness Management Areas. The FLPMA does not intend for protective perimeters of buffer zones to be imposed around any wilderness area. The fact that non-wilderness activities or uses can be seen or heard from areas within a wilderness area shall not, of itself, preclude such activities or uses up to the boundary of the wilderness area.[7]

Recreation Management

The Recreation Management Plan Element allows for the management of various recreational activities, which are divided into High Importance (trail hiking, camping, nature study), Moderate Importance (horseback riding, picnicking, driving), and Low Importance (mountain biking, hunting, motorcycle/dirt bike/ATV use) based on a 1997 survey listed in the NECO Plan. Recreational activities such as hiking, camping, rock climbing and wind sailing are allowed near the proposed Project. The Project is not within BLM managed lands.

National Park Service

NPS, a federal agency within DOI, promotes and regulates the use of national parks to conserve scenery and natural historic objects for future generations.[8] NPS manages 3 national parks within San Bernardino County including the Mojave National Preserve (approximately 30 miles to the north of the Project site), Death Valley National Park (approximately 100 miles to the northwest of the Project site), and Joshua Tree National Park (approximately 30 miles to the south of the Project site). The proposed Project is not located in a national park.

The Mojave National Preserve established in 1994 comprises 1.6 million acres north of I-40. The Preserve was established to protect the natural environment and cultural legacy of the eastern

7 Bureau of Land Management, *Wilderness Act of 1974*, http://www.blm.gov/nv/st/en/fo/ely_field_office/blm_programs/wilderness/wilderness_act_of.html, accessed January 2011.
8 County of San Bernardino, *County of San Bernardino 2007 General Plan*, April 2007, page VI-5.

California desert region. Of the 1.6 million acres, 700,000 are designated Wilderness Areas and approximately half of the Preserve is critical habitat for desert tortoise. The Preserve is managed to facilitate recreational uses that are compatible with ecological preservation including camping and hiking. A museum and interpretive center has been established at the old railroad depot at Kelso. The Preserve plans to receive up to 200,000 visitors per year by the year 2016.[9] Unlike in National Parks, some hunting is allowed in National Preserves, including the Mojave National Preserve where the hunting of quail, mule deer, bighorn sheep, and other wildlife is allowed.

State

California Department of Parks and Recreation

The California Department of Parks and Recreation manages over 270 park facilities. The California State Park closest to the Project area is the Providence Mountain State Recreation Area (SRA), which is located in the eastern Mojave Desert on the east side of the Providence Mountains, approximately 30 miles north of the Project site.[7] Providence Mountain SRA consists of approximately 5,900 acres and activities include hiking, biking, camping, and organized exhibits. The proposed Project is not located in a California State Park.

Local

San Bernardino County Regional Parks

The County of San Bernardino Department of Regional Parks manages recreational facilities throughout the County. There are no County regional parks in close proximity to the Project area. The closest regional park is located in the Mojave River Watershed approximately 120 miles to the west.

4.14.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines, Appendix G*, a project may be deemed to have a significant effect on the environment with respect to recreation if it would:

- Adversely affect the recreational experience of established recreational facilities;
- Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated; or
- Include recreational facilities or require the construction or expansion or recreational facilities which might have an adverse physical effect on the environment.

9 National Park Service, *Mojave National Preserve, General Management Plan*, 2002, page 75.

Methodology

The Project was evaluated to assess its proximity to designated recreational facilities and public access open space.

Groundwater Conservation and Recovery Component

Disruption of Recreational Facilities

Significance Threshold

Would the proposed Project adversely affect the recreational experience of established recreational facilities?

Impact Analysis

Construction of Wellfield and Conveyance Facilities

The Project is not located in the vicinity of County or State recreational facilities or parks. There are no developed camping areas near the Project area. There are several BLM Wilderness Areas located in close proximity to the Project site. Specifically, the Trilobite Wilderness is located approximately 4 miles north of the Project site; the Old Woman Mountains is approximately 180 feet to the east of a portion of the ARZC ROW, within which proposed water conveyance facilities would be constructed. The Cadiz Dunes Wilderness Area is 5 miles south of the Project and approximately 250 feet west of the central portion of the ARZC ROW. The Turtle Mountains is located approximately 3 miles east of the intersection of the ARZC ROW and the CRA.

Construction activities would be visible from distant vista points in the surrounding Wilderness Areas, but would not substantially affect scenic vistas. The pipeline construction would follow the railroad alignment which would minimize the visual impact.

The proposed Project has been designed to completely avoid all BLM lands, including Wilderness Areas. Construction of the proposed Project would not disrupt recreational opportunities and uses. The public would continue to have access to BLM lands in areas where public access is currently provided. Therefore construction related impacts are considered less than significant.

Operation

Once constructed, the underground pipeline would not be visible. The wellfield area would be visible from distant views but would not disrupt the expansive vistas from higher elevations (see Section 4.1, Aesthetics).

Operation of the Project would not generate noise or nighttime lighting that could disrupt distant Wilderness Area visitors (see Sections 4.1, Aesthetics and 4.12, Noise). Operation of the Project would not disrupt recreational opportunities and the public would continue to have access to BLM lands in areas where public access is currently provided. Therefore, the Groundwater Conservation and Recovery Component would result in a less than significant impact to existing recreational facilities.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Deterioration of Recreational Facilities

Significance Threshold

Would the proposed Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Impact Analysis

The Project would be located on lands and easements that are privately owned by Cadiz, Metropolitan, and ARZC and would not encroach onto BLM lands. Construction and operation of the proposed Project would not increase the use of existing neighborhood and regional parks or other recreational facilities. The Project would not require residential development in the Project area nor result in a substantial number of new, long-term, full-time employees that would reside in or near the Project site and potentially recreate in the Project vicinity. The Project would not promote or increase public access to undeveloped lands. The Project is not located in the vicinity of County or State recreational facilities or parks. There are no developed camping areas near the Project site. As a result, the Project would not result in an increase in the physical deterioration of existing park or recreational facilities.

Mitigation Measures

None required.

Significance Conclusion

No impact.

New Recreational Facilities

Significance Threshold

Would the proposed Project include recreational facilities or required the construction or expansion or recreational facilities which might have an adverse physical effect on the environment?

Impact Analysis

The Project does not include recreational facilities or require the construction of new or expansion of existing recreational facilities. The proposed Project has been designed to completely avoid adjacent BLM lands, including designated Wilderness Areas. Construction of the proposed Project would not conflict with recreational uses in the Project vicinity, and access to BLM lands allowing recreation would be unimpeded throughout construction and operation. Therefore, the Groundwater Conservation and Recovery Component of the proposed Project would not have adverse environmental impacts on recreational areas.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Disruption of Recreational Facilities

Significance Threshold

Would the proposed Project adversely affect the recreational experience of established recreational facilities?

Impact Analysis

Similar to the Groundwater Conservation and Recovery Component, the Project is not located in the vicinity of County or State recreational facilities or parks. Construction activities would be visible from distant vista points in the surrounding Wilderness Areas, but would not substantially affect scenic vistas. The expanded wellfield and spreading basin would be visible from distant views but would not disrupt the expansive vistas from higher elevations (see Section 4.1, Aesthetics). The existing natural gas pipeline extending from the Cadiz Property to Barstow is not located in the vicinity of County or State recreational facilities or parks. Operation of the Project would not generate noise or nighttime lighting that could disrupt distant Wilderness Area visitors (see Sections 4.2, Aesthetics and 4.12, Noise). Therefore, the Imported Water Storage Component would result in a less than significant impact to existing recreational facilities.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Deterioration of Recreational Facilities

Significance Threshold

Would the proposed Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Impact Analysis

As with the Groundwater Conservation and Recovery Component, construction and operation of the Imported Water Storage Component would not increase the use of regional parks or other recreational facilities that could result in deterioration of facilities.

Mitigation Measures

None required.

Significance Conclusion

No impact.

New Recreational Facilities

Significance Threshold

Would the proposed Project include recreational facilities or required the construction or expansion or recreational facilities which might have an adverse physical effect on the environment?

Impact Analysis

The Imported Water Storage Component does not include recreational facilities or require the construction of new or expansion of existing recreational facilities. The proposed Project has been designed to completely avoid adjacent BLM lands, including designated Wilderness Areas. Construction of the proposed Project would not conflict with recreational uses in the Project vicinity, and access to BLM lands allowing recreation would be unimpeded throughout construction and operation. Therefore, the Imported Water Storage Component of the proposed Project would not have adverse environmental impacts on recreational areas.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.14-4 presents the impacts and mitigation summary for Recreation.

TABLE 4.14-4
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Disruption of Recreational Facilities	None required	Less than significant
Deterioration of Recreational Facilities	None required	No impact
New Recreational Facilities	None required	No impact
Imported Water Storage Component		
Disruption of Recreational Facilities	None required	Less than significant
Deterioration of Recreational Facilities	None required	No impact
New Recreational Facilities	None required	No impact

4.15 Transportation and Traffic

The purpose of this Section is to identify existing transportation and traffic network within the Project area, analyze potential impacts to transportation and traffic associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. Thresholds of significance for the impact analysis are derived from Appendix G of the 2011 *CEQA Guidelines*.

4.15.1 Environmental Setting

Regional Setting

The proposed Project is located within the eastern Mojave Desert in San Bernardino County. The transportation system in this area is composed primarily of an interconnected network of local roads and State and interstate highways. Regional access to the Project area is provided by Interstate 40 (I-40) via National Trails Highway (also known as Old US 66) from the north, and Interstate 10 (I-10) via State Route (SR) 62 or SR 177 (also known as Desert Center Rice Road) from the south. U.S. Route 95 (US 95) is a north-south interstate highway that provides a link between I-10 and I-40 east of the proposed Project area. US 95 connects to I-40 to the north at Parker Junction and to I-10 to the south at Vidal Junction, which is approximately 20 miles east of the southern extent of the proposed Project, where the ARZC intersects the CRA. **Figure 4.15-1** shows regional and local roadways in the vicinity of the proposed Project.

Regional Roadways

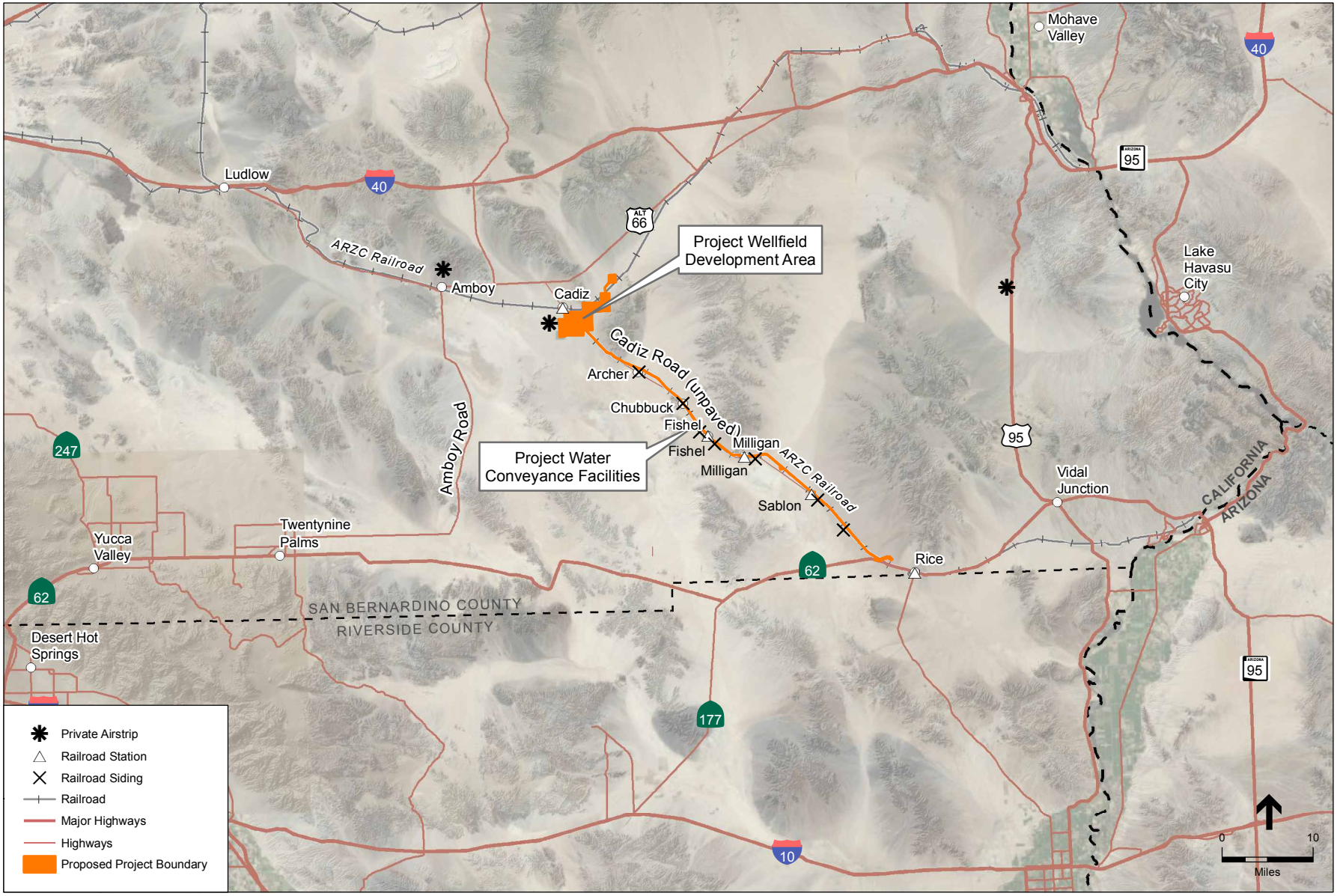
Twentynine Palms Highway (SR 62) is a four-lane State highway that originates at an intersection with I-10 in Riverside County, south of the Morongo Valley. SR 62 travels northeast through the town of Yucca Valley, the community of Joshua Tree, and the City of Twentynine Palms before reaching the intersection with Cadiz-Rice Road. It continues east, past Cadiz-Rice Road, along the southern edge of the San Bernardino County line before ending at Parker Dam Road and the Arizona State Line.

Needles Freeway (I-40) runs along an east-west alignment approximately 20 miles north of the Project site, originating at an intersection with I-15 just east of Barstow and continuing east to the Arizona State Line. I-40 is a major trucking route, providing access to Los Angeles to the west and Flagstaff, Arizona and beyond to the east.[1]

National Trails Highway (US 66) originates at an interchange with I-15 in the City of Victorville, and continues north and east to its terminus at Lenwood Road in the community of Lenwood, just southwest of the City of Barstow.[2] National Trails Highway runs east and west through the Project area and is located approximately 4 miles north of the Project site.

[1] County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report*, February 2007, pages IV-145, IV-169, IV-142.

[2] County of San Bernardino, *San Bernardino County 2007 General Plan Program* F*inal Program Environmental Impact Report*, February 2007, pages IV-145, IV-169, IV-142.



SOURCE: Bing Maps, 2010; ESRI, 2010; Cadiz Inc., 2010; and ESA, 2010

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4-15.1

Regional Transportation Network

San Bernardino Freeway (I-10) travels east-west across the southern edge of the Valley Region in San Bernardino County. This freeway provides access to Los Angeles to the west and Arizona and beyond to the east.[5] I-10 is approximately 35 miles south of the Project site.

U.S. Route 95 (US 95) is a rural highway that travels along the eastern border of San Bernardino County. This roadway provides a connection between Las Vegas, Nevada, I-15, I-40, and I-10.[3] US 95 runs north-south approximately 20 miles to the east of the Project area.

Local Setting

Roadways

Several arterials in the Project area serve regional as well as local needs, although most of the local roadways are unimproved and experience minimal traffic volumes. Amboy Road is a two-lane paved road that connects the National Trails Highway at Amboy (approximately 15 miles west of Cadiz) to Twentynine Palms. Kelbaker Road is a two-lane north-south paved road connecting National Trails Highway to I-40. Unimproved Cadiz-Rice Road runs northwesterly from SR 62 at Freda to National Trails Highway just north of Cadiz, generally following the alignment of the ARZC rail line. Cadiz-Rice Road currently carries approximately 46 trips per day.[4]

Railroads

Current railroad transportation in the area consists of the BNSF and ARZC rail lines. The BNSF rail line closely follows the east-west alignment of National Trails Highway. In the Project vicinity, these rail lines pass through Ludlow, Amboy, Cadiz, and Needles. East of Needles, the BNSF rail line continues into Arizona. The BNSF rail line is a main line facility used for long distance and transcontinental shipments. Activity on this rail line is frequent and cannot be disrupted.

The BNSF rail line connects with the ARZC rail line at Cadiz. The ARZC rail line extends southeast from Cadiz to Phoenix, Arizona. In the Project area, the ARZC railroad track runs northwest/southeast, closely following the alignment of Cadiz-Rice Road. AZRC stations and/or sidings, including Cadiz, Milligan, Freda, and Rice are shown in Figure 4.15-1. The ARZC schedules one train into the Cadiz area daily, Sunday through Friday, to interchange cars with the BNSF system. Extra trains move in and out of the Cadiz area on an as-needed basis, usually two to four times per week. Trains may be using the ARZC rail line at any time of day, depending on that day's scheduling.

Amtrak has two routes that travel through San Bernardino County. The route closest to the Project area is the Southwest Chief near I-40 to the north. The Southwest Chief operates daily

[3] County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report,* September 2006, page IV-145.
[4] Eloy Ruvalcaba, San Bernardino Department of Public Works, *Phone conversation with ESA* October 20, 2010.

between Los Angeles and Chicago and stops in four cities in San Bernardino County – San Bernardino, Victorville, Barstow, and Needles.[5]

Airports

There is a private airstrip located on Cadiz Property, just north of the existing agricultural operations. Regionally, there is a private airstrip located in the community of Amboy, approximately 12 miles west and north of the Project site and at the Iron Mountain Pumping Plant approximately 40 miles south on the CRA. The nearest general aviation airport is located in Twentynine Palms.[6]

Existing Traffic Conditions

Traffic Volumes and Levels of Service

Traffic counts were conducted by San Bernardino County in order to examine roadway conditions related to congestion and delay. Roadway conditions were analyzed based on Average Daily Trips (ADT), Level of Service (LOS) [7], and Volume to Capacity (V/C) data. The ADT and LOS data were provided by the San Bernardino County Public Works Department (see **Table 4.15-1**). In accordance with the San Bernardino County Congestion Management Plan (CMP), LOS standards require that all CMP segments within the Desert Area (as described in the CMP) operate at LOS C or better.[8]

Table 4.15-2 depicts the ADT and LOS for the major roadways in the Project area, based on data collected between 2006 and 2010 for the roadway segments located nearest to the Project site.

4.15.2 Regulatory Framework

The development and regulation of the transportation network in the Project vicinity primarily involves state and local jurisdictions. Applicable State and local laws and regulations related to traffic and transportation issues are discussed below.

State

California Department of Transportation

There are currently over 10,000 miles of roadways located within San Bernardino County. These facilities fall under the jurisdiction of one of three levels of governmental agencies responsible for construction and maintenance of roadway infrastructure. Caltrans manages interregional

5 County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006, pages V-12, VI-I.

6 Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volume I*, September 2001, page 5-119.

7 LOS is a quality measure describing operational conditions within a traffic stream, generally in terms of service measures such as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.

8 County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006, pages V-12, VI-I.

TABLE 4.15-1
LEVEL OF SERVICE DEFINITIONS

LOS Rating	Description	Unsignalized Intersections Delay (sec)	Volume to Capacity Ratio
A	Free Flow. No approach phase is fully used by traffic and no vehicle waits longer than one red indication. Insignificant delays.	0-10	0.00-0.599
B	Stable Operation. An occasional approach phase is fully used. Many drivers begin to feel somewhat restricted within platoons of vehicles. Minimal delays.	> 10-15	0.60-0.699
C	Stable Operation. Major approach phase may become fully used. Most drivers feel somewhat restricted. Acceptable delays.	> 15-25	0.70-0.799
D	Approaching Unstable. Drivers may have to wait through more than one red signal cycle. Queues develop but dissipate rapidly, without excessive delays.	> 25-35	0.80-0.899
E	Unstable Operation. Volumes at or near capacity. Vehicles may wait through several signal cycles. Long queues form upstream from intersection. Significant delays.	> 35-50	0.90-0.999
F	Forced Flow. Represents jammed conditions. Intersection operates below capacity with several delays; may block upstream intersections.	> 50	≥ 1.000

SOURCE: Transportation Research Board, *Highway Capacity Manual,* 2000, page 16.

TABLE 4.15-2
LOCAL ROADWAY SERVICE LEVELS

Roadway	ADT	LOS
SR 62	1600	A
I-40	11,300	A
National Trails Highway	540	A
I-10	23,000	A
US 95	2,500	B
Amboy Road	826	A
Kelbaker Road	520	A
Cadiz-Rice Road	46	A

SOURCE: Eloy Ruvalcaba, San Bernardino Department of Public Works, *Phone conversation with ESA,* October 20, 2010.

transportation facilities, including management and construction of the California highway system, and is responsible for maintaining approximately 1,240 miles of roadway throughout the County. This total includes six federal (Interstate) freeways, two federal (U.S.) highways, and 18 State highways. In addition, Caltrans is responsible for permitting and regulation of the use of State roadways. SR 62 is the only roadway that falls under Caltrans' jurisdiction in the Project area.

Caltrans' construction practices require temporary traffic control planning "during any time the normal function of a roadway is suspended."[9] In addition, Caltrans requires that permits be obtained for transportation of oversized loads, transportation of certain materials, and construction-related traffic disturbances. Caltrans regulations would apply to the transport of construction materials via the California Highway System, in this case SR 62.

California Public Utilities Commission

The CPUC has safety jurisdiction over freight railroads, inter-city passenger railroads (both high speed and conventional speed), commuter railroads, rail transit systems (both light and heavy), and all highway rail crossings. The CPUC has designated its Consumer Protection and Safety Division (CPSD) as the division responsible for implementing the CPUC's rail safety programs operating near the Project site.

Regional

Southern California Association of Governments

On May 8, 2008, the SCAG adopted its 2008 RTP. The 2008 RTP presents the transportation vision for the SCAG region through the year 2035 and provides a long-term investment framework for addressing the region's transportation and related challenges. The RTP focuses on maintaining and improving the transportation system through a balanced approach and considers system preservation, operation, and management, improved coordination between land-use decisions and transportation investments, and strategic expansion of the system to accommodate future growth.

County

San Bernardino County Department of Public Works

The San Bernardino County Department of Public Works is responsible for maintaining approximately 2,830 miles of both paved and unpaved roadways primarily located in unincorporated areas of the County. These facilities range in classification from major arterial highways to local streets. The Cadiz-Rice road that follows the ARCZ railroad is a County road.[10]

San Bernardino Associated Governments

The SANBAG serves in the capacity of County Transportation Committee and is responsible for allocating and programming state and federal funds for regional transportation projects throughout the County. SANBAG also serves as the County Transportation Authority and is responsible for administering the CMP. SANBAG also serves as the Service Authority for Freeway Emergencies.

---

9 Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, November 2003.

10 County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006, pages V-12, VI-I.

Congestion Management Program (CMP)

The CMP in San Bernardino County was created in June 1990 as a provision of Proposition 111. Under this proposition, urbanized areas with populations of more than 50,000 would be required to undertake a congestion management program that was adopted by a designated Congestion Management Agency (CMA). As stated earlier, SANBAG was designated as the CMP by the County Board of Supervisors. The closest applicable city with the population nearing 50,000 is the City of Indio.[11]

4.15.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to agricultural and forest resources if it would:

- Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit;
- Conflict with an applicable congestion management program, including, but not limited to, level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways;
- Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks;
- Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment);
- Result in inadequate emergency access; or
- Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities.

Methodology

Increased traffic volumes estimated for project construction and operation were compared with existing roadway conditions and State and County thresholds of significance.

Groundwater Conservation and Recovery Component

Consistency with Regulations for Circulation System Performance

Significance Threshold

Would the proposed Project conflict with an applicable plan, ordinance, or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all

[11] City of Indio, *Pop-Facts: Demographic Quick Facts 2011 Report,* May 2011, page 1.

modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

Impact Analysis

Roadways

Applicable transportation plans and policies include the San Bernardino County Congestion Management Program, SCAG's RTP, and the Circulation Element of the San Bernardino County General Plan. The San Bernardino County General Plan's alternative transportation-related goals and policies pertain to long-term land use and transportation planning. The Project would not result in significant increases of traffic once construction is completed since the Project would not require a substantial number of on-site workers and only minimal maintenance trips on local roadways including the Cadiz-Rice road. Therefore, the Project would not conflict with the San Bernardino County CMP, the Circulation Element of the San Bernardino County General Plan, or SCAG's Regional Transportation Plan.

The Project would increase traffic on local roadways during construction, though the local roadways currently have very little traffic as the greater Project area is sparsely populated. Construction of the Groundwater Conservation and Recovery Component of the Project is expected to last up to 2 years. The primary impacts from the movement of construction trucks would include short-term and intermittent impacts on roadway capacities due to slower moving vehicles. Traffic-generating construction activities would consist of the arrival and departure of constructions workers, trucks hauling equipment and materials to the construction site, the hauling of excavated soils, and importing of new fill. Trucks leaving roadways onto construction sites would slow any traffic and could result in hazards to fast moving traffic on the sparsely used roads. If lane closures or flagmen are required to manage traffic during delivery of construction equipment, an encroachment permit from Caltrans would be necessary.

Construction traffic would exit the feeder highways (SR-62 or US-66) and follow existing paved and unpaved access roads to the construction sites. Some new access roads may need to be constructed or improved to provide access to heavy machinery. These roads would be entirely within Cadiz Property, Metropolitan property, or the ARZC railroad easement. No new at-grade railroad crossings would be constructed. The Cadiz-Rice road and existing railroad crossings would be utilized for site access.

During any given work shift, approximately 240 workers and 25 pieces of heavy equipment would be required for construction (see Table 3-3). The total number of workers and pieces of heavy equipment operating at one time would vary depending on the construction schedule developed by the construction contractors. Mast workers would stay at the worker housing areas provided on Cadiz Property during the work week and commute out of the area on the weekends. The number of trips per day during the week including worker commute and truck deliveries would not be expected to exceed 100 round trips per day (i.e., 100 coming and 100 going). This is a conservative estimate of a busy day; actual daily auto trips would likely be considerably fewer. The addition of 100 daily round trips on SR-62 or US-66 would not significantly increase average daily traffic counts on those highways. Furthermore, although construction would increase traffic

on Cadiz-Rice road considerably, the level of service is currently so low that delays would not be anticipated. The road would remain passable to non-Project traffic at all times.

Some equipment and crew/employees needed for construction would originate from Desert Center, Morongo Valley, and Twentynine Palms, but the majority of the large equipment would be delivered from the San Bernardino area, Barstow, or Needles. Trucks transporting this equipment and construction employees would be expected to use SR 62 and either Cadiz-Rice Road or the loop around Amboy Road. Trucks transporting this equipment and construction crews would be expected to use Cadiz-Rice Road via I-40 and National Trails Highway.

In summary, the Project would not increase average daily trips on local highways considerably or cause delays on local county roads such as the Cadiz-Rice road. Construction related traffic would slow to exit SR-62 near the Cadiz-Rice road exit and at the Amboy exit on US-66 and may briefly affect through-traffic speeds. Traffic control measures, including turn-off lanes may be necessary to avoid impacts to high speed traffic. Implementation of Mitigation Measures **TR-1 through TR-4** would ensure that construction-related traffic impacts would be less than significant. With implementation of mitigation, construction would not conflict with the San Bernardino County CMP, the Circulation Element of the San Bernardino County General Plan, or SCAG's Regional Transportation Plan.

Railroads

Construction materials and equipment, particularly oversized loads (e.g., pipe segments) may be delivered to the construction site via the BNSF Railroad and dropped off at the intersection with the ARZC rail line. Equipment and materials would then be delivered to construction sites using either the existing ARZC rail system or by truck. Coordination with the ARZC and BNSF Railroad would be required. Currently, the BNSF rail line is used frequently during the day. The ARZC rail line is used a few times per day. Shipments on the BNSF and the ARZC rail lines would not substantially increase the overall number of trains running on the BNSF or ARZC rail lines, but may add a few trains per day during peak delivery periods.

Part of the wellfield manifold system would cross under the BNSF rail lines, and the water conveyance pipeline would cross under the ARZC rail line multiple times. Construction at rail line crossings would be either by jack and bore or conventional tunnel with ribs and lagging or lineal plate. All construction operations at rail line crossings would be coordinated with the affected railroad companies to ensure that normal operations would not be affected.

Mitigation Measures

TR-1: A Traffic Control Plan shall be implemented that includes the following elements:

- Identify hours of construction and hours for deliveries and include a discussion of haul routes;
- Identify all access restrictions, parking restrictions, and signage requirements on major roads (e.g., speed limit);
- Identify signage and flag men necessary at turn-off lanes on SR-62 and US-66 to avoid traffic hazards on fast moving roads;

- Include a plan to coordinate all construction activities with emergency service providers in the area at least one month in advance. Emergency service providers shall be notified of the timing, location, and duration of construction activities. All roads shall remain passable to emergency service vehicles at all times; and
- Arrange for a telephone resource to address public questions and complaints during Project construction.

TR-2: The construction contractor shall submit construction plans for construction within the railroad easement to the railroad owner and operator for their review and approval. Any plans to deliver materials on the rail lines shall be reviewed and approved by the railroad owner and operator. The construction contractor shall obtain approval from the railroad operator for material delivery and staging activities within the railroad right-of-way.

TR-3: During construction, all at-grade railroad crossings shall be clearly flagged and barricaded to ensure that all vehicular traffic comes to a full stop prior to crossing railroad tracks.

TR-4: The construction contractor shall implement mandatory railroad safety training and implement railroad safety measures requested by the railroad operator.

Significance Conclusion

Less than significant with mitigation.

Congestion Management Program / LOS Standard

Significance Threshold

Would the proposed Project conflict with an applicable congestion management program, including, but not limited to, level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?

Impact Analysis

LOS standards for roadways that are part of the San Bernardino County CMP network are intended to regulate long-term traffic increases resulting from the operation of new development. The CMP's LOS standard requires that all CMP segments operate at LOS C or better. Local roadways in the Project vicinity all have LOS A or B ratings. Project operations, which would result in a negligible increase in maintenance trips to the Project site per day, would not affect LOS standards on roads in the Project vicinity. Construction activities could increase daily trips by 100 round trips per day. This amount of trips would not be sufficient to reduce LOS on any local roadway below LOS C.

The proposed Project would not introduce facilities that would conflict with an applicable congestion management program or cause a significant increase in traffic that would negatively impact the surrounding roadway network. Implementation of the traffic control/management plan and other measures described above in Mitigation Measures **TR-1 through TR-4** would ensure that the Project would have a less than significant effect on congestion.

Mitigation Measures

Implement Mitigation Measures **TR-1 through TR-4**.

Significance Conclusion

Less than significant with mitigation.

Air Traffic

Significance Threshold

Would the proposed Project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

Impact Analysis

During construction of the Groundwater Conservation and Recovery Component there may be a slight increase in air traffic at the Cadiz airstrip due to travel by Project staff and contractors. Currently the airstrip is used a few times per month. The Amboy airstrip, which is located approximately 10 miles northwest of the site, would not be affected since the Cadiz airstrip could accommodate all air transportation needs of the Project. The increase is estimated to be less than five flights per week (i.e., four arriving and four leaving), which would not change established air traffic patterns. Once the Project is constructed, ongoing use of the Cadiz airstrip would be similar to existing conditions. This slight, temporary increase in air traffic would not result in substantial safety risks and impacts would be considered less than significant.

Furthermore, the Project would not change air traffic patterns because there are no structures proposed to be constructed within the Project site that would be tall enough to encroach into or physically affect existing air traffic patterns

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Traffic Hazards

Significance Threshold

Would the proposed Project substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

Impact Analysis

The Project would not construct or modify roadways or alter the existing regional circulation system. Therefore, it would not introduce hazardous design features into the existing environment. Currently, the Cadiz Property accommodates agricultural vehicles. During certain

times of year, traffic on the site already increases substantially as a result of an increase in the number of workers arriving to harvest or plant crops. Vehicles using highways and roadways in the Project vicinity to transport workers, equipment, and materials during construction would have slower movements and larger turning radii compared to personal vehicles. Installation of pipelines within the ARZC ROW would require installation of the pipeline within the existing railroad easement and is not anticipated to cause road closures. Implementation of the traffic control/management plan and other measures described above in Mitigation Measures **TR-1 through TR-4** would ensure that the Project would have a less than significant effect.

Mitigation Measures

Implement Mitigation Measures **TR-1 through TR-4**.

Significance Conclusion

Less than significant with mitigation.

Emergency Access

Significance Threshold

Would the proposed Project result in inadequate emergency access?

Impact Analysis

The Project would not impede traffic in the Project area and would not create obstacles to emergency service providers since no road or lane closures would be necessary. The nearest fire station is the Wonder Valley fire station, located approximately 33 miles west of the Project site. The average fire response time to the Project site is 35 minutes to one hour depending on where the emergency is located on the Cadiz-Rice road. Police protection services are provided by SBCSD's Morongo Basin Station, located 78 miles west of the Project site. The average police response time is one hour. Mitigation Measure **TR-1** requires coordination with emergency service providers at least one month prior to construction within roadways that might affect emergency response times. Adherence to this mitigation measure would reduce any potential impacts regarding emergency services to less than significant levels.

Mitigation Measures

Implement Mitigation Measure **TR-1**.

Significance Conclusion

Less than Significant with mitigation.

Public Transit, Bicycle, or Pedestrian Facilities

Significance Threshold

Would the proposed Project conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?

Impact Analysis

There are no bus stops, sidewalks, or bike routes located near the Project area. The Project area is located in a remote desert area. The closest community is Chambless approximately five miles north and Amboy approximately 15 miles northwest of the proposed wellfield. Therefore, no impacts to these types of facilities would occur.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Consistency with Regulations for Circulation System Performance

Significance Threshold

Would the proposed Project conflict with an applicable plan, ordinance, or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

Impact Analysis

Construction of the spreading basins, pipeline extension, and expanded wellfield for the Imported Water Storage Component would take approximately 12 months to complete. Similar to the Groundwater Conservation and Recovery Component, the primary impacts from the movement of construction trucks would include short-term and intermittent impacts on roadway capacities due to slower moving vehicles and the larger turning radii of construction trucks, compared to passenger vehicles. Roads providing access to construction sites would be constructed within Cadiz Property. An access road to the proposed spreading basins would need to be constructed that would include crossing the BNSF railroad tracks. No new crossings would be constructed. The locations of the spreading basins would dictate the location of the new access roads. Implementation of Mitigation Measures **TR-1 through TR-4** would reduce impacts of construction worker trips and material deliveries to less than significant levels.

Construction-related traffic during activities at the existing natural gas pipeline would be limited and short-term, but could create intermittent impacts on roadway capacities as a result of larger slower moving vehicles. Implementation of Mitigation Measure **TR-1** would ensure impacts remain less than significant.

Mitigation Measures

Implement Mitigation Measures **TR-1 through TR-4**.

Significance Conclusion

Less than significant with mitigation.

Congestion Management Program / LOS Standard

Significance Threshold

Would the proposed Project conflict with an applicable congestion management program, including, but not limited to, level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?

Impact Analysis

The Imported Water Storage Component would not conflict with an applicable congestion management program or cause a significant increase in traffic that would negatively impact the surrounding roadway network. Construction of the expanded wellfield, recharge basins, and existing natural gas pipeline appurtenances would temporarily require workers to commute to the site, but the impact to level of service in the local roadways would be similar to or less than the Groundwater Conservation and Recovery Component. Implementation of the traffic control/management plan and other measures described above in Mitigation Measures **TR-1 through TR-4** would ensure that the Project would have a less than significant effect on congestion.

Mitigation Measures

Implement Mitigation Measures **TR-1 through TR-4**.

Significance Conclusion

Less than significant with mitigation.

Air Traffic

Significance Threshold

Would the proposed Project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

Impact Analysis

During construction of the Imported Water Storage Component there may be a slight increase in air traffic at the Cadiz airstrip due to travel by Cadiz staff and contractors. This increase is estimated to be less than two flights per week, which would not change established air traffic patterns. The Amboy airstrip, which is located approximately 10 miles away, would not be affected. This slight, temporary increase in air traffic would not result in substantial safety risks. Also no buildings or structures are anticipated to be constructed which would interfere with air traffic.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Traffic Hazards

Significance Threshold

Would the proposed Project substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

Impact Analysis

The Imported Water Storage Component would not introduce hazardous design features into the existing environment. Regarding the hazard created by construction activities occurring in proximity to area roadways and rail lines, implementation of the traffic control/management plan and other measures described above in Mitigation Measures **TR-1 through TR-4** would ensure that the Project would have a less than significant effect.

Mitigation Measures

Implement Mitigation Measures **TR-1 through TR-4**.

Significance Conclusion

Less than significant with mitigation.

Emergency Access

Significance Threshold

Would the proposed Project result in inadequate emergency access?

Impact Analysis

The Imported Water Storage Component would not impede traffic in the Project area and would not create obstacles to emergency service providers since no road or lane closures would be necessary. Implementation of Mitigation Measure **TR-1**, which requires coordination with

emergency service providers at least one month prior to construction, would reduce any potential impacts regarding emergency services to less than significant levels.

Mitigation Measures

Implement Mitigation Measure **TR-1**.

Significance Conclusion

Less than significant with mitigation.

Public Transit, Bicycle, or Pedestrian Facilities

Significance Threshold

Would the proposed Project conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?

Impact Analysis

There are no bus stops, sidewalks, or bike routes located near the Project area. The Project area is located in a remote desert area. The closest community is Chambless approximately 5 miles north. Amboy is approximately 15 miles northwest of the proposed wellfield. Therefore, no impacts to these types of facilities would occur.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Mitigation Measure Summary Table

Table 4.15-3 on the following page presents the impacts and mitigation summary for Transportation and Traffic.

TABLE 4.15-3
IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Consistency with Regulations for Circulation System Performance	**TR-1 through TR-4**	Less than significant with mitigation
Congestion Management Program/ LOS Standard	**TR-1 through TR-4**	Less than significant with mitigation
Air Traffic	None required	Less than significant
Traffic Hazards	**TR-1 through TR-4**	Less than significant with mitigation
Emergency Access	**TR-1**	Less than significant with mitigation
Public Transit, Bicycle, or Pedestrian Facilities	None required	No impact
Imported Water Storage Component		
Consistency with Regulations for Circulation System Performance	**TR-1 through TR-4**	Less than significant with mitigation
Congestion Management Program/ LOS Standard	**TR-1 through TR-4**	Less than significant with mitigation
Air Traffic	None required	Less than significant
Traffic Hazards	**TR-1 through TR-4**	Less than significant with mitigation
Emergency Access	**TR-1**	Less than significant with mitigation
Public Transit, Bicycle, or Pedestrian Facilities	None required	No impact

CHAPTER 5
Cumulative Impacts

5.1 Introduction and Approach

5.1.1 CEQA Statutory Guidance

CEQA requires that an EIR assess the cumulative impacts of a project with respect to past, present, and probable future projects within the region. According to Section 15355 of the *CEQA Guidelines*:

> *"Cumulative impacts" refer to two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts.*
>
> *(a) The individual effects may be changes resulting from a single project or a number of separate projects.*
>
> *(b) The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time.*

Pertinent guidance for cumulative impact analysis is given in Section 15130 of the *CEQA Guidelines*. The necessary components of an adequate cumulative effects analysis include (CEQA Guidelines §15130[b]):

- Either: (A) a list of past, present, and reasonably anticipated future projects producing related or cumulative impacts; or (B) a summary of projections contained in an adopted general plan or related planning document that is designed to evaluate regional or area wide conditions.
- A summary of the expected environmental effects to be produced by those projects.
- Analysis of the cumulative impacts of the relevant projects in combination with the Project.
- Reasonable options for mitigating or avoiding the project's contribution to any significant cumulative effects.

Consistent with CEQA Guidelines §15130(b), the discussion of cumulative impacts must reflect the severity of the impacts and the likelihood of their occurrence; however, the discussion need

not be as detailed as the discussion of environmental impacts attributable to the project alone. The discussion need not discuss impacts which do not result in part from the project. (CEQA Guidelines §15130[a][1].) Further, the discussion is guided by the standards of practicality and reasonableness. Accordingly, the discussion of cumulative impacts in this EIR focuses on significant and potentially significant cumulative impacts (CEQA Guidelines §15130[a]).

5.1.2 Approach

Significance Threshold

Would the proposed Project result in substantial adverse effects when viewed in connection with the effects of past projects, the effects of other concurrent projects, and the effects of probable future projects?

Impact Analysis

The following steps were followed for this cumulative effects analysis, pursuant to the CEQA statutory guidance summarized above: (1) the potential impacts of the proposed Project, which are identified in Chapter 4 of this EIR, were reviewed to determine (a) resource areas of no impact that could be screened from further evaluation and (b) resource areas that would be affected by Project activities that should be evaluated in this cumulative effects analysis; (2) other relevant past, present and reasonably foreseeable future projects, plans, and programs were identified for evaluation in this cumulative effects analysis; and (3) potential cumulative effects of the proposed Project were identified and, when it was determined that the Project could result in a cumulatively considerable contribution to a significant cumulative effect, mitigation measures were identified to minimize the proposed Project's contribution to the cumulative effect. This evaluation of cumulative effects considers both the Groundwater Conservation and Recovery Component and the Imported Water Storage Component of the Project. Additional project-level environmental review of the Storage Component of the Project will be completed when sufficient details have been developed and, as appropriate the cumulative effects analysis will be reviewed to determine if evaluation is required.

Project Impacts Considered in the Cumulative Effects Analysis

The potential environmental impacts associated with the proposed Project are summarized in the Executive Summary, Tables S-1 and S-2, and evaluated throughout Chapter 4 of this EIR. For those environmental resource areas on which the proposed Project would have no impact, the proposed Project would not contribute to cumulative effects in these areas.

No Impacts

The proposed Project would not contribute to cumulative effects in the following resource impact areas and therefore these areas are eliminated from further consideration in this analysis:

Aesthetics – Designated Scenic Highways: The Project area does not include any designated scenic highways. For this reason, no scenic highways would be adversely affected by Project activities.

Agriculture and Forestry Resources – Conversion of FMMP-Designated Agricultural Lands, Williamson Act Contracts; Forest Lands, Timberlands: Neither the Project site nor the surrounding areas have been designated as Prime Farmland, Unique Farmland or Farmland of Statewide Importance, and no such designated farmland would be converted. The Project site and vicinity are not under Williamson Act contracts, thus no cancellation of contracts would take place. The proposed Project is not located on forest land or timberland and no such designated lands are located in the Project vicinity. Because the proposed Project would not result in any impacts to forest land or timberland resources, this resource area is not discussed further in this cumulative effects analysis.

Cultural Resources – Indian Trust Assets – Neither Project construction nor operation would create any impacts on ITAs since none are located in the areas of the Project. Therefore, there would be no adverse cumulative impacts on ITAs.

Hazards and Hazardous Materials – Interference with Emergency Response or Evacuation Routes: The Project site is located more than ¼ mile away from any school. The Project would not interfere with adopted emergency response plans or evacuation routes defined by any local jurisdictions as there are none in the project area.

Hydrology and Water Quality – Flood, Seiche, Tsunami or Mudflow Hazard: The proposed Project does not include any construction of housing that would increase risk associated with flooding, seiche, tsunami or mudflow.

Land Use and Planning – Resource Plan Consistency and Dividing a Community: The Project area is not covered by any established Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs). No established communities are present within or immediately adjacent to the Project site.

Land Use and Planning – Environmental Justice: Neither the construction nor operation of the Project would disproportionately impact any disadvantaged populations. Therefore, no adverse cumulative impacts on environmental justice would arise as a result of the Project.

Land Use and Planning – Socioeconomics: Neither the construction nor operation of the Project would result in adverse economic or socioeconomic effects that would, in turn, result in adverse environmental effects. On the contrary, the Project would have a beneficial effect on regional economic and socioeconomic conditions as a result of the job opportunities created by Project construction, and to a lesser degree, operation. Therefore, no adverse cumulative impacts on socioeconomic conditions would arise as a result of the Project.

Recreation: The proposed Project does not include recreational facilities or require the construction of new or expansion of existing recreational facilities. The proposed Project has been designed to completely avoid adjacent BLM lands, including designated Wilderness Areas. Construction of the proposed Project would not conflict with recreational uses in the Project vicinity because access to BLM lands would be unimpeded throughout construction and operation. Because the proposed Project would not result in recreation impacts, this resource area is not discussed further in this cumulative effects analysis.

Transportation and Traffic – Transit, Pedestrian or Bike Routes: There are no bus stops, sidewalks, or bike routes located near the proposed Project. The closest community, Amboy, is approximately 15 miles northwest of the proposed wellfield. Due to the remote location of the proposed Project, no adverse impacts to public transit, bicycle or pedestrian facilities would occur.

Environmental Impacts

The majority of the environmental impacts associated with the proposed Project would result from construction of the proposed Project facilities. Facilities construction would result in impacts on aesthetic, biological, cultural and mineral resources; air quality and greenhouse gas emissions; soils; hazardous materials; hydrology, drainage, and water quality; noise; utilities; and traffic/transportation. Most of the construction-related impacts, such as increased levels of noise and traffic, would be temporary, short-term impacts that would cease at the end of construction; other temporary construction-related impacts, such as the digging of trenches for pipeline installation, would be repaired and/or restored to pre-construction conditions following construction.

A small number of Project effects would occur over the long-term and/or would be permanent, including the permanent loss of up to 250 acres of desert habitat due to the footprint of permanent aboveground facilities (well pads, roads, spreading basins, and pump stations); the permanent introduction of visible aboveground facilities, such as power poles (Project may employ overhead powerlines or underground powerline; to be determined during Project design), pump stations, and spreading basins; and the long-term (albeit minor, intermittent) disruption of wildlife habitat associated with wellfield operation and maintenance. There would be very few impacts associated with the proposed groundwater management program, including pumping and delivery of groundwater to participating agencies under the Groundwater Conservation and Recovery Component and the surface water import, groundwater recharge and storage, and return of surface water via groundwater banking under the Imported Surface Water Component. The potential impacts associated with Project operation for groundwater pumping and storage would be mitigated to less than significant by implementation of measures included in the GMMMP prepared for the project.

Appropriately, this cumulative effects analysis is focused on the areas where the Project would have environmental effects and where it could make a cumulatively considerable contribution to a significant cumulative impact.

Identification of Relevant Past, Present, and Reasonably Foreseeable Future Projects

This chapter considers the potential cumulative effects of the proposed Project in combination with other relevant development projects occurring in the Project area, vicinity, and/or region, depending upon the environmental resource area. For the purposes of this cumulative effects analysis, "relevant projects" are those that would affect the same footprint or defined geographic areas; those that would involve similar construction and/or operational features and/or would have similar types of environmental effects on the same environmental resource areas (for example, projects that would contribute similar groundwater effects within the same groundwater basin); and those that would occur over a similar timeframe.

Relevant projects, plans, and/or programs were identified using a combination of the "list" approach and the "plan/projection" approach described in the CEQA Guidelines. Because cumulative environmental impacts are most likely to arise when a relationship exists between a proposed activity and other projects expected to occur in a similar location, involving similar actions, and/or occurring over a similar time period, the following parameters were used to refine the list of projects to those that are relevant to this cumulative effects analysis:

- *Geographic Scope and Location* – a relevant project is one that would occur within the defined geographic scope for a particular environmental resource area.
- *Similar Environmental Impacts* – a relevant project would contribute to effects on environmental resource areas that would also be affected by the proposed Project.
- *Temporal Scope* – the timing and schedule for construction and implementation, or the ongoing operational effects associated with a relevant project would overlap in time with the proposed Project.

Geographic Scope

The geographic scope defines the geographic area within which projects may contribute to a specific cumulative impact, when considered in combination with the proposed Project. According to the *CEQA Guidelines* (CCR, Title 14, § 15130(b)(3)), a lead agency should provide a reasonable explanation of the geographic limitation used in the cumulative impacts analysis. This cumulative effects analysis generally covers the area bounded by the Old US 66 and I-40 corridor to the north; I-95 to the west; SR-62 to the south; and the Marine Corps Air Ground Combat Center, SR-247, and SR-62 through Yucca Valley to the east (see **Figure 5-1** on page 5-10). However, the geographic scope of cumulative impact analyses varies for each environmental resource area that is analyzed. **Table 5-1** defines the geographic scope of the analysis for each of the environmental resource areas analyzed for cumulative effects in Section 5.3, below. For example, the geographic scope of the analysis for cumulative aesthetics, noise, geology, soils, and vegetation impacts is localized and generally limited to the Project site and areas and proposed activities immediately adjacent to the Project site. Conversely, the geographic scope of the analysis for cumulative air quality and wildlife species impacts is more broad and, as a result, projects located within the air basin and/or that would occur within the range of a particular sensitive species would be considered. The general geographic limits and the geographic scopes associated with each environmental resource area (Table 5-1) were used to generate the list of past, present, and probable future projects, plans, and programs that are considered in this analysis.

This cumulative effect analysis assumes that projects located beyond these general geographic boundaries would be unlikely to result in cumulative impacts that would compound those associated with the proposed Project. For example, there are at least 29 proposed solar projects and nine proposed wind projects along the I-10 corridor between Palm Springs and Blythe, in the Coachella Valley, and numerous proposals for solar, wind, and geothermal development in the Imperial Valley of Imperial County. While collectively these other projects promote the same federal and state mandates for renewable energy development, they are considered to be outside the geographic scope of this analysis because they are located along different transportation and transmission corridors, in a slightly different climate and ecosystem (the Colorado Desert / "low

desert"), and are located at such distance from the proposed Project (the nearest is located about 25 miles to the south) that cumulative effects would be unlikely.

TABLE 5-1
SUMMARY OF ENVIRONMENTAL RESOURCE AREAS AND ASSOCIATED GEOGRAPHIC SCOPES FOR THE CUMULATIVE EFFECTS ANALYSIS

Environmental Resource Area / Project Impact	Geographic Scope	Resource Area Overview
Aesthetics	Local. Travel corridors in close proximity (SR-62 and 66), and higher elevation areas from which the Project site is visible.	The visual environment consists of an arid landscape with sparsely vegetated mountains, broad valleys with expansive bajadas, and scattered dry lakes. Land consists of open space and undeveloped natural areas, with scattered, isolated development.
Agriculture and Forestry	Regional. Eastern San Bernardino County (Desert Regions).	About 90 percent of the County's land area is desert. Agriculture accounts for 2.32 percent, or 41,793 acres, of the land and has decreased over time.
Air Quality	Regional. Mojave Desert Air Basin (MDAB).	Due to the proximity of coastal and central regions and the blocking nature of the Sierra Nevada Mountains to the north, air masses pushed onshore in southern California by differential heating are channeled through the MDAB. Wind comes from the west, west-southwest, and southwest.
Biological Resources	Local and Regional. The portion of the Mojave Desert bounded by I-40 and Old US 66 to the north, I-95 to the east, SR-62 to the west, and SR 247 to the west. Also, regional habitat range of the Desert Tortoise. Also Fenner Watershed for assessment of groundwater affects on biological resources.	The only formally-listed species with medium to high potential to occur in the Project area is the desert tortoise. However, the Groundwater Conservation and Recovery Component would not be within designated critical habitat or any DWMAs. Four native plant communities would be impacted by the proposed Project. Other special-status species with potential to occur in the Project area include 7 birds, 3 mammals, 1 reptile, and 3 plant species.
Cultural Resources	Local. Project footprint and views from the surrounding mountains.	The records search indicated that 50 cultural resources have been previously recorded within the study area. A total of 41 resources were documented along the proposed pipeline. No prehistoric resources or artifacts were observed during the survey and no isolated artifacts were recorded.
Geology and Soils	Site-specific. Project site and immediately adjacent areas.	Soils in the Project area are predominantly composed of sand and gravel grain sizes; very low to negligible amounts of clay material have been noted.

Environmental Resource Area / Project Impact	Geographic Scope	Resource Area Overview
Greenhouse Gas Emissions	Statewide. State of California. GHG emissions contribute to a global climate change but for purposes of this analysis, cumulative GHG emissions are evaluated in light of the State's GHG reduction goals.	Global warming may result in loss of snow pack, sea level rise, more extreme heat days per year, more high ozone days, more large forest fires, and more drought years.
Hazards and Hazardous Materials	Site-specific. Project area, including the construction zone and the area within a one-quarter-mile radius.	Current and historical uses in the Project area include agriculture, aviation, former military use, historical mining activities, and existing natural gas pipelines. There are no residences, industrial facilities or gasoline service stations in the Project area.
Hydrology and Water Quality	Local. Fenner, Bristol, Cadiz, and Orange Blossom Wash Watersheds. Because the Project is located in a closed surface and groundwater basin, activities in the broader region, outside the Watersheds, do not contribute to cumulative effects.	The total area of the combined Fenner (including Orange Blossom Wash), Bristol and Cadiz groundwater basin system is approximately 2,710 square miles. Groundwater ranges from approximately 270 feet bgs to the northeast, to 140 feet bgs in the southwest, becoming shallower with proximity to the Dry Lakes. Beneath the Dry Lakes groundwater is saline.
Land Use and Planning	Local and Regional. Communities within the southeast portion of the Desert region of San Bernardino County, generally bounded by the Morongo Valley to the east, I- 95 to the west, I-40 and Old US 66 to the north, and SR-62 to the south.	Land uses in Cadiz Valley include desert conservation, open space, recreation, agriculture, military facilities, mining, salt extraction, and numerous transportation and utility corridors. Cadiz is the largest private landowner in the area, with approximately 45,000 acres of landholdings in the Project vicinity, including approximately 34,000 contiguous acres. Of this total, 9,600 acres of land are zoned for agriculture. The Project area is located in the northeastern portion of the contiguous acreage. The proposed Project wellfield would occupy 115 acres.
Mineral Resources	Regional. Eastern San Bernardino County.	Playas in the area have produced and are currently producing evaporite minerals.
Noise	Local. Project site and immediately adjacent areas.	The noise environment is typical of open space and agricultural areas. The predominant sources of noise include railroad, roadway traffic, and equipment noise from existing agricultural operations. Military operations including explosions and low-flying aircraft also generate noise in the Valley.
Public Services and Utilities	Local. The area generally bounded by Twentynine Palms and Joshua Tree to the west, I-95 (Fort Mohave and Needles) to the east, I-40 and Old US 66 to the north, and SR-62 to the south.	Medical aid and ambulance services are provided from Twentynine Palms, Joshua Tree, and Needles. Numerous water and utility corridors traverse the Project area. The Twentynine Palms Landfill has the capacity to receive solid waste into the foreseeable future. SCE provides electrical service to Amboy, Cadiz and other communities near the proposed Project area. The proposed pipeline would cross numerous natural drainage systems.

Environmental Resource Area / Project Impact	Geographic Scope	Resource Area Overview
Transportation and Traffic	Local. I-40 and Old US 66 (also known as National Trails Highway) to the north; SR-247 and SR-62 to the west; SR-62 and I-10 to the south; and US 95 and SR-177 to the east.	All of the local and regional transportation corridors operate at an acceptable Level of Service (LOS), either A or B.

SOURCE: ESA, 2011.

Similar Environmental Impacts

The potential environmental impacts associated with the proposed Project were used to help identify relevant projects, plans, and programs for evaluation in this cumulative effects analysis. As described above, facilities construction would result in impacts to aesthetic, biological, cultural and mineral resources; air quality and greenhouse gas emissions; soils; hazardous materials; hydrology, drainage, and water quality; noise; utilities; and traffic/transportation. Most of the construction-related impacts would be temporary, short-term impacts, but a few Project effects would occur over the long-term and/or would be permanent, including loss of desert habitats and introduction of visible aboveground facilities. Operation and maintenance of Project facilities would result in the long-term periodic disruption of wildlife habitat. Projects, plans, and programs with the potential to result in similar environmental impacts were included in this cumulative effects analysis.

Temporal Scope

This cumulative impact analysis considers other projects that have recently been completed, are currently under construction, or are in the planning process. Both short-term and long-term cumulative impacts of the proposed Project, in conjunction with other cumulative projects in the area, are evaluated.

Schedule is particularly relevant to the consideration of cumulative impacts, since construction impacts tend to be relatively short-term. As described in Chapter 4 of this EIR, the majority of impacts associated with implementation of the proposed Project are short-term impacts associated with the construction phases, rather than with long-term Project operation. Therefore, the analysis of cumulative impacts pays particular attention to any cumulative projects with construction schedules that could overlap with the proposed construction schedule for this Project. The Groundwater Conservation and Recovery Component would have a two-year construction period that is estimated to take place between 2012 and 2014. The schedule for the Imported Water Storage Component has not yet been established. For purposes of analysis, construction of the Imported Water Storage Component facilities is projected to occur approximately 5 to 10 years after the Groundwater Conservation and Recovery Component, sometime between 2019 and 2024, on a mid-term horizon.

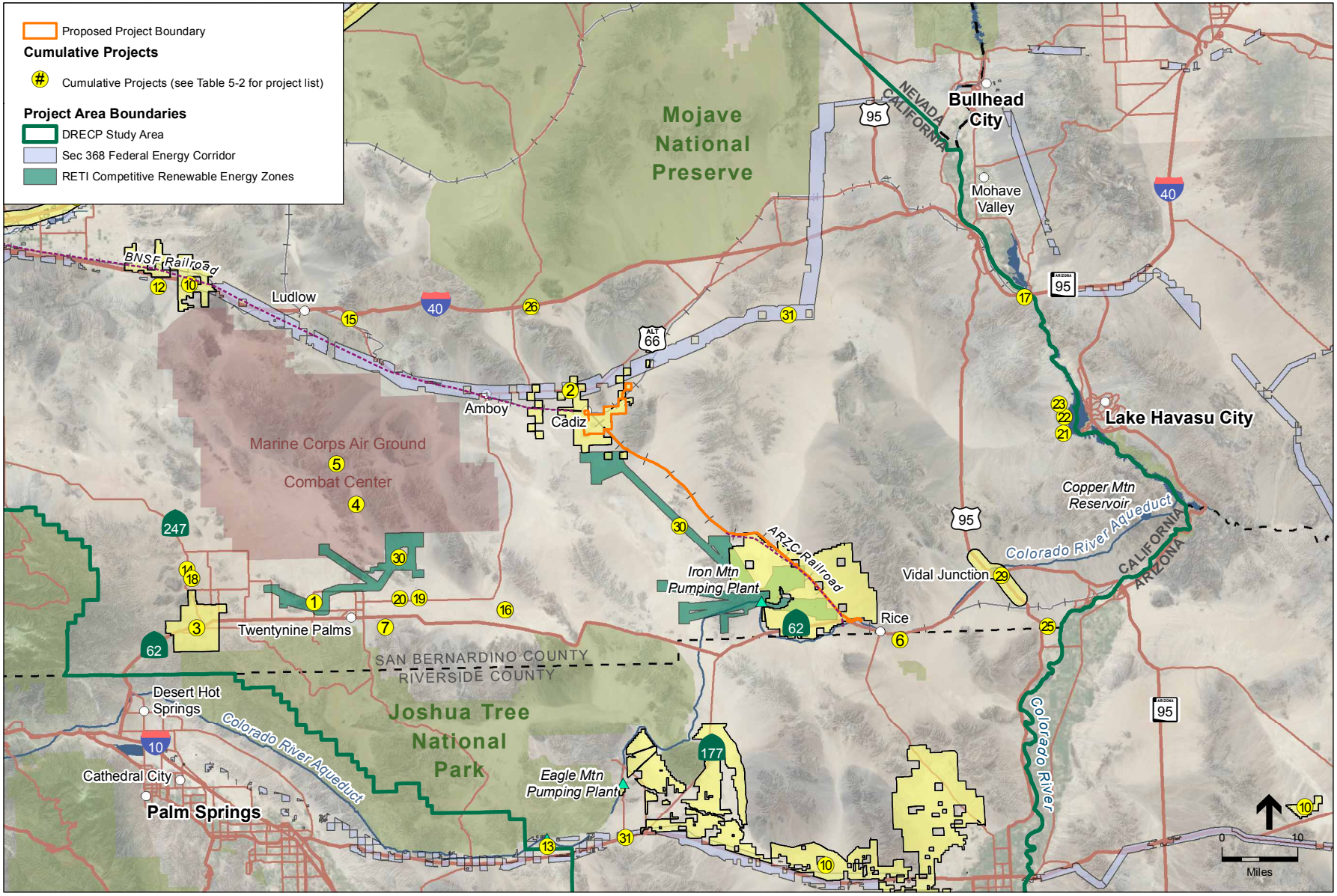
5.2 Projects, Plans, and Programs Relevant to the Project Region

Figure 5-1 shows the general location and **Table 5-2** on page 5-20 lists and briefly describes the past, present, and reasonably foreseeable future projects, plans, and programs (collectively referred to as "cumulative projects") that have the potential to contribute to cumulative impacts when considered together with the proposed Project. Figure 5-1 and Table 5-2 are located at the end of this subsection. The information in Table 5-2 was obtained from contact with San Bernardino and Riverside counties, review of City and County agency websites and available plans and environmental review documents, and correspondence with state and federal agencies and internet searches.

Six major land use and resource management plans associated with or affecting the Project region were reviewed for this cumulative effects analysis. These include the County of San Bernardino General Plan, four major renewable development energy plans or programs, and one open space / conservation plan. The four coordinated renewable energy development plans and programs have a federal and/or state mandate to identify or help identify suitable areas for renewable energy development and transmission corridors and/or streamline the review, approval, and permitting of renewable energy development projects in and around California's Mojave Desert region. They are included in this cumulative effects analysis because they cover the Project area and would, upon approval, limit, control, and/or direct renewable energy development in the Project vicinity. The open space / conservation plan, known as the CDPA of 2011, proposes to protect in perpetuity 1.6 million acres of federal lands. These plans and programs are described in detail in Section 5.2.1, Energy Plans and Programs, and Section 5.2.2, Open Space / Conservation Plans, below, and briefly summarized in Table 5-2.

Of the 21 entries in Table 5-2, two large (greater than 15 acres) land development projects (the Marine Corps Air Ground Combat Center Land Acquisition and Airspace Establishment Project (Marine Corps Base Expansion, Figure 5-1, Map #5) and the Rice Solar Energy Project (RSEP, Figure 5-1, Map #6)) and development associated with one of the large renewable energy programs (the Renewable Energy Transmission Initiative (RETI) (Figure 5-1, Map #30) have the greatest potential to result in environmental impacts that could compound or increase those associated with the proposed Project. About 524,000 acres of land within the geographic scope of this cumulative effects analysis could be affected by these four actions.

Table 5-2 includes several completed development projects, including the El Paso Line 1903 Pipeline Conversion Project (see Figure 5-1, Map #2) and the 29 Palms PV Project (Figure 5-1, Map #4). At least two other projects, Caltrans' SR-62/I-95 improvements project (Figure 5-1, Map #29) and the Twentynine Palms Mine Expansion (Figure 5-1, Map #7) will be completed well before the proposed Project begins construction. Operation and maintenance of these facilities are evaluated as part of this cumulative effects analysis. Other past, present, and ongoing future activities in the Project area, including periodic operation and maintenance of existing railroad facilities (BNSF and ARZC railroads) and utilities (electric transmission lines, natural



SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 5-1

Cumulative Projects

gas and oil pipelines, water conveyance facilities); agricultural and salt mining operations; limited community development; and open space/conservation, research, monitoring, and recreation activities on BLM lands, the Mojave National Preserve (approximately 30 miles north) and Joshua Tree National Park (approximately 30 miles south), are not listed in Table 5-2 but are discussed generally in this cumulative effects analysis, where applicable.

The other local land development, energy, infrastructure, and highway projects in Table 5-2 would have limited minor, resource-specific cumulative impact potential that would not be similar in magnitude to the proposed Project. These small- to moderate-sized projects are discussed in a consolidated manner, where applicable.

None of these projects would be located on Cadiz Property, although Cadiz Inc. has been approached by private renewable energy developers, conservation groups, and other entities interested in exploring the renewable energy development potential of the Cadiz Property. However, currently there are no other active development proposals, permit applications, or renewable energy projects proposed for the Cadiz Property.

5.2.1 Energy Plans and Programs

Nationally, interest in increasing energy efficiency, reducing dependence on fossil fuels, increasing domestic energy production, and curbing greenhouse gas emissions has led to a variety of federal mandates for renewable energy development, including the following:

- Executive Order (EO) 13212, Actions to Expedite Energy-Related Projects, in which the President ordered that executive departments and agencies "…take appropriate actions to expedite projects that will increase the production, transmission, or conservation of energy."
- Section 211, of the Energy Policy Act of 2005 (P.L. 109-58) which dictated that the Secretary of the Interior should, within 10 years of enactment of the Act, "…seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity."
- The Energy Independence and Security Act of 2007 that required Department of Energy (DOE) to facilitate integration of utility-scale solar energy into regional electricity transmission system.
- EO 13514, which requires federal agencies to help advance local efforts for renewable energy development.
- Interior Secretary Ken Salazar's Secretarial Order No. 3285A1 (signed March 11, 2009 and amended in February 2010), which announced a policy goal of identifying and prioritizing specific locations on public lands that are best suited for large-scale production of solar energy and calls for establishing renewable energy zones and transmission infrastructure to facilitate renewable energy development.[1]

[1] California Energy Commission, *Desert Renewable Energy Conservation Plan Notice of Preparation*, July 2011.

- California's Renewable Portfolio Standards (RPS)[2] are among the most ambitious in the nation, and the State has long-established energy policies to promote renewable electricity generation. EO S-14-08 raised California's renewable energy goals to 33 percent by 2020.[3]

In response to EO S-14-08 and federal Secretarial Order 3285A1, the State of California and the DOI established the Renewable Energy Policy Group (REPG), consisting of members of the DOI, California Governor's office, and California Natural Resources Agency (with signatories including CDFG, CEC, BLM, and USFWS). The REPG is responsible for identifying areas most suitable for Renewable Energy Development Zones (REZs) and transmission corridors, as well as those most suitable for regional multispecies and habitat conservation and mitigation incentive options.[4] The Agencies are also initiating in-depth study of specific locations for production of solar energy.

To implement and track the progress of EO S-14-08, the CEC and the CDFG signed an MOU formalizing a Renewable Energy Action Team (REAT).[5] The REAT's primary mission is to streamline and accelerate the permitting processes for renewable energy projects, while contributing to the conservation of special-status species and natural communities at the ecosystem scale. Together, the CEC, CDFG, BLM, USFWS, and the National Fish and Wildlife Foundation established a financial account for monies paid in connection with mitigating impacts of renewable energy development projects, to be used for conservation, protection, enhancement, restoration, and adaptive management activities in the Mojave and Colorado Deserts of California.[6]

EO S-14-08 also mandated the development of the Desert Renewable Energy Conservation Plan (DRECP) for the Mojave and Colorado Desert regions, with the goal of reducing the time and uncertainty normally associated with licensing new renewable projects.[7] In response to hundreds of proposals[8] to develop renewable energy projects on BLM-administered lands in California, DOE, CEC, CDFG, USFWS, and BLM are devising an expedited application and permitting process for renewable energy development that will identify key renewable energy development areas, develop a BMP manual, and reduce the time and expense for developing renewable energy on federally-owned California lands by as much as half for projects sited in designated renewable energy development areas.[9] EO S-14-08 directs state agencies to minimize the environmental

2 A Renewable Portfolio Standard (RPS) is a regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal.
3 California Pulbic Utilities Commission, *California Renewables Portfolio Standard,* http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm, accessed August 2011.
4 MOU between the State of California and the Department of the Interior on Renewable Energy, October 12, 2009.
5 California Energy Commission, *Implementing the Renewable Energy Executive Order,* http://www.energy.ca.gov/33by2020/, accessed August 2011.
6 The Renewable Energy Action Team Mitigation Account Memorandum of Agreement between the Renewable Energy Action Team Agencies and the National Fish and Wildlife Foundation, May 2010.
7 California Energy Commission, *Implementing the Renwable Energy Executive Order,* http://www.energy.ca.gov/33by2020/, accessed August 2011.
8 National Public Radio, *California Desert Becomes Home for Renewable Energy,* http://www.npr.org/templates/story/story.php?storyId=102679730, accessed August 2011.
9 California Energy Commission, *Implementing the Renewable Energy Executive Order,* http://www.energy.ca.gov/33by2020/, accessed August 2011.

impacts of this development, and when complete, the DRECP will provide the regulatory framework necessary to support investment in renewable energy resources and related transmission, while ensuring effective protection and conservation of the State's wildlife, plants, and natural communities.

As part of the DRECP, the California Renewable Energy Permit Team (REPT) was established to facilitate coordination between agencies to develop guidelines for siting, developing, permitting, and constructing qualified RPS projects in the Mojave and Colorado Desert regions while enhancing and maximizing environmental protections. REPT goals and objectives are to cooperate in developing BLM's Solar Energy Development Program, develop a multispecies conservation strategy (the DRECP) to facilitate and streamline compliance with all applicable State and federal laws, develop BMPs and interim guidelines to assist in siting projects in suitable locations, and to minimize environmental impacts by guiding development and construction of qualified RPS projects pending completion of the DRECP. The REPG is also required to participate in the DRECP and to work with the Solar PEIS and RETI efforts.

This cumulative effects analysis addresses the potential for several significant, interrelated regional plans and programs addressing land use, energy development and open space / conservation to result in environmental effects that could compound or increase those associated with the proposed Project. Five regional plans and programs are evaluated: the West-Wide Energy Corridor Program (West-wide Program; #31), BLM's Solar Energy Development Program (Solar Program, #10), the Renewable Energy Transmission Initiative (RETI, #30), the California Desert Renewable Energy Conservation Plan (DRECP, #9), and the California Desert Protection Act of 2011 (CDPA, #11). Each of these plans and programs is described below and summarized in **Table 5-2**:

- **West-wide Energy Corridor Program – Section 368 Federal Energy Corridors** (Figure 5-1 and Table 5-2, #31)**.** Section 368 of the Energy Policy Act of 2005 (the Act), Public Law 109-58 (H.R. 6), enacted August 8, 2005, directs the Secretaries of Agriculture, Commerce, Defense, Energy, and the Interior to designate under their respective authorities corridors on federal land in 11 Western States (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities (energy corridors). In response, the Agencies conducted a detailed programmatic environmental analysis and prepared the West-wide Energy Corridor PEIS that examined the long-term needs of increased energy infrastructure in the West and evaluated potential impacts associated with the designation of these multi-modal energy corridors. The proposed designation of more than 6,000 miles of Section 368 energy corridors among the various Agency land use plans would not result in any direct impacts on the ground that may significantly affect the quality of the human environment. One 368 Federal Energy Corridor crosses the Project vicinity to the north, along Old US 66, and another is located about 30 miles south of the Project site, along the I-10 corridor.

- **Renewable Energy Transmission Initiative (RETI) / Competitive Renewable Energy Zones (CREZs)**[10] (Figure 5-1 and Table 5-2, #30). The State of California, through the California Energy Commission, is identifying key linkages throughout the State to tie the existing and potential new transmission lines to the most promising energy sites with the least environmental impacts. Phases 1 and 2 of the RETI resulted in the identification of CREZs, focusing on already-disturbed or less-sensitive lands close to existing or planned transmission systems, which are areas that hold the greatest potential for cost-effective and environmentally responsibly renewable development.[11] Land use, water use, and other environmental considerations, including the following factors, were considered during the CREZ identification process: proximity to existing infrastructure and highways; availability of wastewater resources for cooling and cleaning; previously disturbed sites; contaminated sites (agricultural or industrial); minimizing impacts to sensitive areas (Category 1 and Category 2 lands); efficiency of the production of electricity; output per acre; capability of accommodating more than one source of power; minimization of impacts on scenic resources; biological resources (species richness/diversity and number/type of onsite habitat types).
- Of the 32 RETI CREZs in California, two are located in the Project vicinity: the Twentynine Palms CREZ and the Iron Mountain CREZ. The Iron Mountain CREZ lies parallel to and overlaps slightly with the Project area along the ARZC ROW and near the CRA tie-in. The Iron Mountain CREZ has an estimated capacity of 4,800 MW solar thermal and 62 MW wind, for a total 4,862 MW, and it ranked 32 of 32 (last) in terms of affordability (average weighted cost per MW). The proposed Twentynine Palms CREZ is located about 25 miles west of the Project site and has an estimated capacity of 1,805 MW solar thermal. The Twentynine Palms CREZ ranked 17 of 32 (with 1 being best) in affordability. Currently, there are 6 solar projects or proposals in the Twentynine Palms CREZ (SEPV2, SEPV8, SEPV9, 29 Palms PV, Wonder Valley PV, and Cascade Solar).[12]
- **BLM's Solar Energy Development Program** (Figure 5-1 and Table 5-2, #10)**.**[13] The BLM is developing a new Solar Program in six western States (Arizona, California, Colorado, New Mexico, Nevada, and Utah). BLM prepared a Draft PEIS for the Solar Program that evaluates a no action alternative and two action alternatives—the Solar Energy Development Program Alternative and the Solar Energy Zone (SEZ) Program Alternative. Under the no action alternative, only BLM-administered lands currently prohibited from development by law, regulation, Presidential proclamation or Executive Order (e.g., lands in the National Landscape Conservation System) would be excluded from development. Under the Solar Energy Development Program Alternative, the preferred alternative, additional lands would be excluded, including lands that (1) have slopes greater than or equal to 5 percent, (2) have solar insolation levels below 6.5

10 California Energy Commission, *Renewable Energy Transmission Initiative Phase 2B Final Report*, May 2010.
11 Bureau of Land Management, *Energy Policy Act of 2005, Section 211*, August 2005.
12 California Energy Commission, *Renewable Energy Action Team Generation Tracking Projects, California Desert Protection Act of 2011 and Draft Proposed Competitive Renewable Energy Zones*, October 2011.
13 U.S. Department of Interior, Bureau of Land Management and U.S. Department of Energy, *Draft Environmental Impact State on Solar Energy Development in Six Southwestern States*, December 2010.

kWh/m2/day, and (3) have known resources, resource uses, or special designations identified in local land use plans that are incompatible with solar energy development. A subset of the lands that would be available for ROW application under the Solar Energy Development Program Alternative would be identified as SEZs (i.e., areas with few impediments to utility-scale production of solar energy where the BLM would prioritize solar energy and associated transmission infrastructure development). Under the Solar Energy Development Program Alternative, 22 million acres of BLM land would be opened to solar development.

The SEZ Program Alternative would focus solar development on 676,000 acres of SEZs; only the lands within the proposed SEZs would be available for ROW application. In California, approximately 11,067,366 acres of land would be available for ROW application under the no action alternative, and 1,766,543 acres of land would be available under the Solar Energy Development Program Alternative.

The SEZs would provide directed, landscape-scale planning for future solar projects and allow for a more efficient permitting and siting process. The BLM identified 24 SEZs based on criteria including quality of solar resources, suitable slope, proximity to roads and transmission, acreage, and the conservation value of the land. Four SEZs were identified in California: Imperial East (5,722 acres), Iron Mountain (106,522 acres), Pisgah (23,950 acres), and Riverside East (202,896 acres). The Iron Mountain SEZ was the one SEZ proposed within proximity to the Project. It was to be located on BLM-administered land in Ward Valley adjacent to and overlapping parts of the Project's proposed conveyance pipeline route and CRA tie-in facility. However, in October 2011, BLM issued a Supplement to the Draft Solar PEIR that revised the proposed plan, and modified the preferred alternative to reflect only 17 remaining solar energy zones totaling about 285,000 acres for development.[14] Zones that had development constraints or serious resource concerns were refined or removed. The Iron Mountain SEZ was one of the zones eliminated from further consideration. Thus, energy development in this particular zone, which might have occurred in proximity to the Project and potentially contribute to cumulative effects, is no longer proposed.

- **DRECP** (Figure 5-1 and Table 5-2, #9). As described above, ES S-14-08 mandated the development of the DRECP and established the REAT to oversee the implementation of the DRECP, consisting of the CEC, CDFG, BLM, and the USFWS. Other participating agencies include the CPUC, California Independent System Operator, NPS, USEPA, and the Department of Defense. The DRECP is intended to advance state and federal conservation goals while facilitating and streamlining the review, approval, and timely permitting of renewable energy projects within California's desert regions. Projects will include large-scale solar thermal, solar PV, wind, and other forms of renewable energy, and associated infrastructure such as electric transmission lines. The planning goals of the DRECP include the following:

[14] U.S. Department of Interior, Bureau of Land Management and U.S. Department of Energy, *Supplement to Draft Environmental Impact State on Solar Energy Development in Six Southwestern States*, October 2011.

a. Build on the Competitive Renewable Energy Zones identified by RETI;

b. Further identify the most appropriate locations within the DRECP Planning Area for the development of utility-scale renewable energy projects;

c. Provide a means to implement Covered Activities in a manner that complies with the Natural Communities Conservation Planning Act (NCCPA), FESA, CESA, NEPA, CEQA, and other relevant laws;

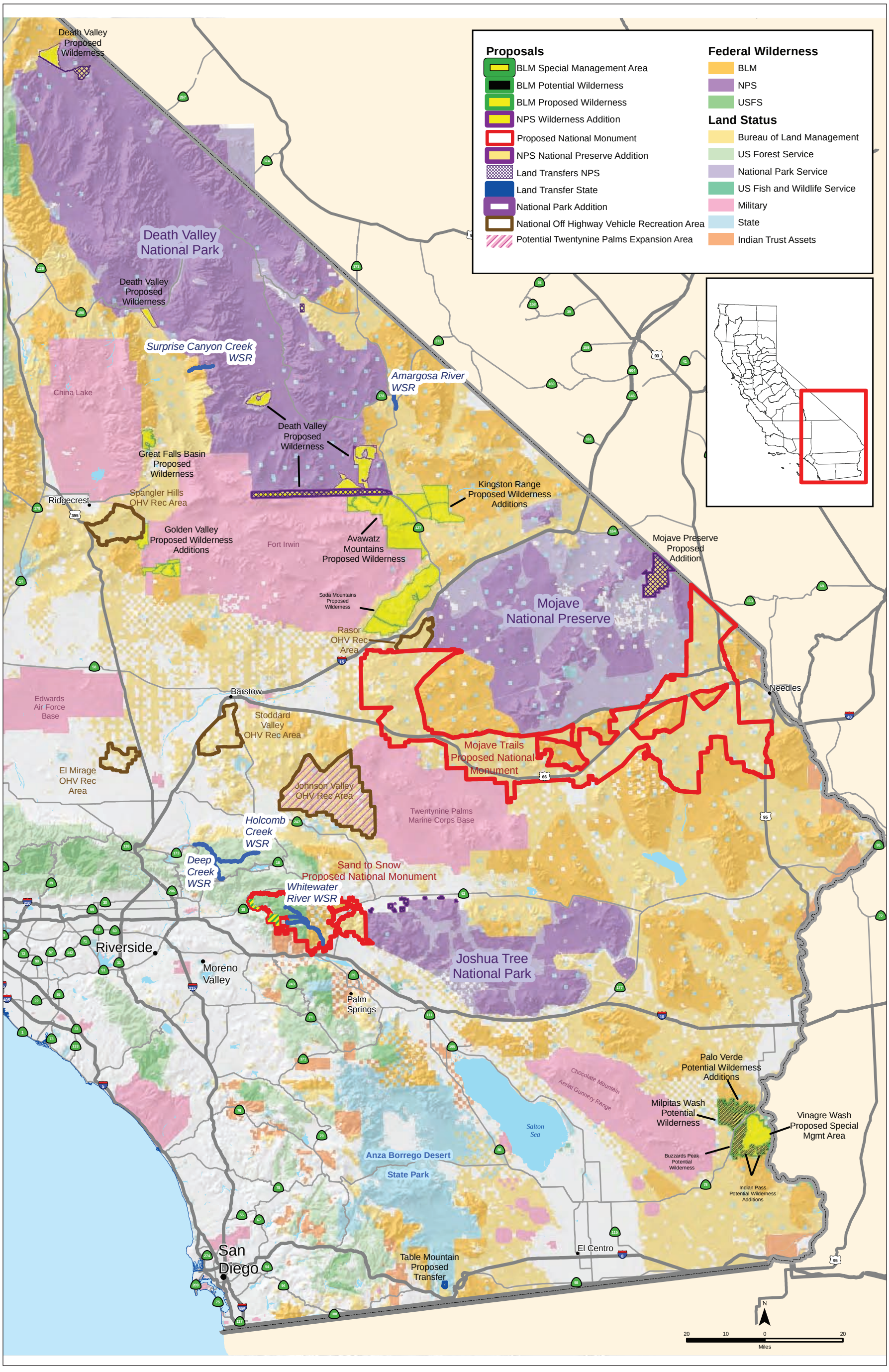
d. Provide a framework for a more efficient process by which proposed renewable energy projects within the Planning Area may obtain regulatory authorizations and which results in greater conservation values than a project-by-project, species-by-species review; and

e. Identify and incorporate climate change adaptation research, management objectives, and/or policies into the final plan document.

The DRECP is an HCP/NCCP that is intended to resolve conflicts between threatened and endangered species and renewable energy development by allowing solar and other qualified RPS energy development in a manner that avoids or minimizes environmental impacts. "Covered Species" in the DRECP are those species for which conservation actions will be implemented and for which the participating entities will seek authorization for take under the NCCP Act and Section 10 of the FESA. Initial analysis resulted in the following list of covered species: Mojave monkeyflower, Arroyo toad, desert tortoise, burrowing owl, Swainson's hawk, Mohave ground squirrel, and bighorn sheep. The list of proposed Covered Species will continue to be evaluated and revised throughout development of the DRECP. Currently the REAT is preparing the joint EIR/EIS for the DRECP. The goal is to complete the DRECP in 2.5 years; by June 1, 2012, the final DRECP should provide binding, long-term endangered species permit assurances, facilitate the Mojave and Colorado Desert project approval process, and provide a vehicle for federal and state conservation funding to implement the DRECP.

5.2.2 Open Space / Conservation Plans

Introduced by Senator Dianne Feinstein (D-CA) in January 2011, the proposed California Desert Protection Act of 2011 (CDPA) (S.138) (**Figure 5-2** and Table 5-2, #11) would preserve approximately 1.6 million acres of public lands, create two new National Monuments, expand Joshua Tree and Death Valley National Parks and the Mojave National Preserve, and establish new wilderness areas and wild and scenic river segments throughout Southern California. The bill would also preserve historic trails, Native American cultural areas, and portions of Old US 66. The CDPA seeks to protect designated lands in order to focus, guide, and mitigate renewable energy development projects on already-disturbed or private lands, preserve habitat for rare and sensitive species, and balance recreational opportunities in the California desert. If enacted, the CDPA would establish the following:



SOURCE: BLM, 1/27/2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 5-2

Proposed California Desert Protection Act of 2011

This page left intentionally blank

- The Mojave Trails National Monument (approximately 941,413 acres), which would link Joshua Tree National Park with Mojave National Preserve and 13 wilderness areas with a 941,413 acre monument. The National Monument status would protect existing land uses, including Old US 66, and would improve existing wildlife corridors. The proposed National Monument aims to direct renewable energy development away from pristine public lands and onto consolidated federal Solar Energy Study Areas and along existing transmission lines. A portion of the proposed Monument is adjacent to the northern border of the proposed Project.
- The Sand to Snow National Monument (approximately 133,524 acres) between Joshua Tree National Park on the east and the San Gorgonio Wilderness in the San Bernardino National Forest to the west. Access points would be from SR-38, SR-62, and I-10. The proposed Monument contains two of the most critical wildlife movement corridors in southern California, would link Joshua Tree National Park to the Santa Rosa and San Jacinto Mountains National Monument, and is located at a unique convergence point between the Mojave and Sonoran deserts, Inland Valleys, and mountain environments, creating a potential evolutionary hotspot and area of tremendous biological diversity. The proposed Sand to Snow National Monument is located about 100 miles southwest of the project site.

Among many other activities, the CDPA would enlarge Joshua Tree National Park by approximately 2,900 acres along the northern boundary, between Yucca Valley and Twentynine Palms. The expansion area includes prime habitat for the desert tortoise and burrowing owl, wildlife connectivity corridors for bobcats and bighorn sheep, and excellent habitat for LeConte's thrasher, a CDFG species of special concern. The proposed CDPA would also enlarge Death Valley National Park by approximately 40,740 acres; enlarge four existing wilderness areas by 172,247 acres, including the Death Valley National Park Wilderness (90,152 acres), Golden Valley Wilderness (21,633 acres), Kingston Range Wilderness (53,321 acres) and San Gorgonio Wilderness (7,141 acres); and add three areas encompassing 173,861 acres to the National Wilderness Preservation System, including the Avawatz Mountains Wilderness (86,614 acres), Great Falls Basin Wilderness (7,871 acres) and Soda Mountains Wilderness (79,376 acres).

TABLE 5-2
PLANS, PROGRAMS, AND PROJECTS EVALUATED IN THE CUMULATIVE EFFECTS ANALYSIS

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
GENERAL PLANS						
A	**--**	County of San Bernardino General Plan	Guides land use and planning in the County and future development; facilitates economic development; enhances neighborhoods and commercial areas; and ensures adequate infrastructure, services and facilities are present to support projected growth. The Project is exempt from County zoning ordinances and no CUP is required because facilities "related" to water receive qualified immunity, subject to confirmation by SMWD at a public hearing (Gov. Code § 53096(b)). The General Plan EIR[15] requires projects in the Desert Region to mitigate impacts on biological resources to less than significant in order to obtain permits. The General Plan policies are considered provisionally to assess Project consistency.	The Project area is in the Desert Region within unincorporated portions of San Bernardino County zoned for resource conservation (RC) and agriculture (AG).	The General Plan was adopted March 13, 2007. A draft supplement amendment, the Greenhouse Gas Reduction Plan[16] was prepared in March 2011.	Aesthetics, Agriculture, Air Quality, Biological Resources, Fire Hazard, and Traffic. Project would not conflict with General Plan goals or policies, preclude continued agricultural use, or prevent agricultural expansion into adjacent AG-zoned lands to the west. Regional development would have construction and operational impacts on scenic resources, AG conversion, air quality, biological resources, fire hazards, and traffic.
B	3	Yucca Valley General Plan Update / SR-62 Realignment	The Town of Yucca Valley is updating their General Plan,[17] which will, among other things, evaluate traffic and circulation alternatives for re-routing SR-62 around the Old Town planning area. The General Plan Update process will be coordinated with other agencies, including Riverside County and Caltrans.	The Town of Yucca Valley is approximately 50 miles west of the Project area. Vehicles would use SR-62 to access Project site.	The General Plan Update process began in 2011 and is expected to take 2 years. Certification of the EIR is anticipated to occur in 2013.	Traffic. SR-62 is the primary transportation corridor in the region, connecting the Morongo Basin, Town of Yucca Valley, community of Joshua Tree, and Twentynine Palms to the I-10 and Riverside County.
ENERGY PROJECTS, PLANS, and PROGRAMS						
C	30	Renewable Energy Transmission Initiative (RETI) / Competitive Renewable Energy Zones (CREZs)	Statewide initiative to identify, designate, and facilitate the permitting and development of renewable energy and associated transmission projects. 32 Competitive Renewable Energy Zones (CREZs) have been identified in California: areas that can be developed in a cost effective and environmentally benign, responsible manner. There are 2 CREZs in the Project vicinity: the Twentynine Palms CREZ and Iron Mountain CREZ (Black & Veatch, 2010).[18] Iron Mountain ranks last and Twentynine Palms ranks 17 of 32 in affordability.	The Iron Mountain CREZ (~40,000 acres) lies parallel to and overlaps slightly with the Project area along the ARZC ROW, near the CRA tie-in. The Twentynine Palms CREZ (~18,256 acres) is 25 miles west.	Transmission segments and CREZs have been identified and detailed environmental and cost assessments have been conducted[19]. There is one pending application in the Iron Mountain CREZ and 6 solar projects in the Twentynine Palms CREZ.[20]	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with up to 4,800 MW solar thermal and 62 MW wind, for a total 4,862 MW within Iron Mountain CREZ and up to 1,805 MW solar thermal at Twentynine Palms CREZ.

15 County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006, pages I-3 through I-26.
16 Pacific Municipal Consultants, *General Plan Amendment and Greenhouse Gas Reduction Plan, Draft Supplemental Program Environmental Impact Report*, March 2011.
17 Town of Yucca Valley, *General Plan*, March 2011.
18 California Energy Commission, *Renewable Energy Transmission Initiative Phase 2B Maps*, July 2010.
19 California Energy Commission, *Renewable Energy Transmission Initiative Phase 2B Final Report*, May, 2010.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
D	9	California Desert Renewable Energy Conservation Plan (DRECP)	DRECP[21] will be an NCCP that facilitates and streamlines the approval and permitting of renewable energy projects in the Desert Region and serves as the basis for one or more HCPs under FESA. Projects will include large-scale solar thermal, solar PV, wind, and associated infrastructure / transmission. Covered species include Mojave monkeyflower, Arroyo toad, desert tortoise, burrowing owl, Swainson's hawk, Mojave ground squirrel, and bighorn sheep. Goal is to complete the DRECP by 6-1-12.	Covers the Project area (Figure 5-1); will apply to renewable energy projects in the Planning Area.[22] Six REAT Solar Projects located 31 miles and 42 miles west of the Project site, respectively.	The Best Management Practices and Guidance Manual and the DRECP Framework Conservation Strategy and starting point maps are complete. Currently the REAT is preparing the joint EIR/EIS for the DRECP.	Biological Resources. The final DRECP will provide binding, long-term endangered species permit assurances and facilitate the project approval process for renewable energy projects in the Planning Area, including projects within the nearby CREZs and SEZ and associated transmission corridors.
E	**31**	West-wide Energy Corridor Program	Federal directive to designate corridors[23] on federal land for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (energy corridors). Of the 6,000 miles of Federal 368 Energy Corridors designated across 11 States, two 368 Energy Corridors are located in the Project vicinity, along Old US 66 and I-10, respectively. The Corridor nearest the Project site extends from Barstow to the Nevada border, following I-40 and Old US 66 northwest of the Project site. Northeast of the Project site, the alignment veers directly north and travels along / adjacent to (but outside of) the Mojave National Preserve before heading east into Nevada[24].	One 368 Federal Energy Corridor traverses the northernmost portion of the Project area, intersecting the proposed wellfield and spreading basin areas along Old US 66. A second corridor is located 30 miles south of the Project site along the I-10.	Agency-specific RODs were issued by both the BLM and the U.S. Forest Service on January 14, 2009. An evaluation of site-specific impacts at the local project level will occur in the event that a project proposal is submitted for consideration.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with transmission corridor projects north and south of the Project site.
F	**10**	BLM Solar Energy Development Program	BLM is evaluating utility-scale solar energy development in Arizona, California, Colorado, Nevada, New Mexico, and Utah. The Draft Solar PEIS[25] analyzes a no action alternative, the Solar Energy Development Program Alternative under which 22 million acres of BLM land would be opened to solar development, and the SEZ Program Alternative that would focus solar development on 676,000 acres of SEZs. The BLM identified 24 SEZs, four in California. The proposed Iron Mountain SEZ, located on BLM-administered land in Ward Valley, was the closest SEZ to the project area and would have overlapped with the area proposed for the Project conveyance pipeline and the CRA tie-in facility. However, the Iron Mountain Sez was eliminated from further consideration as part of a revised program	The Iron Mountain SEZ (106,522 acres) was located immediately adjacent to and overlapping the proposed Project area along the ARZC ROW and near the CRA tie-in. The proposed SEZ surrounded several Cadiz parcels. This SEZ has been eliminated from further consideration	On October 27, 2011, BLM issued a Supplement to the Draft Solar PEIS to update the proposed program. As part of the update, the Iron Mountain Sez (among others) was eliminated from further consideration.	Because the Iron Mountain SEZ has been eliminated from further consideration, energy development previously anticipated and described in the BLM Solar PEIS is no longer anticipated. Therefore no cumulative effects are analyzed for this program.

20 California Energy Commission, *Current Renewable Energy Transmission Initiative Projects*, August 2011.
21 Desert Renewable Energy Conservation Plan, http://www.drecp.org/, accessed September 2011.
22 Desert Renewable Energy Conservation Plan, *Boundary Area Map*, February 2011.
23 Argonne National Laboratory, *Proposed Section 368 Energy Corridors*, November 2008.
24 Argonne National Laboratory, *Visual Resources Analysis Map Series*, 2008.
25 Solar PEIR, http://solareis.anl.gov/maps, accessed September 2011.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
			proposal released by the DOE and BLM in October 2011. As a result, no cumulative effects associated with the BLM program would occur.			
G	**1**	SEPV2 Solar PV Electricity Generation Facility	SEPV2, LLC/Solar Electric Solutions, LLC (SEPV2) would establish a 2 MW photovoltaic (PV) solar electricity generation facility on a 20-acre parcel. The site will house all structures, including solar panels, tracking/support structures, and interconnection facilities, all of which will be enclosed by a perimeter chain-link fence. The project would provide enough power for approximately 900 average-sized homes. Electricity would be collected and transported to the grid via an overhead connection to an existing 25 kV SCE line adjacent the project site. The project would be constructed over a four-month period by 12 workers per day. Construction would be completed by the third quarter of 2011.	SEPV2 is 42 miles west of the Project area and located in Twentynine Palms, CA (southwest corner of Lear Avenue and Cove View Road).	The Notice of Availability for an Initial Study was published on January 10, 2011. The San Bernardino County Land Use Services Department intends to adopt a Mitigated Negative Declaration for the project.[26]	Air Quality, Biological Resources, GHG, Transportation. Typical construction and operation impacts associated with development. Cumulative impacts to desert tortoise. Vehicles would likely utilize SR-62.
H	**4**	29 Palms PV Project	Independent Energy Solutions, Inc. (IES) constructed a 213 kW (dc) solar electric (photovoltaic) carport / shade structure installation at the Marine Corps Air Ground Combat Center in Twentynine Palms. The system can generate about 312,000 kW-h of electricity annually while providing shade and cover for parked cars. It produces enough electricity to power 28 average single-family homes and will offset about 405,000 pounds of greenhouse gases annually – the environmental equivalent of taking 52 cars off the road[27].	29 Palms PV is 31 miles west of the Project area.	On July 22, 2011, IES announced completion and "powering-up" of the project.	Biological Resources, Transportation. Cumulative impacts to desert tortoise. Trucks would likely utilize SR-62.
I	**24**	SECP Development Company	Conditional Use Permit to establish a 100 MW solar PV power generating facility on 560 acres[28].	SECP is 16 miles west of the Project area (APN 0592-251-01-0000).	Conditionally Approved	Transportation. Trucks would utilize SR-62.

[26] County of San Bernardino, *Land Use Services Projects*, http://www.sbcounty.gov/landuseservices/Public%20Notices/Projects/Projects.htm, accessed September 2011.
[27] PR Newswire, *29 Palms PV Project Press Release*, http://www.prnewswire.com/news-releases/independent-energy-solutions-powers-up-new-us-marine-corps-solar-project-in-29-palms-126215078.html, accessed September 2011.
[28] County of San Bernardino Planning Department, *Accepted Application APN 0592-251-01-0000*, October 2010.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
J	6	Rice Solar Energy Project (RSEP)	RSEP[29] proposes a 150 MW power tower facility in eastern Riverside County. The facility would use concentrating solar power (CSP) technology, with a central receiver tower and an integrated thermal storage system. The proposed technology generates power from sunlight by focusing energy from a field of sun-tracking mirrors called heliostats onto a central receiver. The proposed 2011 to 2013 (30-month) construction period would require 780 AFY of water. Process water requirements for facility operations, commencing by the end of 2013, would be up to 180 AFY, assuming an operating capacity factor of 37 percent.	1,410 acres of a privately-owned 2,560-acre parcel in eastern Riverside County, 6 miles southeast of the Project area, south of SR-62.	RSEP was approved on 12/15/2010.[30]	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with 150 MW facility. Site access would be via SR-62. Propane would be used for auxiliary heating. The workforce would average 280 construction workers and 47 full-time staff, mostly locals (CEC 2009).
OPEN SPACE / CONSERVATION PLANS						
K	11	California Desert Protection Act (CDPA) of 2011	If approved, the CDPA[31] would create two new National Monuments, expand Joshua Tree and Death Valley National Parks and the Mojave National Preserve, and establish new wilderness areas throughout Southern California. The Bill would preserve about 1.6 million acres of public lands, including historic trails, Native American cultural areas, and portions of Old US 66. The Mojave Trails National Monument [32] would link Mojave National Preserve and 13 wilderness areas with the 941,413 acre monument and direct renewable energy development away from pristine public lands and towards federal Solar Energy Program Areas.	Figure 5-2 depicts the proposed spreading basin area for the Phase 2 Imported Water Storage Component would overlap slightly with the southernmost portion of the proposed Mojave Trails National Monument.	Senator Feinstein reintroduced CDPA 2011, S.138 on January 25, 2011. and the Bill was referred to the Senate Energy & Natural Resources Committee. No action has been taken in Committee as of September 2011.	Aesthetics, Air Quality, GHG, Biological and Cultural Resources, Land Use. Protections placed on large swaths of land in the Project area would render them undevelopable and thereby protect aesthetic, biological, and cultural resources in these areas.
DEVELOPMENT AND INFRASTRUCTURE PROJECTS						
L	5	Marine Corps Base Expansion[33]: Land Acquisition and Airspace Establishment to Support	The Marine Corps is studying alternatives for a large-scale training facility that would accommodate a new program of sustained, combined-arms, live-fire, and maneuver training for a Marine Expeditionary Brigade-sized Marine Air Ground Task Force. The project would expand the existing air and ground operating areas at the Combat Center to establish the required sized facility for the training. Three major components include acquisition of land next to the existing Combat Center, modification and establishment of special use	Current Base boundary is 12 miles west of Project area. One of the land acquisition alternatives (Alternative 3) overlaps substantially with the Project area and, if chosen, would render the Project	The Final EIS is scheduled for release in December 2011. The Department of the Navy plans to issue an ROD in April 2012.	Air Quality, Biological Resources, GHG, Land Use, Transportation. Depending on the alternative, potential take of 19 to 725 desert tortoise and impacts on up to 130,000 acres of desert tortoise habitat. Acquisition of up to 200,000 acres would close two active mines and conflict with AG zoning on the Project site. From 6,

29 Rice Solar Energy Project, http://ricesolarenergy.com, accessed June 2011.
30 California Energy Commission, *Rice Solar Energy Project*, http://www.energy.ca.gov/sitingcases/ricesolar/index.html, accessed May 2011.
31 Campaign for the California Desert, http://www.californiadesert.org/, accessed September 2011.
32 Campaign for the California Desert, *Mojave Trails National Monument*, http://www.californiadesert.org/places/mojave_trails_national_monument, accessed September 2011.
33 U.S. Marine Corps, Twentynine Palms Marine Corps, *Land Acquisition and Air Space Establishment Study Updates,* http://www.marines.mil/unit/29palms/LAS/pages/updates.aspx, accessed July 2011.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
		Large-Scale Marine Air Ground Task Force Live Fire and Maneuver Training	airspace, and expanded training. Nearly 20,000 public comments have helped to develop a range of reasonable alternatives to meet MEB training requirements, including an "Alternative 6", the DEIS preferred alternative. Alternative 6 would accommodate continued public access to 40,000 acres in the West Study Area. Alternative 3 proposes to add approximately 22,000 acres of land to the South and approximately 177,000 acres to the East of the 29 Palms Base.	infeasible (this Alternative has not been selected as the preferred alternative in the PEIS). The proposed land acquisition areas total 380,000 acres.		000-10,000 Marines (up to 12,000) would arrive via bus (~200 buses) over ~10 days via SR-62, with up to 200 buses arriving same day. In addition, up to 40 instructor vehicles would travel on SR-62 up to 30 days annually.
M	**7**	Twentynine Palms Mine Expansion	Granite Construction Company proposes a Conditional Use Permit (CUP) and Reclamation Plan, Development Agreement, and General Plan Amendment/Zone Change [from RL 2.5(Rural Living) to CI (Community Industrial)] for a 356-acre mine expansion at an existing 113.5-acre mine site (for operations through 2092). 178 acres would be mined, with the remaining 178 acres set aside for habitat conservation. Current operations distribute sand, gravel asphalt and ready-mix concrete throughout the region; expanding the Mine would allow Granite to continue to meet these needs.[34]	The expansion area is located 36 miles west of the Project area on 7451 Mojave Road; 1 mile south of SR-62 in Twentynine Palms.	On March 24, 2011, the Twentynine Palms City Council, Center for Biological Diversity, Desert Tortoise Council and Granite Construction agreed to reduce the construction footprint from 178 acres to ~15 acres. Granite must seek Federal and State approval to expand beyond 15 acres.	Biological (desert tortoise, burrowing owl), GHG, Transportation. Trucks would utilize SR-62. Impacts to desert tortoise would contribute to cumulative impacts to the species.
N	**8**	Desert Xpress High-speed Passenger Train Project	DesertXpress proposes a fully grade-separated, double-track passenger-only railroad along an approximately 200-mile corridor between Victorville, California and Las Vegas, Nevada. The project would bring 35,000 jobs to Clark County and several thousand more jobs to southern California once the project begins.	At its nearest point, the project is located 57 miles northwest of the Project area.	The FRA issued the ROD on July 8, 2011.[35] The company aims to break ground before the end of 2012. [36]	Air Quality, Biological Resources, GHG, Transportation. Trucks would utilize I-40, Old US 66, I-95, and SR-62. Cumulative impacts to desert tortoise.
O	**29**	Caltrans Improvements on I-95 / SR-62	Caltrans contracted with Granite Construction Company, Inc. for cold in-place recycling, overlay with HMA (type A), and shoulder backing services from Vidal 1.2 miles west on Blythe / Rice Road to 3.8 miles west of the I-95/SR-62 separation[37]. Granite is responsible for a stormwater pollution prevention plan (SWPPP) that is required for the project.	The project is 17 miles east of the Project area, along SR-62.	Caltrans awarded the contract on May 27, 2011 and the work is anticipated to be completed by June 14, 2011.	Transportation. Improved road conditions following construction.

[34] KCDZ FM, http://www.kcdzfm.com/news/fullstory032411.html, accessed July 2011.
[35] U.S. Department of Transportation Federal Railroad Administration, *Record of Decision, DesertXpress High-Speed Passenger Train*, July 2011.
[36] Federal Railroad Administration, *DesertXpress – Las Vegas to Victorville*, http://www.fra.dot.gov/rpd/freight/1703.shtml, accessed July 2011.
[37] State of California Department of Transportation, *Statement of Ongoing Contracts as of 06/20/11*, June 2011.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
P	**2**	Wilson, James W – Recreational Vehicle Park.	A conditional use permit to establish a 7.33-acre RV park / campground consisting of 27 spaces for RVs, a 532-SF residence with a 361-SF carport, a 324-square foot caretaker's residence, a 239-SF building with a 400-SF covered patio to be used as a convenience store and snack bar, a 180-SF storage building, a 50-SF storage building and a 450-SF carport on 7.33 acres. The site is regulated by the Biological Resources and Paleontological Resources Overlays.	The Vehicle Park is located 2 miles northeast of the Project area in Cadiz, California, on the south side of Old US 66 and approximately 1,200 feet west of Cadiz Road.	The San Bernardino County Land Use Services Department completed an Initial Study and adopted a Mitigated Negative Declaration[38].	Air Quality, Biological Resources (burrowing owl), Cultural Resources, GHG, and Transportation (Old US 66). Typical construction impacts associated with development. Operational impacts on Old US 66.
Q	**2**	Natural Gas Line 1903 Pipeline Conversion Project	The Line 1903 project converted the 304-mile crude oil All American Pipeline pipeline to natural gas service[39]. As part of the conversion, a lateral extension was constructed in Cadiz to connect Line 1903 tothe existing Mojave Natural Gas Pipeline (Line 1900).	304 miles of pipeline from Ehrenberg, Arizona to Wheeler Ridge near Bakersfield. The Cadiz lateral pipeline and facilities are located on private land and BLM lands. Some portions of the pipeline that was converted is at the Project area.	The Finalizing Addendum to the EIR was certified on April 26, 2005, by the California State Lands Commission. A portion of the pipeline was converted in 2005-2006 and mitigation monitoring was completed in 2006. A large portion of pipeline around Tehachapi was not completed.	Utilities. Coordination with existing utilities is required to avoid impacts to underground lines.
R	**16, 19, 20**	Minor Subdivisions	Proposed subdivision of a parcel or parcels of land shown as a unit under a common ownership, and that is proposed for subdivision for the purpose of sale, lease, financing, or other conveyance, into two, three or four lots, parts or parcels and a remainder parcel. The following proposals are under consideration: • Bryan Case - Minor subdivision to create two parcels on 1,840 acres. APN 0592-251-01-0000. Accepted.[40] • Galstian, Andranik Eddie. Tentative Parcel Map 19157 to create four parcels on approximately 157 acres. APN 0626-131-07-0000. Accepted.[41] • Galstian, Andranik Eddie. Tentative Parcel Map 19158 to create four parcels on approximately 147 acres. APN 0626-231-13-0000. Accepted.[42]	The three minor subdivision proposals are located 16 miles west, 31 miles west, and 33 miles west of the Project area, respectively.	• The Bryan Case minor subdivision was accepted in October, 2010. • The Galstian, Andranik Eddie parcel map was accepted in January, 2011. • The Galstian, Andranik Eddie parcel map was accepted in January, 2011.	Land Use. Only impact associated with splitting parcels is land use-related. Future site-specific projects would be subject to individual environmental reviews. No projects are currently proposed.

38 County of Bernardino, *Land Use Services Department Projects*, http://www.sbcounty.gov/landuseservices/Public%20Notices/Projects/Projects.htm, accessed July 2011.
39 California State Lands Commission, *El Paso Line 1903 Pipeline Conversion Project*, http://www.slc.ca.gov/Division_Pages/DEPM/DEPM_Programs_and_Reports/El_Paso/ElPaso_PipelineConversion_DEIR.html, accessed September 2011.
40 County of San Bernardino Planning Department, *Accepted Application APN 0592-251-01-0000*, September 2010.
41 County of San Bernardino Planning Department, *Accepted Application APN 0626-131-07-0000*, January 2011.
42 County of San Bernardino Planning Department, *Accepted Application APN 0626-231-13-0000*, January 2011.

Table ID.	Map No.	Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
S	**18**	Flamingo Heights Ranch, LLC	a) General Plan Land Use Zoning District Amendment from Hv/Rl (Homestead Valley/Rural Living) to Prd (Planned Residential Development) on 640 acres; b) Tentative Tract Map 18537 to create 243 numbered lots and 3 lettered lots on 640 acres; c) Planned Residential Development for 243 units in 4 phases on 640 acres.[43]	The project is located 55 miles west of the Project area. APN 0629-181-01-0000	Accepted March, 2008	Air Quality, GHG, Land Use, Transportation. Construction- and operation-related air quality and GHG impacts. Vehicles would utilize SR-62.
T	**22**	Omdahl Development	a) General Plan Land Use Zoning District Amendment From SD-RES TO SD-RES (Prd-2008-Xx) On 15.60 Acres; b) Tentative Tract 18582 to create a one lot subdivision for condominium purposes on 15.60 acres; c) Planned Residential Development for 78 condominium units with amenities to include a community pool and a common recreation area on 15.60 acres.[44]	The development is located 38 miles east of the Project area. APN 0649-201-02-0000	Conditionally Approved	Air Quality, GHG, Transportation. Construction- and operation-related air quality and GHG impacts. Vehicles would utilize SR-62.
U	**25**	URIEL, GUY D	Conditional Use Permit to establish a motor sports facility with various support structures on 280 acres.[45]	The project is located 25 miles southeast of the Project area. APN 0647-061-08-0000	Conditionally Approved	Air Quality, GHG, Land Use, Transportation. Construction- and operation-related air quality and GHG impacts. Vehicles would utilize SR-62.

43 County of San Bernardino Planning Department, *Accepted Application APN 0629-181-01-0000,* March 2011.
44 County of San Bernardino Planning Department, *Accepted Application, APN 0649-201-02-0000,* 2007.
45 County of San Bernardino Planning Department, *Accepted Application, APN 0647-061-08-0000,* July 2006.

5.3 Cumulative Impacts Analysis

The potential cumulative contribution of the proposed Project, in conjunction with the other projects listed in Table 5-2, is discussed below by environmental resource area. There is only one area identified where the Project could make a cumulatively considerable contribution to a significant cumulative effect include:

- Air Quality – Construction emissions of NOx

No other cumulatively considerable contributions to significant cumulative effects would result with implementation of the Project.

5.3.1 Aesthetics

The Project viewshed is flat and characterized by wide open views. Generally good air quality and a lack of obstructions allow visibility for great distances under favorable atmospheric conditions. The Project site is in the viewshed of multiple congressionally designated wilderness areas, a scenic ACEC, and other specially designated federal lands. In addition to the proposed Project, other projects within the geographic scope that could result in visual impacts during construction or operation include the Rice Solar Energy Project, the West-wide Energy Corridor Program, , and the RETI and potential development within the proposed Iron Mountain CREZ. Collectively these developments concentrate development along two public transportation corridors: Old US 66 to the north, near the proposed Project wellfield, power distribution facilities, access roads, and spreading basins, and SR-62 to the south, near the ARZC ROW and CRA and the proposed pipeline alignment, Project staging areas, tie-in to the CRA, CRA diversion structure, and pump station(s). Based on the aggressive renewable energy goals in California and the focus on development within the desert region, it is highly likely that energy project development will occur in close proximity to the proposed Project. Construction activities associated with renewable energy projects would require the use and storage of heavy equipment in the Project vicinity. During construction, excavated trenches, stockpiled soils, equipment storage, and staging areas/activities would alter the quality of the visual environment along Old US 66 and SR-62. Because construction activities would be short-term and the majority of viewers would be driving, viewers would experience degraded views for a very short period of time, and construction-related visual impacts are considered less than significant.

Development of the proposed energy projects in the Project region could result in significant cumulative effects on aesthetics resources. However, the incremental effects associated with the permanent aboveground Project facilities would not be cumulatively considerable. Other projects include a multi-modal transmission corridor linking California to Nevada along Old US 66, a federal 368 energy corridor along I-40 and Old US 66, and development of solar and/or wind technology within the approximately 40,000-acre Iron Mountain CREZ and. While the exact nature of projects slated for construction within the federally-identified areas will depend on the specific proposals (location, size, technology, etc.), together, the RSEP and the CREZ would potentially cover approximately 60,000 acres of currently undeveloped lands with above-ground

renewable energy facilities that, collectively with other associated infrastructure (i.e., transmission), would significantly degrade the viewshed in the Project area, particularly from sensitive public vantage points in adjacent BLM Wilderness Areas. These projects would dominate the views for miles, even for remote viewers. Potential impacts could include night sky pollution, increased skyglow, light spillage, and glare; presence of industrial-looking facilities, loss of visual character and quality, and the general conversion of this remote, relatively undeveloped desert environment to a more commercial-industrial corridor.

In contrast, much of the Project infrastructure would be installed underground (43 miles of water conveyance pipelines, possibly power distribution facilities and interconnected wellfield pipelines), on private property (Cadiz Property, ARZC ROW, Metropolitan lands), and in remote areas not generally accessible by the public. Project facilities that would be visible above ground include the proposed spreading basins and possibly overhead power lines (power lines may be installed underground but if aboveground then power poles would be approximately 30 feet high) that could be visible from certain vantage points on publicly-accessible BLM lands as well as the proposed CRA tie-in facilities (tie-in, diversion structure, and one or more pump stations) which could be visible from SR-62 and Cadiz Road. However, as discussed in Section 4.1, Aesthetics, the Project would have less than significant effects on aesthetic resources. These Project facilities would not result in cumulatively considerable aesthetic impacts as they would have little effect on the overall view. The wellfield would appear as connected pads within a large undeveloped valley. If overhead powerlines are used instead of underground lines, impacts to the scenic quality of the area would be adversely affected. However, the 30-foot tall poles would blend into the long range views from local roads and surrounding areas and would not significantly affect the scenic vistas since the overhead lines would constitute a low intensity development in the desert area which is compatible with the long-range, generally uninterrupted views. In the area of the Proposed CRA tie-in facility there is already aboveground water infrastructure present and aboveground water features are not generally considered negatively by viewer groups. Implementation of Mitigation Measure **AES-1** would reduce light- and glare-related impacts to a less than significant level by requiring all lighting to be shielded and directed onto the Project site and away from adjoining property and public ROWs. Based on the limited footprint of the aboveground Project facilities and the implementation of Mitigation Measure **AES-1**, and the magnitude and type of development proposed along the energy corridors, the Project's incremental effect on aesthetic resources would not be cumulatively considerable.

5.3.2 Agriculture and Forestry Resources

The proposed Project would convert some agricultural land uses to other uses but would not preclude ongoing agricultural use of the Project site. Agriculture accounts for approximately 41,793 acres, or 2.32 percent, of County land area, and while the majority of the Project area is undeveloped, 9,600 acres of land in the Project vicinity and 2,295 acres of land within the Project site are zoned AG. Approximately 1,600 acres of active agricultural lands are located in the northeast portion of the Cadiz Property. The Project would avoid active agricultural areas to the maximum extent feasible in order to avoid direct impacts to agricultural lands. The proposed spreading basins and most of the expanded wellfield, as well as the rest of the Project

infrastructure, would be located in areas that are not zoned AG. As part of the Project, Cadiz may cease further agricultural irrigation and, therefore, it could remove some or all of the current 1,600 acres from production, which represents approximately 3.8 percent of the County's agricultural acreage. Therefore, construction and operation of the Project would not result in significant effects on agricultural resources.

Beyond the irrigated agriculture on the Cadiz Inc. Property, there is little agriculture activity in the Project vicinity and none of the other projects identified in eastern San Bernardino County (within the geographic scope for cumulative analysis of agricultural resources) would result in significant effects on agricultural uses or convert significant proportions of agricultural lands to non-agricultural uses. Therefore, the incremental effects of the proposed Project, when considered together with other projects listed in Table 5-2, would not result in a cumulatively considerable impact on agricultural resources.

5.3.3 Air Quality

The geographic scope of cumulative air quality impacts is the MDAQMD. Notably, any project that would individually have a significant air quality impact would also be considered to have a significant cumulative air quality impact.

As discussed in Section 4.3 Air Quality, with implementation of Mitigation Measures AQ-**1 through AQ-5**, Project emissions would meet MDAQMD significance thresholds for criteria air pollutants and be less than significant except for NOx emissions. NOx emissions during construction would exceed MDAQMD thresholds and remain a significant and unavoidable effect of Project construction. As shown in Table 4.3-6, the projected long-term operational emissions associated with the Project, however, would be less than significant.

Other projects that would contribute to cumulative impacts on air quality are shown in Table 5-2. (Please note that Table 5-2 only includes projects in the general vicinity of the proposed Project and does not purport to list all construction projects within the MDAQMD). Concurrent construction of the Project, together with other projects in the air basin, would generate emissions of criteria pollutants and toxic air contaminants, including suspended and inhalable particulate matter and equipment exhaust emissions. Because the Project construction alone would exceed significance thresholds established by the MDAQMD for activities and operations within the high desert portion of the Mojave Desert Air Basin, when considered in conjunction with overlapping construction projects in the MDAQMD, its contribution to cumulative air quality impacts are cumulatively considerable.

Project operations would not create emissions that would exceed the MDAQMD thresholds due to minimal daily operational trips and low emissions from engine operations (see Table 4.3-6). Long-term Project operations would not result in significant cumulative impact.

5.3.4 Biological Resources

Though development and growth in the Project vicinity has been infrequent and sporadic over the last 50 years, regionally, renewable energy development in the Mojave and Sonoran Deserts has recently increased and with it, impacts to biological resources have and will continue to increase. The cumulative projects listed in Table 5-2 and depicted in Figure 5-1 demonstrates that development pressure is increasing in the Project area due to (1) identification of renewable energy development zones (i.e., CREZs) in the Project vicinity for which streamlined project approval and permitting is anticipated; (2) the number, magnitude, and concentration of proposed projects; and (3) the number of acres/areas set aside and/or proposed to be set aside for conservation and resource protection (by preserving 1.6 million acres of public lands throughout California and hundreds of thousands of acres in the Project vicinity, the CDPA of 2011 would also direct development towards designated areas such as CREZs). For these reasons, the DRECP, now in preparation, will function as an NCCP, provide the basis for future HCPs, and establish a framework for more efficient renewable energy project permitting within the Planning Area, resulting in greater conservation than would occur from a project-by-project, species-by-species review. The Project site is located within the DRECP Planning Area, but it would not be covered by the DRECP because it is not a renewable energy proposal.

The geographic scope of the cumulative effects analysis for biological resources varies based on the biological resource being evaluated. As described in Table 5-1, the overall geographic scope for the cumulative analysis of impacts to biological resources includes the portion of the Mojave Desert bounded by I-40 and Old US 66 to the north, I-95 to the east, SR-62 to the west, and SR 247 to the west. However, Project footprint impacts on plant species, habitats, and species with limited distribution are evaluated at a site-specific, local level, while the direct and indirect impacts of Project activities (construction and operation) on regionally-distributed and important species such as desert tortoise are evaluated more broadly.

Of the cumulative projects, plans, and programs listed in Table 5-2, those that would affect large geographic areas and similar environmental resource areas and that would occur in close proximity to the proposed Project would be most likely to contribute to cumulative impacts on biological resources. These include the following: RETI development within the Iron Mountain CREZ (~ 40,000 acres), which intersects and overlaps with the Project site along the southern portion of the ARZC ROW and CRA-tie-in; implementation of the RSEP on BLM lands south of SR-62; the Marine Corps Base Expansion on up to 380,000 acres of land west of the Project site; RETI development within the Twentynine Palms CREZ to the west (~18,256 acres); implementation of the High-Speed Passenger Train Project to the northwest and the West-Wide transmission corridor to the north; construction and operation of the James W Wilson RV Park located just north of the Project site; and implementation of the DRECP (which includes the Project site in its Planning Area), and potential adoption of the CDPA of 2011. Together with the proposed Project, all of these projects and activities, with the exception of the DRECP and CDPA, would result in direct losses and degradation of habitat (either through removal or temporary disturbance) and soils (i.e., through dust deposition), habitat fragmentation and disruption of wildlife corridors / wildlife movement in the Project vicinity; construction noise

impacts on wildlife species (i.e., impacts to nesting birds and bats); attraction of predators to the area; introduction and spread of exotic weed species; and loss, disruption, or degradation of sensitive communities, including desert washes and drainages.

The DRECP, a planning document and NCCP, and the CDPA, an open space/conservation plan, are both intended to help avoid, minimize, and/or mitigate the cumulative effects of planned renewable energy development across the region; target substantial acreage of land for open space and habitat conservation; and have the potential to contribute to meaningful resource conservation in the region. Implementation of these plans would have a beneficial impact on biological resources that would, in part, mitigate the effects of the development described herein.

If the projects and plan areas listed above are constructed and/or reach full build-out conditions, permanent and temporary losses of desert habitats / vegetation communities would occur. In addition to direct impacts (removal and disturbance) on up to 250 acres of Mojave creosote bush scrub, Mojave wash scrub, and stabilized desert dunes/desert sand fields associated with implementation of the proposed Project, other projects with cumulative impacts on biological resources would result in direct impacts including up to 40,000 acres of development within the Iron Mountain CREZ; 1,410 acres of RSEP development; up to 380,000 acres associated with the Marine Corps Base Expansion; and up to 18,256 acres of development within the Twentynine Palms CREZ, including the 6 projects listed in Table 5-2, for an estimated cumulative disturbance of up to 524,000 acres and temporary losses of desert habitats. The federal 368 corridor would also disturb the existing habitats along the Old US 66 and I-40 corridors.

The EIS for the Marine Corps Base Expansion concluded that impacts to creosote bush scrub would be cumulatively considerable but that other habitat disturbance – based on the nature of military maneuvers – would not be significant.[46] That is, of the 524,000 acres of potential disturbance associated with cumulative development in the Project area, up to 380,000 acres would be subject to periodic disturbance from military maneuvers over the long-term, but the Base Expansion Project would not denude large areas of habitat.

For the remaining 144,000 acres of impacts associated with renewable energy development projects and programs in the Project area and vicinity, it is assumed that full-build-out of designated renewable energy development zones (CREZs) would remove habitats. There are several factors that make the Project's contribution to effects on habitats and associated species less than cumulative considerable. First, Project effects would be mitigated through avoidance and minimization measures coupled with compensatory habitat acquisition and management. Second, renewable energy development within designated CREZ areas is to be sited to avoid and minimize effects and to also be fully mitigated through the DRECP effort. In addition, there is substantial acreage in the project region that is protected from use directly or indirectly for habitat conservation including the existing Joshua Tree National Park (1,017,750 protected acres) and Mojave National Preserve (1,419,800 protected acres), numerous BLM Wilderness areas and

[46] U.S. Department of the Navy, Bureau of Land Management, Federal Aviation Administration, and U.S. Marine Corps, *Draft Environmental Impact Statement Land Acquisition and Airspace Establishment to Support Large-Scale Marine Air Ground Task Force Live Fire and Maneuver Training, Marine Corps Air Ground Combat Center, Twentynine Palms, CA*, February 2011.

ACECs in the Project area (there are 3.6 million acres within BLM Wilderness Areas in California); and the proposed protection of an additional 1.6 million acres of desert lands proposed under the CDPA of 2011, including 941,413 acres for the proposed Mojave Trails National Monument located immediate north of the Project site, 133,524 acres for the proposed Sand to Snow National Monument near the intersection of SR-62 and the I-10 and the addition of 2,900 acres to Joshua Tree National Park, 40,740 acres to Death Valley National Park, and 7,141 acres to the San Gorgonio Wilderness.,

Approximately 250 acres of desert habitats would be affected from implementation of the proposed Project. Much of this disturbance is parallel to an existing active railroad and is previously disturbed. None of the Project area would affect high quality habitat that is within an area proposed for conservation. Wildlife and vegetation potentially using the affected habitats have been described in Section 4.4 Biological Resources in detail. The only species listed within either the State or federal ESA is the desert tortoise. The Project facilities would not be located in any Wilderness Area or critical habitat except a portion of the area identified for the spreading basins for the Imported Water Storage Component extend into the designated critical habitat for the desert tortoise. Given the comparative impacts of other projects in the region that could affect up to 524,000 acres, and the size of the National Parks, National Preserves, DMWAs, and ACECs that have been developed to protect the desert ecosystem resources including the desert tortoise, the Project's contributions would not be significant or cumulatively considerable.

Mitigation Measures **BIO-1 through BIO-18** have been identified in the Draft EIR to mitigate for direct impacts of the Project, such that no impact would remain significant and unavoidable. Effects to all species including special status species such as the desert tortoise and County-protected plants would be avoided where possible. Where impact to species is unavoidable, compensation and restoration is proposed as mitigation. Implementation of these mitigation measures listed in Section 4.4 including compensating Project effects with conserved lands in perpetuity as approved by resource agencies would lessen the Project's direct effects on biological resources in the region.

These mitigation measures to preserve habitat in perpetuity to compensate direct Project effects also assist in diminishing contributions to the cumulative effect. In addition, federal, State and local plans have been established to preserve desert ecosystems including the CDPA and local ordinances. Compatibility and consistency with the CDPA, federal ESA, federal CWA, and local ordinances would ensure that the impacts of the proposed Project would not contribute considerably to a cumulatively significant impact to biological resources in the eastern California deserts.

5.3.5 Cultural Resources

The geographic scope of potential cumulative impacts related to cultural resources includes the proposed Project site and its immediate vicinity. The Valleys in the Project vicinity were important areas for gathering both salt and food resources for both the Mohave and Chemehuevi, and the remains of campsites are scattered throughout the valley, there are panels of rock art in

the adjacent mountains, and historic resources such as railroad sidings are located along the proposed pipeline alignment. Though no paleontological resources were observed on the site surface during 2010 surveys, construction of the proposed Project would include earthmoving activities that could unearth previously unknown archaeological or paleontological resources. Cultural sites identified during construction would be recorded at the San Bernardino Archaeological Information Center. Of the historic structures near the proposed Project, several of the resources located within the pipeline alignment could be affected by other planned or proposed Projects that overlap geographically.

Other development projects planned for the area could also encounter cultural resources. It is possible that the development of projects within the Iron Mountain CREZ, and of other projects likely to occur in the area, could contribute cumulatively to cultural resource impacts. However, further investigation in those areas would be needed, including a cultural resource survey of the affected areas of potential effects to identify resources; no surveys of the CREZs have occurred to date. Each project would be responsible for recording new sites appropriately. However, historic properties would be avoided or mitigated to the extent possible in accordance with state and federal regulations.

Similarly, through ongoing consultation with the California SHPO and appropriate Native American governments, it is likely that many adverse effects on significant resources in the Ward Valley could be mitigated to some extent. Uncovering archaeological and paleontological resources generally adds to the regional understanding of the area's history and would not result in a cumulatively considerable adverse impact to cultural resources unless those resources were destroyed. Impacts related to visual resources and Native American concerns related to views are addressed above, under Aesthetics. The impacts on cultural resources of the proposed Project, considered together with other renewable energy development projects, would have less than cumulatively considerable effects on cultural resources and are considered less than significant.

5.3.6 Geology and Soils

The geographic scope of the cumulative impact analysis for geology, soils, and seismicity, includes the Project site and areas immediately adjacent. The construction activities described in Chapter 3, Project Description, would include earthmoving, trenching, and some temporary stockpiling, which could lead to soil erosion. Most of the projects listed in Table 5-2 would include some degree of ground-disturbance and excavation and therefore would have the potential to contribute to cumulative soil erosion effects. However, all projects, including the proposed Project, must comply with pertinent federal, State, and local laws, which require preparation of SWPPPs to address stormwater, minimize erosion and sedimentation by implementing BMPs for erosion control features, and adhere to construction practices that prevent soil erosion. Further, implementation of Mitigation Measures **GEO-1** and **HYDRO-1** would ensure that Project impacts to stormwater runoff and water quality are minimized to the maximum extent feasible. Because SMWD and its contractors would implement measures and design features to prevent soil erosion, as would other projects in the region, the Project's contribution to soil erosion impacts would not be cumulatively considerable.

The proposed Project and other cumulative project facilities would comply with the CBC and be designed to minimize the potential effects of liquefaction, ground shaking, landslides, and other seismic activity effects. The Project would install shut-off valves and blow-off valves in pipelines to minimize water releases in the event of a pipe break. Well pads and interconnections would be installed on flat terrain with minimal liquefaction hazards.

Project operation would result in the long-term withdrawal of groundwater, which could potentially lead to a reduction in groundwater levels in the Project vicinity and concomitant subsidence or land settlement could occur due to the loss of interstitial water from soils and sediments. Subsidence is a concern with any drawdown of groundwater, although if surface water is returned via groundwater banking, that would ameliorate this impact, at least partially. The area with the greatest potential for subsidence would be the western part of the Project wellfield, in the vicinity of the Cadiz Inc. agricultural operations, because this area contains a higher proportion of fine-grained subsurface sediments below the water table. Implementation of Mitigation Measure **GEO-2** would minimize subsidence-related impacts on rail line and underground pipelines near the Project wellfield. None of the other projects being described in this Chapter that would also withdraw groundwater would draw more than nominal quantities of water from the same groundwater aquifer system as the proposed Project. Therefore, this impact is not considered cumulatively considerable.

5.3.7 Greenhouse Gas Emissions

GHG and climate change-related impacts are considered to be exclusively cumulative impacts; there are no non-cumulative greenhouse gas emission impacts from a climate change perspective.[47] Section 4.7, Greenhouse Gas Emissions, provides a detailed discussion of the Project's contribution to the cumulative impact of global warming. The geographic context for GHG emissions is global. However, the State of California has established protocols, policies and attainment goals that apply to the Project and all local projects listed in this analysis.

The MDAQMD does not have a GHG policy at this time, so the Project would not result in a conflict. The County is currently preparing their Countywide GHG Emissions General Plan Amendment, GHG Reduction Plan, and Development Code Amendments, which are in development. Mitigation Measures **GHG-1** and **GHG-2** provide for emissions reductions or the purchase of offsets to minimize emissions of GHG. As a result, as described in Section 4.7 Greenhouse Gases, the Project would not contribute considerably to global warming.

5.3.8 Hazards and Hazardous Materials

The geographic scope of impacts associated with hazardous materials generally encompasses the Project site and a 0.25-mile-radius area around the Project site. As described in Chapter 4, the proposed Project could expose workers, the public, and the environment to hazardous materials

[47] California Air Pollution Control Officers Association, *CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act*, January 2008.

that may be present in excavated soil or groundwater. Hazardous materials used during construction also could be released in the event of accidental upset. The adjacent Iron Mountain CREZ the RSEP, the federal 368 transmission corridor, and the James W. Wilson RV Park (north of the Project wellfields) would be most likely to contribute to cumulative impacts associated with the transport, use onsite, and potential storage of hazardous materials during construction and operation, though transport-related hazards would be increased as a result of all of the projects that utilize the major transportation corridors in the area: SR-62, I-40, Old US 66, SR-247, and I-95.

Project construction and operations activities associated with the Imported Water Storage Component of the proposed Project would result in the construction of recharge basins and associated piping in an area with a known history of military use, and UXO has been found in others areas. Construction activities situated within previous military use areas could expose workers and equipment to a hazardous condition; potential hazards to human health are associated with the presence of ordnance and explosive waste. The presence of ordnance and explosive wastes would pose the greatest risk during construction, when earth moving activities are likely to result in disturbance. Explosive materials may become more unstable over time, increasing the possibility of harm from residual wastes. Implementation of Mitigation Measures **HAZ-1**, **HAZ-2**, and **HAZ-3** would ensure that Project impacts associated with exposure to hazardous materials would be less than significant. Other projects listed in Table 5-2 have unknown levels of risk related to previous military activity but site-specific measures would be required to be implemented on a project-by-project basis to ensure avoidance of UXO. Thus, the incremental effect of the Project on UXO discovery risk is not anticipated to be cumulatively considerable.

The proposed Project would be located within a sparsely-vegetated desert area. The CAL FIRE, fire hazard severity zone map identifies the Project area as a non-very-high fire hazard severity zone, the lowest possible risk category. Implementation of the proposed Project would have a beneficial impact on fire risk because new turn-outs at crossings and sidings would be used for fire suppression. Therefore, the cumulative contribution of the Project to the risk of wildland fires is not considerable.

5.3.9 Hydrology and Water Quality

The geographic scope of potential cumulative water quality impacts encompasses the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds and the tributaries and associated drainage areas within the Project area. Because the Project is located within a topographically-closed drainage system, the drainage basin is separated from surrounding drainage basins by topographic divides. The only projects listed in **Table 5-2** that could potentially use groundwater from the Cadiz Valley groundwater basin are the James W. Wilson RV Park, which would require nominal quantities of groundwater, and potential renewable projects in the Iron Mountain CREZ, which could potentially draw water from the Cadiz Valley groundwater basin. The RSEP would meet water demands of 780 AFA of construction water and 180 AFY of process water by drawing water from the Rice Valley Basin.

As discussed in Section 4.9, Hydrology and Water Quality, mitigation measures have been developed to ensure that direct Project impacts remain less than significant. The direct impacts of the Project take into consideration all the other users of the groundwater basin. Mitigation measures are designed to ensure that other beneficial uses of the groundwater basin and surface water resources are not significantly affected. The proposed Project would result in far greater groundwater extractions than the other projects combined. Cumulative extractions from groundwater basin would essentially be the condition analyzed in this Draft EIR since other contributions to groundwater extraction is low. Therefore, the direct and cumulative impacts to groundwater and surface water resources would be less than significant and would not be cumulatively considerable.

5.3.10 Land Use and Planning

The geographic scope of land use impacts encompasses the communities located between the Morongo Basin and I-95, as they would be most affected by traffic accessing the Project site and other nearby development projects, most likely via SR-62 from the I-10. Access roads to most of the Project area currently exist, the proposed water conveyance pipeline would be installed within an existing railroad ROW; and the proposed wellfield and spreading basin areas, staging areas, and areas associated with proposed power distribution facilities are privately owned and vacant.

The cumulative projects listed in Table 5-2 would be located in remote, rural, and largely undeveloped areas. Transportation corridors exist in all four directions (north, south, east, and west of the Project site) to serve the projects, and major highways including Old US 66, I-95, I-15, I-40, and SR-62, as well as the ARZC and BNSF railroads could be used to transport goods and heavy equipment to and from the construction areas. Existing overhead transmission lines and multiple underground power, water, and natural gas lines traverse the region, and a proposed 368 federal transmission corridor has been designated along I-15 and Old US 66, connecting California to Nevada. Thus, infrastructure already exists in the region to support the proposed Project.

The Project area is located within the DRECP Planning Area and adjacent to areas covered by the proposed CDPA of 2011. The DRECP will be an NCCP and will serve as the basis for future HCPs for renewable energy projects in the California deserts. The multiple ongoing renewable energy plans and projects, such as the Solar E Program, the West-Wide Energy Corridor Program, and the RETI continue to coordinate their efforts and the proposed solar and renewable energy study areas and zones are consistent with the DRECP. DRECP Planning Maps have been revised to accommodate areas proposed to be set aside under the CDPA of 2011. Therefore, the cumulative projects do not conflict with land use plans or policies, including proposed or pending HCP or NCCPs.

Several large-scale land use plans are currently in progress. While most of the General Plan Update effort that Yucca Valley is undertaking is not applicable to the proposed Project, the EIR for the Yucca Valley General Plan will evaluate several realignment alternatives for re-routing SR-62 around Old Town in order to slow traffic through the historic town center and allow trucks

and other through traffic to maintain higher speeds on arterial highways (currently speed limits are 40 mph along the 10- to 15-mile stretch through the town of Yucca Valley). This is not a land use consistency issue; the proposed Project and other cumulative projects would comply with rerouting and detour requirements for traffic utilizing SR-62. However, it is a consideration under traffic and transportation, below.

Several land use conflicts based on overlapping project areas could arise. The biggest potential land use conflict is the overlap between the Marine Corps Expansion Project Eastern Alternative (Alternative 3), which overlaps substantially with the proposed Project and would require eminent domain action on the part of the DOD for the taking of private lands. The Eastern Alternative however was not selected as the preferred alternative in the Draft EIS for the Expansion Project. Six alternatives are under consideration, including a revised western alternative that would allow the public continued access to lands when not under active military training use. This alternative has been selected as the preferred alternative (Alternative 6).

Lands in the Project vicinity are located within up to five military training routes (MTRs) which are part of a large, interconnected system of training routes throughout the southwest. The development of facilities that encroach into the airspace of MTRs could create safety issues and conflict with military training activities. The proposed Project does not propose aboveground infrastructure that would interfere with military airspace regulations.

The proposed Iron Mountain CREZ on BLM lands could provide for energy development in areas that overlap with the Proposed Project. The CREZ boundaries have been established around an area that includes approximately 2,600 acres of private lands and 650 acres of State lands; another 560 acres of State lands are located adjacent and south of the SEZ.[48] Neither program proposes to use eminent domain to acquire these lands. Conflicts associated with adjacency will need to be evaluated on a project-by-project basis once renewable and solar projects have been identified. Conflicts with underground (natural gas, water) and/or aboveground utilities (overhead electric), transportation corridors (ARZC ROW), and Metropolitan's landholdings, including the CRA, as well as the proposed Project tie-in to the CRA, diversion structure, pump stations, and staging areas, do not appear to be inconsistent with the CREZ or SEZ proposals. Thus, no cumulative considerable effects on land use are anticipated.

Impacts associated with renewable energy development would be partly ameliorated by implementation of the DRECP and the CDPA of 2011, which would provide protections for biological resources and sensitive public lands, respectively. The intention of the CDPA of 2011 is to protect high-quality biological functioning areas for preservation, in part to offset the renewable energy development occurring in California's desert region. Together, these protections and planning efforts would partly offset the cumulative effects associated with development in the Project region.

[48] U.S. Department of Energy and U.S. Department of the Interior, *Draft Solar Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States*, December 2010.

Nevertheless, the concentration of renewable energy development contemplated within the Iron Mountain CREZ in the Project vicinity, along with the RSEP south of SR-62, and the expansion of the Military Base, the character of the Project region may change considerably as a result of proposed development. However, the proposed Project would not create a considerable change in land use – additional wells would be added to an area within which wells are currently active; the majority of the Project facilities would be installed underground; the proposed conveyance pipeline would be constructed within previously disturbed portions of the ARZC railroad easement; and the tie-in to Metropolitan's facilities would be in keeping with the existing infrastructure in the Project region. Thus, the Project itself would not have a cumulatively considerable impact on land use.

5.3.11 Mineral Resources

Most of the Project elements would be located away from existing or potential mineral resources. Some portions of the water conveyance pipeline cross areas of potential mineral resources (gypsum, metals and non-metals, sodium [salt], oil and gas, uranium and/or thorium) that are on public lands managed by the BLM. However, these mineral resources are not in active use and the BLM evaluation is largely based on limited data such as aerial surveys. In addition, the water conveyance pipeline would be located within the ARZC ROW, where potential future mineral resource exploration and use is not permitted for safety reasons. The wellfield facilities are located on private land do not support mineral extraction.

The salt production at the Cadiz and Bristol Dry Lakes uses saline water pumped from wells beneath the Dry Lakes. The following mining operations currently exist in the area:

• Tetra Technologies, Inc. is authorized to mine 10,835 acres on Bristol Dry Lake for the production of calcium chloride and sodium chloride.

• National Chloride Company of America is authorized to mine 162 acres on Bristol Dry Lake for the production of liquid calcium chloride and sodium chloride.

Implementation of Mitigation Measure **MIN-1** would ensure that groundwater production in the Fenner Gap area does not adversely impact the salt mining operations at Bristol and Cadiz Dry Lakes. Impacts on the nearby mining operation could result from Project operation (drawdown of water) and the implementation of other cumulative projects. Within the KSLA, multiple use-management may allow for uses other than sodium mineral development, but only if those other uses do not interfere with or restrict the production of sodium minerals. Other projects in the vicinity would affect mining leases. For example, expansion of the Combat Center under Alternative 3 would end two existing mining leases. However, with mitigation, the Project's incremental effects on mining operations in the Project vicinity would not be cumulatively considerable.

5.3.12 Noise

Cumulative noise and vibration impacts are evaluated on the Project site and areas immediately adjacent, due to the attenuating effects of noise. Construction and operation of projects listed in **Table 5-2** would generally not result in cumulative noise effects due to their scattered, remote locations. Projects with the potential to create cumulative noise impacts include the RSEP, development within the Iron Mountain CREZ , the federal 368 transmission corridor traversing Old US 66 and I-40, and the James W. Wilson RV Park.

As described in Section 4.11, Noise, the construction and operation of the proposed Project would result in less than significant noise impacts. The Project's individual contribution to noise impacts would not significantly contribute to the overall noise environment. During construction of cumulative projects, construction equipment could temporarily increase noise levels over short durations during the day. However, after the construction phases are complete, there would be very little noise associated with Project operations. The Project would not create a cumulatively considerable contribution to cumulative noise impacts due to the separation of projects, the sparse population of the region, and the short-term nature of noise-generating activities.

5.3.13 Public Services and Utilities

As described in Section 4.12, Public Services and Utilities, the proposed Project would not result in significant impacts to public services. Approximately 240 workers would be employed at any given time at the Project site during construction. The proposed Project does not include residential development and would not bring a substantial number of new, full-time employees to the Project area that would require the expansion of public facilities construction of which could result in adverse physical impacts. All of the required public service providers have indicated that they have the capacity to serve the proposed Project. Because the proposed Project does not include residential development and would not add a substantial number of new, full-time employees to the Project area, it would not result in a cumulative contribution to impacts on public services.

The proposed Project would potentially impact existing utilities and storm water drainages during construction of linear facilities (i.e., water conveyance pipelines) that would cross numerous existing utilities and drainages located along the ARZC ROW. Projects listed in Table 5-2 may also cross existing utility lines and/or existing drainages in the Project vicinity. Implementation of Mitigation Measure **UTIL-1** would ensure drainages are returned to their original contours and flow capacity following Project construction. Implementation of Mitigation Measures **UTIL-2** and **UTIL-3** would ensure Project construction and operation does not impact existing natural gas pipelines or disrupt utility services. The Project wellfield and spreading basin areas and water conveyance pipeline alignments have been designed to minimize crossings of high pressure gas lines, and construction activities would be coordinated with the utility companies / owners to minimize impacts to service providers.

To support the California Energy Action Plan II to reduce the State's overall energy usage, the Project would incorporate energy efficient equipment, such as pumps and lighting, to minimize energy impacts. Mitigation Measure **UTIL-4** would require the installation of energy efficient equipment consistent with County goals of reducing natural gas consumption. Considered together with the suite of renewable energy development areas (CREZs) and federal transmission corridors that have been identified in the Project vicinity, the proposed Project would not have a cumulatively considerable contribution on utility services.

5.3.14 Transportation and Traffic

The geographic scope for evaluating cumulative traffic impacts consists of I-40 and Old US 66 (also known as National Trails Highway) to the north; SR-247 and SR-62 to the west; SR-62 and I-10 to the south; and US 95 and SR-177 to the east. As described in Section 4.15, Transportation/Traffic, the proposed Project would increase traffic on local roadways during construction, which is expected to last approximately 2 years, between 2013 and 2015. The primary impacts from the movement of construction trucks would include short-term and intermittent impacts on roadway capacities due to slower moving vehicles, traffic-generating construction activities associated with the arrival and departure of constructions workers, trucks hauling equipment and materials to the construction sites, the hauling of excavated soils, and importing new fill. Trucks exiting the construction sites and entering the regional highway network would slow traffic and could create temporary, local hazards to faster moving vehicles. Construction would generate increased vehicle trips (by construction workers and construction vehicles) on area roadways; require temporary road closures on some public roadways; increase potential traffic safety hazards; increase wear and tear on haul routes; and increase demand for parking in the vicinity of construction sites.

Construction traffic would exit the feeder highways (SR-62 or US-66) and follow existing paved and unpaved access roads to the construction sites. Some new access roads may need to be constructed or improved for heavy machinery. No new at-grade railroad crossings would be constructed. Cadiz-Rice Road and existing railroad crossings would be utilized for site access, and new turn-outs at crossings and sidings would be used for fire suppression.

During any given work shift, up to 240 workers and 25 pieces of heavy equipment would be required for construction. The total number of workers and pieces of heavy equipment operating at one time would vary depending on the construction schedule developed by the construction contractors. Most workers would stay at the worker housing facilities provided on Cadiz Property during the work week and commute from the area on the weekends. The number of trips per day during the week, including worker commute and truck deliveries, would not be expected to exceed 100 round trips per day (i.e., 100 coming and 100 going). This is a conservative estimate of a busy day; actual daily auto trips would likely be fewer. The addition of 100 daily round trips on SR-62 or US-66 would not significantly increase average daily traffic counts on those highways. Furthermore, although construction would increase traffic on Cadiz-Rice Road considerably, the level of service is low and delays would not be anticipated. The road would remain passable to non-Project traffic at all times.

Some trucks transporting equipment and construction employees for the proposed Project would be expected to use SR-62 and either Cadiz-Rice Road or the loop around Amboy Road. However, most of the equipment and crew/employees needed for construction would be delivered from the San Bernardino area, Barstow, or Needles, and trucks transporting this equipment and construction crews would be expected to use Cadiz-Rice Road via I-40 and Old US 66. Construction related traffic would slow to exit SR-62 near the Cadiz-Rice Road exit and at the Amboy exit on US-66 and may briefly affect through-traffic speeds. Traffic control measures, including turn off lanes may be necessary to avoid impacts to high speed traffic. Implementation of Mitigation Measures **TR-1 through TR-5** would ensure that construction-related traffic impacts would be less than significant. With implementation of mitigation, construction would not conflict with the San Bernardino County CMP, the Circulation Element of the San Bernardino County General Plan, or SCAG's Regional Transportation Plan. Furthermore, the proposed Project would not introduce new traffic hazards, nor impede traffic in the Project area that would create obstacles for emergency service providers.

Other construction projects that could contribute to cumulative traffic impacts in the area include those listed in Table 5-2. The RSEP workforce would add an average of 280 construction workers and 47 full-time staff (CEC 2009). Construction and operational vehicle and truck trips associated with potential energy development within the 40,000 acre Iron Mountain CREZ, as well as the expansion of Marine Corps Base operations, which would bring up to 12,000 Marines to the Combat Center over a 10-day period (up to 200 buses would arrive at the Combat Center on a single day) would contribute a substantial number of vehicles to the regional roadway network, particularly SR-62. Together with Yucca Valley's circulation alternative that could re-route SR-62 around Old Town and the Flamingo Heights Ranch Project, which would create 243 lots on 640 acres, could further exacerbate traffic and circulation on SR-62.

The Project would contribute up to 100 round trips per day on SR-62 or SR-66 during construction. Once the Project is constructed, vehicle trips associated with Project operations would be negligible. Due to the small contribution of traffic on the local roadways, the Project's contribution to traffic congestion (if any) would not be cumulatively considerable.

CHAPTER 6
Growth-Inducement Potential and Secondary Effects of Growth

6.1 Introduction

This Chapter analyzes the growth inducement potential of the proposed Project and the associated secondary effects of growth, as required by *CEQA Guidelines* §15126.2(d). The statutory requirements of CEQA that pertain to analyzing growth and other laws and regulations pertinent to land use and water supply planning are discussed in Section 6.1. This first section also reviews the approach to the analysis of growth inducement potential and describes the Project Water Area of Use (areas that would potentially receive Project water). Section 6.2 describes each participating water provider, including their service areas, population served, growth projections, and projected water demands through 2035 and evaluates the growth inducement potential of the Project for each participating water provider. Section 6.2 also describes Metropolitan and its relationship to the proposed Project, regional planning agencies and growth projections, and the associated water demand in Metropolitan's service area. Section 6.3 assesses the potential secondary effects associated with growth.

6.1.1 CEQA Requirements

CEQA[1] requires an EIR to evaluate the growth-inducing impacts of a proposed project. Under *CEQA Guidelines* §15126.2(d), an EIR must:

> Discuss the ways in which the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are projects which would remove obstacles to population growth (a major expansion of a waste water treatment plant might, for example, allow for more construction in service areas). Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects. Also discuss the characteristic of some projects which may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It must not be assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.

A project can have a direct effect on population growth if it would involve construction of substantial new housing. A project can have indirect growth-inducement potential if it would (1)

[1] *CEQA Guidelines*, California Code of Regulations Title 14, Chapter 3, §15126.2(d).

establish substantial new permanent employment opportunities (e.g., commercial, industrial, or governmental enterprises) or otherwise stimulate economic activity; or (2) remove an obstacle to additional growth and development, such as removing a constraint to or increasing the capacity of a required public service. For example, an increase in the capacity of utility or road infrastructure could allow either new or additional development in the surrounding area.

6.1.2 Approach to Analysis

To assess the growth-inducement potential of the Cadiz Valley Water Conservation, Recovery, and Storage Project, the following question must be addressed: "Would the proposed Project directly or indirectly support economic or population growth or residential construction?" A variety of factors influence new development or population growth in the areas that would or could be served by Project water, including economic conditions of the region, adopted growth management policies in the affected communities, and the availability of adequate infrastructure (e.g., water service, sewer service, public schools, and roadways, etc.), but economic factors are generally the lead driver. While the provision of water service is only one of many factors affecting the growth potential of a community, it is one of the chief public services needed to support urban development, and the lack of a reliable water supply can sometimes constrain future development.

The following steps were taken to investigate the Project's growth inducement potential and to characterize the secondary effects on the environment resulting from such growth:

- **Identify the Project Water Area of Use.** For the purposes of this analysis, the Project Water Area of Use, or the locations within which Project water has the potential to be used, is defined below. In general, the Area of Use includes the service area of each of the known Project Participants as well as the broader service area of the Metropolitan Water District of Southern California. This is described in more detail below.
- **Describe the Regulatory Context for Water Supply and Land Use Planning.** Section 6.1.3 presents an overview of water supply and land use planning in California to provide the reader with an understanding of the authorities and responsibilities that shape the nexus between decisions about water and land use.
- **Characterize Water Use and Growth Trends, Projected Future Supply, and the Growth Inducement Potential of the Project within each Project Participant's service area.** Section 6.2 summarizes population growth trends, projected water demand and known and potential water supply sources within each Project Participant's service areas. Information about each Project Participant is summarized from current 2010 Urban Water Management Plans (UWMP). In light of the each Project Participant's projected future water demand and supply portfolio, the growth inducement potential of the Project is evaluated to assess the extent to which the Project would help improve the reliability of the Project Participant's existing supplies and/or might also contribute to serving additional planned growth within the service area.
- **Characterize Water Use and Growth Trends, Projected Future Supply, and the Growth Inducement Potential of the Project for Future Project Participants within the**

Metropolitan Service Area. Section 6.2.7 summarizes population growth trends, projected water demand, and known and potential water supply sources within the six-county Southern California region served by Metropolitan. Information regarding growth trends and projected water demand and supply in the broader Southern California region is based on data compiled from regional planning agencies (SCAG and San Diego Association of Governments [SANDAG]) as well as Metropolitan's 2010 Regional Urban Water Management Plan. This section evaluates the growth inducement potential of the remaining "unsubscribed" capacity of the Project's Groundwater Conservation component as well as the growth inducement potential of the Project's Storage Component within the Metropolitan service area.

- **Characterize the Secondary Effects of Planned Growth.** Planning for additional growth and development within the Project Water Area of Use is the responsibility of the many city and county jurisdictions that have land use planning and approval authority. These land use jurisdictions present their plans for growth and development in their adopted General Plans. The environmental impacts or secondary effects that would result from planned growth have been evaluated in CEQA environmental documents, generally EIRs, prepared on each city or county General Plan. As the Project could help each Project Participant meet the water demands of planned growth within its service area, it is useful and appropriate to look at the General Plan EIRs to summarize the expected effects of planned growth and to review the mitigation measures that the land use agencies have adopted to address the effects of their planned growth. Because the Project Water Area of Use encompasses portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties, the General Plan EIRs for each of the six counties in Metropolitan's Southern California service area are summarized along with the General Plan EIR for select cities in the region. For this analysis, multiple published reports that have evaluated growth in the study area were reviewed and their findings summarized and supplemented (presented in Section 6.3). Within each participating water provider service area, future project-specific EIRs on new development will consider direct, indirect, and cumulative contributions of those projects on resources in the context of changes in the regulatory (and physical) environment.

Project Water Area of Use

As discussed in Chapter 3, Project Description, a portion of the 50,000 AFY of Project water to be developed under the Conservation Component has not yet been subscribed, and none of the specific participants for the Storage Component have been identified yet. Thus, not all of the water providers that will ultimately participate in the Project have been identified. It is therefore necessary to make assumptions about where the Project water could be used or might be used. This analysis assumes that Project water developed under the Groundwater Conservation and Recovery Component and Imported Water Storage Component would be used within the Metropolitan service area and/or the service areas of the participating water providers: SMWD, Three Valleys, Suburban, Golden State, JCSD, and Cal Water.

The facilities proposed for Groundwater Conservation and Recovery Component of the Project include construction of a wellfield and manifold (piping) system to carry pumped groundwater to a new 43-mile conveyance pipeline that would be constructed along the ARZC ROW, and tie into the CRA, which would distribute water to Project Participants. Since the proposed Project would

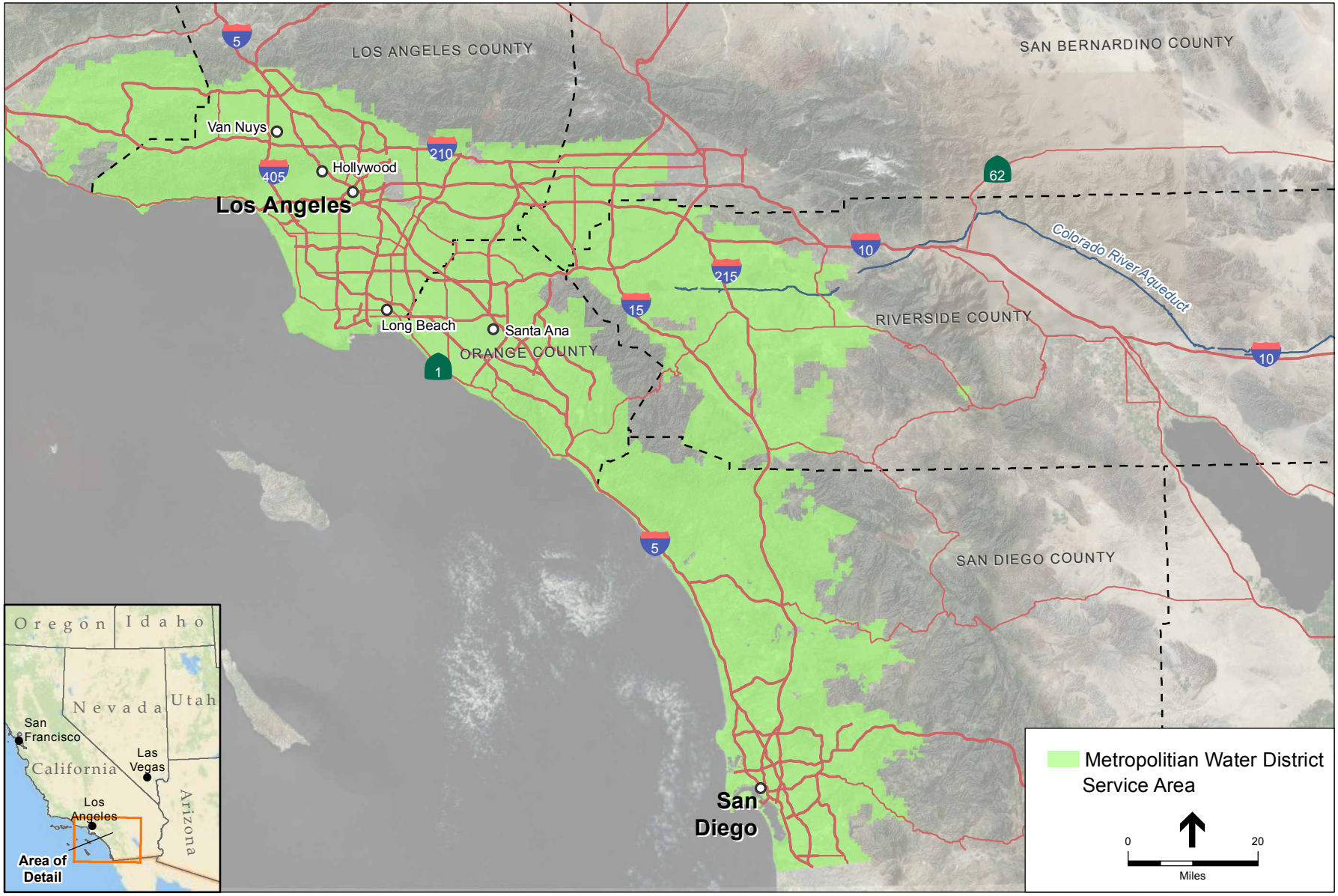
connect to Metropolitan's CRA, Project water would be available for distribution within Metropolitan's service area. Metropolitan's water infrastructure provides a reasonable framework for consideration of the Project Water Area of Use. Metropolitan's 26 member agencies serve 152 cities, 89 unincorporated communities,[2] and 86 percent of the population in six Southern California counties. The Groundwater Conservation and Recovery Component of the proposed Project relies on the infrastructure of Metropolitan's system to convey Project water to Metropolitan's member agencies.

The facilities proposed for the Imported Water Storage Component of the Project include expansion of the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply and distribution facilities; and a CRA diversion structure and pump station. This Project component would utilize the 43-mile pipeline constructed for the Conservation Component to bring surface water supplies to the Project site for storage. The CRA would also be used under the Imported Water Storage Component to convey stored water to Metropolitan's CRA. As such, future participants in the Imported Water Storage Component are also expected to be located within Metropolitan's service area. It is possible that the Project would also connect to the SWP as part of the Imported Water Storage Component, as described in Chapter 3.0, Project Description. Even with an intertie to the State system, it is assumed that participating water providers and the Project Water Area of Use would be located within Metropolitan's service area. Metropolitan is described in greater detail in Section 2.6.2. Metropolitan's service area is shown in **Figure 6-1**.

Each of the Project Participants in the Project's Groundwater Conservation and Recovery Component receive imported water supply via Metropolitan, either directly or indirectly: Three Valleys is a Metropolitan member agency; SMWD is served by a Metropolitan member agency (MWDOC); Suburban is served by several Metropolitan member agencies (including Central Basin Municipal Water District [MWD], Three Valleys, and Upper San Gabriel Valley MWD); and many of Golden State's water systems are served by Metropolitan member agencies (including Calleguas MWD, Central Basin MWD, Upper San Gabriel Valley MWD, West Basin MWD, and MWDOC). JCSD relies solely on local groundwater at present for its direct water supply. However, although JCSD does not directly receive imported water supply, it does receive it indirectly as the Chino Basin Water Master recharges the regional groundwater basin with stormwater, imported SWP surface water supplies provided by Metropolitan, and recycled water.[3] Cal Water's Westlake District is served by Calleguas Municipal Water District (CMWD) which is a member agency of Metropolitan. In addition, Cal Water has current connections with Metropolitan and could therefore take Project water directly into their system.

2 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-7.

3 Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011, page 27.



SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 6-1

Metropolitan Water District Service Area

6.1.3 Regulatory Context for Land Use Planning and Water Supply Planning

In California, cities and counties have primary authority[4] over land use decisions while water agencies, through laws and agreements, are expected and usually required to provide water service if water supply is available. Land use planners throughout the State employ various procedures and practices based upon legal and contractual requirements to evaluate whether adequate water and other utilities are available to support growth. The laws and agencies described below provide the regulatory and planning context for coordination among water agencies and cities and counties and yield key documents (e.g., general plans and regional projections) used as the basis for this analysis.

- **Regional Planning: SCAG and SANDAG.** Councils of Government (COGs) are associations of cities and counties that have been formed throughout the State, based on joint powers agreements between the participating jurisdictions, to coordinate the planning activities within a region. SCAG and SANDAG are the two key COGS in the study area. Both also function as the Metropolitan Planning Organization (MPO) for their respective areas (Los Angeles, Orange, San Bernardino, Riverside, and Ventura counties for SCAG, and San Diego County for SANDAG). As such, they are mandated by the federal government to research and develop plans for transportation, growth management, and other resources of regional importance. Both SCAG and SANDAG are responsible for developing population and employment forecasts for their respective regions. Their population, housing unit, and employment forecasts are the accepted standard in the region and are used in plans produced by city and county governments, transportation and air quality planning agencies, and special districts. Metropolitan's 2010 RUWMP cites current SCAG and SANDAG forecasts as the key basis for its service area growth assumptions, as do the other participating water agencies.
- **General Plan Requirements.** Pursuant to State law,[5] each city and county is required to adopt a comprehensive, long-term general plan for the physical development of the jurisdiction. The general plan is a statement of development policies and is required to include land use, circulation, housing, conservation, open space, noise, and safety elements. The land use element designates the proposed general distribution, location, and extent of land uses and includes a statement of the standards of population density and building intensity recommended for lands covered by the plan. The city or county is required to prepare the water section of the conservation element in coordination with any countywide water agency and with all districts and/or city agencies that develop, serve, control, or conserve water for that jurisdiction. The water section must include

4 Although cities and counties have primary authority over land use planning, there are exceptions to this, including the California Coastal Commission (regulating development along the coast), the California Energy Commission (with permit authority and CEQA lead agency status for some thermal power plant projects), and the California Public Utilities Commission (with regulatory authority and CEQA lead agency status for certain utility projects), among others.

5 California Government Code, §65300 *et seq*.

discussion and evaluation of water supply and demand information contained in any applicable UWMP that has been submitted to the city or county by a water agency.

- **Urban Water Management Planning Act.** Every water supplier that provides water to 3,000 or more customers or provides over 3,000 acre-feet of water annually is required to prepare an UWMP for the purpose of "actively pursu[ing] the efficient use of available supply."[6] In preparing the UWMP, the water supplier is required to coordinate with other appropriate agencies, including other water suppliers that share a common source, water management agencies, and relevant public agencies. When a city or county proposes to adopt or substantially amend a general plan, the water agency is required to provide the planning agency with the current version of the adopted UWMP, the current version of the water agency's capital improvement program or plan, and other information about the system's sources of water supply. The Urban Water Management Planning Act also requires urban water suppliers, as part of their long-range planning activities, to make every effort to ensure the appropriate level of reliability in their water service sufficient to meet the needs of their customers during normal, dry, and multiple dry water years.
- **Senate Bill 7 of the Seventh Extraordinary Session (SBx7-7).** Adopted by the State Legislature in November 2009, SBx7-7 (Steinberg) creates a framework to reduce California's per capita water consumption 20 percent by 2020. Specifically, the bill:
  - Establishes means for urban water suppliers to achieve the 20 percent reduction. Means specified include: setting a conservation target of 70 percent of their daily per capita water baseline; utilizing performance standards for indoor, landscaping, industrial, and institutional uses; meeting the per capita water goal for their specific hydrologic region as identified by DWR and other State agencies in the 20 percent by 2020 Water Conservation Plan; or using an alternative method that is to be developed by DWR by December 31, 2010. SBx7-7 also requires DWR to work cooperatively with the California Urban Water Conservation Council.
  - Requires urban water suppliers to set an interim urban water use target and meet that target by December 31, 2015.
  - Requires DWR to work cooperatively with the California Urban Water Conservation Council to establish a task force to identify BMPs to assist commercial, industrial, and institutional users in meeting the 20 percent reduction in water use by 2020 goal.
  - Makes any urban or agricultural water supplier who is not in compliance with the bill's water conservation and efficient water management requirements ineligible for State grant funding.
  - Requires DWR to report to the Legislature on agricultural efficient management practices being undertaken and reported in agricultural water management plans in 2013, 2016 and 2021.

6 California Water Code, §10610.2 *et seq.*

  - Requires DWR, SWRCB, and other State agencies to develop a standardized reporting system.[7]

- **Senate Bills 610 and 221.** In 2001, the California legislature adopted two bills pertaining to coordination between land use and water supply planning and decision making: SB 610 and SB 221 are companion legislative measures that took effect in January 2002 and require increased efforts to identify and assess the reliability of anticipated water supplies and increased levels of communication between municipal planning authorities and local water suppliers.
  - **SB 610**[8] requires that CEQA review for most large projects[9] and specified smaller projects include a water supply assessment. The water supply assessments must address whether existing water supplies will suffice to serve the proposed project and other planned development over a 20-year period in average, dry, and multiple-dry year conditions, and must set forth a plan for finding additional supplies necessary to serve the proposed project. Cities and counties can approve projects notwithstanding identified water supply shortfalls, provided that they address such shortfalls in their findings.
  - **SB 221**[10] requires that cities and counties impose a new condition of tentative subdivision map approval, requiring that the applicant provide detailed, written verification that sufficient water supply will be available before the final subdivision map can be approved. It applies to projects similar in size to those addressed in SB 610.

State Policies Encouraging Compact and Sustainable Development

Several recent legislative efforts have sought to refocus planning efforts to reduce sprawl, preserve farmland, increase the viability of public transportation, and reduce the emission of greenhouse gases. These efforts promote compact and sustainable development, which allow for the more efficient provision of public services and reduce the consumption of resources – including water supply. Sustainable development includes the concept of more efficient water use, including the incorporation of water conservation and efficiency measures such as the use of recycled water, water efficient fixtures, and drought tolerant landscaping.

- **Assembly Bill (AB) 32,**[11] the Global Warming Solutions Act of 2006, was adopted with the goal of reducing greenhouse gas emissions to 1990 levels by the year 2020. The plan identifies measures to reduce the energy requirements associated with providing reliable water supplies. These measures include increased water use efficiency and water recycling and increasing water system energy efficiency.

---

7 California Water Code, §10610.16 *et seq*; Metropolitan Water District of Southern California, *Regional Urban Water Management Plan*, November 2010, page 1-4.

8 Codified at California Water Code §§10631, 10656, 10910, 10911, 10912, and 10915.

9 Large projects include residential developments with more than 500 units; retail uses with more than 500,000 square feet of floor space; office buildings with more than 250,000 square feet of floor space; hotels or motels with more than 500 rooms; industrial uses occupying more than 40 acres or having more than 650,000 square feet of floor area; and mixed-use projects that include any use or combination as large as the above uses.

10 Codified at California Business and Professional Code §65867.5 and Government Code §§66455.3 and 66473.7.

11 Codified at California Health and Safety Code §38500 *et seq*.

- **SB 375**[12] was adopted in 2008 to require COGs to align their housing and transportation plans and to develop a "sustainable communities strategy" that will reduce sprawl and improve air and water quality.
- **SB 732**[13] was signed into law in 2008 and establishes the Strategic Growth Council, a cabinet-level committee that is tasked with coordinating the activities of State agencies to improve air and water quality, protect natural resources, and assist in the planning of sustainable communities.
- **AB 857**,[14] signed into law in 2002, establishes three planning priorities for the State: promoting infill development, protecting natural resources, and encouraging efficient development patterns. These priorities are to be incorporated into the Governor's Environmental Goals and Policy Report,[15] which provides a 20- to 30-year overview of State growth and development and guides the commitment of State resources in agency plans and infrastructure projects.
- The **Regional Blueprint Planning Program** is a grant program operated by the California Department of Transportation that provides assistance to COGs in developing long-range plans with the intent of supporting greater transit use, encouraging more efficient land use, improving air quality, and protecting natural resources.

6.2 Growth Inducement Potential

6.2.1 Introduction

Organization and Approach

To assess the growth inducement potential of the Project in terms of its contribution to a stable water supply for the Project Participants and whether Project water could be used to support additional growth and development, this section reviews the service area growth projections, water demand forecasts, and water supply options for each of the participating water providers and for Metropolitan. Then, in the context of each water provider's future water demand and supply picture, the contribution that Project water could make to each provider's water supply portfolio is described and the Project's growth inducement potential is assessed.

Supply Reliability Overview

As described in Chapter 3, Project Description, the overall purpose of the proposed Project is to make available a new, more reliable water supply than is available to the Project Participants currently. It is also aimed at making available additional water storage capacity for Southern California water providers in order to replace or supplement existing supplies and enhance supply reliability. The objectives of the Project include improving water supply reliability for Southern

12 Codified by amendments to California Government Code §§65080, 65400, 65583, 65584.01, 65584.02, 65584.04, 65587, 65588 and California Public Resources Code §21061.3 and the addition of Government Code §§14522.1, 14522.2 and 65080.01 and Public Resources Code §§21159.28 and 21155 *et seq.*

13 Codified by amendments to California Public Resources Code §§75076 and 75077 and the addition of §§75100 *et seq.* and 775120 *et seq.*

14 Codified at California Government Code §65041.1.

15 Required in California Government Code §65041.

California water providers to protect against drought and other water delivery interruptions; reducing dependence on imported water by utilizing a source of water that is local to the region; and enhancing dry-year water supply reliability, water supply opportunities, and delivery flexibility by providing storage capacity to help participating water providers better manage and leverage their existing water supplies.

The Southern California region faces several water supply reliability issues that affect both its imported sources of supply and some of its local sources of supply. Metropolitan serves 86 percent of the population in six Southern California counties and provides 45 to 60 percent of the water supply used in the service area.[16] Metropolitan imports water from the Colorado River via its CRA and from the Sacramento-San Joaquin Delta via the SWP. Annual supplies received by Metropolitan from each of these two imported sources varies but is roughly one-third CRA and two-thirds SWP.[17] Metropolitan's water supplies and supply reliability are described in more detail in below but, in summary, Metropolitan is taking several steps to address reliability issues associated with both of its imported supply sources.

On the Colorado River system a multi-year drought coupled with the need for Metropolitan to permanently reduce its level of imports, along with litigation over the negotiated multi-party settlement agreement intended to reduce California's reliance on the Colorado River, raise concerns about the reliability of the Colorado River water over the long term.[18] On the Sacramento-San Joaquin Delta system, current endangered species issues, litigation, drought, and infrastructure limitations have combined to effectively reduce the long-term reliability of the SWP.[19] Climate change is expected to affect water supply in the Delta further in the future. The State's SWP 2009 Reliability Report indicated during in a multi-year wet period the overall reliability of the SWP system would range from 74 to 94 percent (of maximum Table A amounts), while during a multi-year dry period, average annual deliveries would be only 32 to 34 percent (maximum Table A amounts).

The City of Los Angeles also imports surface water supply to the region from the Mono Basin and Owens Lake area via the Los Angeles Aqueduct. Court decisions and other actions related to environmental concerns have reduced supply availability from this supply source as well. Finally, with respect to local supplies, groundwater represents up to 86 percent of local water supply in Southern California.[20] Some of this supply is jeopardized by groundwater contamination. Metropolitan works with local agencies to implement projects to recover and use contaminated groundwater.

16 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, Table 1-7, page 1-20.
17 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, Table 1-8, page 1-21.
18 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, pages 3-2 through 3-9.
19 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, pages 3-10 through 3-15.
20 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan,* November 2010, page 1-21.

As all of the water providers participating in the Project's Groundwater Conservation and Recovery Component receive imported water from Metropolitan, either directly or indirectly, they must also address reliability issues associated with the imported water supplies and be prepared to respond to supply shortfalls in some years. As a result, water providers throughout Southern California, including those participating in the Project, are working to diversify their water supply portfolios and develop supply redundancy as well as infrastructure interties that will improve the reliability and flexibility of their water supply systems. This reliability is needed with or without planned growth. As described in this section, for each of the participating water providers, potential participation in the Project represents one of many steps each of these providers is taking to secure a long-term reliable water supply for the communities they serve. The water storage capability provided by both components of the Project makes the Project particularly effective as a means to improve water supply reliability as it allows Project Participants to reserve back-up supply in storage for use when their other existing or primary supplies are reduced. Without storage capability it is more difficult to manage supplies through drought or other periods of shortage.

The Groundwater Conservation and Recovery Component of the Project would make a new water supply of up to 50,000 AFY available to Southern California water providers. **Table 6-1** lists the water providers participating in this Project component along with their proposed contracted quantities of Project water, and the amount of unsubscribed Project water remaining available to other future Project Participants. The Imported Water Storage Component of the Project would not result in creation of new water supply but would create substantial new storage capacity (up to 1 MAF) in the region allowing water providers to better manage and leverage the various supplies available to them, particularly during periods of drought or other supply shortages. This component of the Project would help participants improve the reliability of their water supply portfolios.

TABLE 6-1
PROJECT WATER SUBSCRIPTIONS FOR
THE GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Project Participant	Contracted Annual Amount (AF)	Optional Allocated Amount (AF)
Santa Margarita Water District[a]	5,000	10,000
Three Valleys Municipal Water District	5,000	
Golden State Water Company	5,000	
Suburban Water Systems	5,000	
Jurupa Community Services District	5,000	
California Water Service Company	5,000	
ARZC rail operations support supply	10 – 100	
Total Annual Project Water Subscribed	**30,100 – 40,100**	
Project Supply Available for Subscription	**9,900 – 19,900**	
TOTAL PROJECT SUPPLY	**50,000**	

[a] As described in Chapter 3, Project Description, SMWD has the option to take an additional 10,000 AFY for a total subscription of up to 15,000 AFY. If SMWD exercises this option, then the total Project water subscribed out of the 50,000 AFY available will be 40,100 AFY and the remaining supply available for additional Project Participants will be 9,900. If SMWD does not exercise its right, its subscribed amount will be 5,000 AFY and the remaining supply available for additional Project Participants will be 19,900.

SOURCE: ESA, 2011.

For each of the participating water providers, **Table 6-2** summarizes the current and projected water demand, population growth, projected supply, and relationship of the Project water to the overall water supply portfolio. This information is presented for each water provider in the sections below.

6.2.2 Santa Margarita Water District (SMWD)

SMWD provides water and wastewater service to residents and businesses in southern Orange County. SMWD receives its water from three main sources: the San Juan Basin, which is managed by the San Juan Basin Authority (SJBA); recycled water; and imported water from MWDOC. MWDOC purchases its imported water from Metropolitan, which delivers water to the region from northern California via the SWP and from the Colorado River via the CRA. Water from both sources is treated and tested at Metropolitan's Diemer Filtration Plant in Yorba Linda before it is piped to SMWD for distribution to its customers. Groundwater is pumped from one well in the southeast of SMWD's service area.[21]

Land Use and Population

SMWD serves a total population of 155,229 throughout its 97-square-mile service area, which is bounded on the north by EI Toro Road in the City of Lake Forest, on the east by the Cleveland National Forest, on the south by U.S. Marine Corps Base Camp Pendleton and San Diego County, and on the west by the City of San Juan Capistrano and Moulton Niguel Water District (see Figure 1-2).[22] SMWD's service area includes portions of Rancho Santa Margarita, Coto de Caza, Las Flores, Ladera Ranch, Talega, and Mission Viejo.

SMWD's customer classes include single-family residential, multi-family residential, commercial/industrial/institutional (CII), dedicated landscape, and agriculture. SMWD is primarily a residential community. The typical commercial and industrial uses within SMWD are retail and warehouse, with a minor amount of manufacturing. Retail is concentrated in areas central to each of the communities and typically is a mix of grocery, restaurant, and medical uses. Manufacturing is primarily in the Rancho Santa Margarita Business Park.

Table 6-3 shows the population projections within SMWD's service area for the next 25 years. There has been continual growth in SMWD's service area since the early 1970s, and for the last 10 years, SMWD has added over 2,000 connections per year.[23] SMWD went from 40,768 connections in fiscal year (FY) 1999-00 to 60,425 in FY 2009-10 and is expected to add 15,819 more connections by 2035.[24] Population growth is expected to increase by 40 percent in the next 25 years.

[21] Santa Margarita Water District, *2010 Urban Water Management Plan, Executive Summary*, June 2010, page 1.
[22] Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 1-4.
[23] Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-3.
[24] Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-4.

TABLE 6-2
GROWTH AND WATER DEMAND PROJECTIONS SUMMARY FOR
PARTICIPATING WATER PROVIDERS IN THE GROUNDWATER CONSERVATION AND RECOVERY COMPONENT

Participating Water Provider	Service Area / Geography Served	Projected Change in Population Between 2010 and 2035	Water Demand 2010	Projected Water Demand 2035	Projected Water Supply in 2035	Estimated Maximum Delivery from Project	Project Water as % of 2035 Total Supply
Santa Margarita Water District (SMWD)[a]	97 square miles Rancho Santa Margarita, Coto de Caza, Las Flores, Ladera Ranch, Talega, portions of Mission Viejo	2010 - 155,229 2035 - 217,339 40% increase	34,169 AFY	46,409 AFY 36% increase	46,409 AFY	5,000 - 15,000 AFY	11% - 32%
Golden State[b1]	17 water systems located in Ventura, Orange, and Los Angeles counties	2010 – 863,355 2035 – 970.856 12.5% increase	116,940 AFY	159,316 AFY[b2] 36% increase	159,316 AFY	5,000 AFY	3%
Three Valleys Municipal Water District[c]	133 square miles in eastern Los Angeles County Azusa, City of Industry, Covina, Claremont, Diamond Bar, Glendora, Hacienda Heights, La Puente, La Verne, Pomona, Rowland Heights, San Dimas, Walnut, and West Covina	2010 - 573,800 2035 - 712,253 24% increase	127,621 AFY	154,144 21% increase	155,144 AFY	5,000 AFY	3%
Suburban[d]	42-square-miles in Los Angeles and Orange counties Glendora, Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, and Buena Park	2010 - 293,500 2035 - 294,200 0.24% increase	49,500 AFY	51,570 AFY 7.6% decrease	60,130 AFY	5,000 AFY	10%

Participating Water Provider	Service Area / Geography Served	Projected Change in Population Between 2010 and 2035	Water Demand 2010	Projected Water Demand 2035	Projected Water Supply in 2035	Estimated Maximum Delivery from Project	Project Water as % of 2035 Total Supply
JCSD[e]	Jurupa Valley area of western Riverside County. Sunnyslope, Indian Hills, Glen Avon, Pedly, Mira Loma, Jurupa Valley, and Eastvale.	2010- 101,700 2035 - 137,000 35% increase	23,660 AFY	35,648 AFY 51% increase	35,648 AFY	5,000 AFY	14%
Cal Water[f]	13-square miles in the eastern section of Ventura County Westlake, within the City of Thousand Oaks	2010 -16,880 2035 -17,260 2.25% increase	7,130 AFY	7,101 AFY 0.3% decrease	8,025 AFY	5,000 AFY	62.3%

SOURCES:

a Santa Margarita Water District, *2010 Urban Water Management Plan,* June 2010.

b1 Golden State Water Company, *2010 Urban Water Management Draft Plan*, *Multiple Water Systems,* 2010.

b2 The projected 40% increase in demand between 2010 and 2035 for Golden State reflects the decrease in demand that occurred between 2008 and 2010; hence the estimated percent increase over 2010 demand reflects first recovery of demand to pre-2008 levels.

c Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, 2010.

d Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011.

e Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011.

F Cal Water, *Westlake District 2010 Urban Water Management Plan*, June 2011,

TABLE 6-3
CURRENT AND PROJECTED POPULATION IN THE SMWD SERVICE AREA

	2010	2015	2020	2025	2030	2035-opt
Service Area Population	155,229	167,663	180,097	192,531	204,965	217,399

SOURCE: Center for Demographic Research, California State University, Fullerton, 2010; Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010.

There is one major development plan being implemented within the SMWD service area that represents the majority of future growth. The Ranch Plan includes a mix of residential and commercial development in six planning areas and represents the build-out of the remaining open space within SMWD. The proposed residential development will consist of 14,000 units with 6,000 of the units being age-restricted units which have a lower water demand because of lower occupancy. The proposed commercial development is estimated to be 5.2 million square feet.

Water Demand and Supply – SMWD

Water Demand

SMWD's water use was 34,169 AF in 2010, consisting of 28,077 AF of imported water (82 percent), 65 AF of groundwater (0.2 percent), and 6,027 AF of recycled water (18 percent).[25] SMWD is projecting an increase in water demand over the next 25 years, but future water demands are expected to increase at a lower rate than the projected population growth due to proactive water conservation efforts. Population within the SMWD service area is expected to increase by 40 percent, compared to demand, which is expected to increase by 36 percent.[26] Past, current, and projected demand is shown in **Table 6-4** by water-use sector.

TABLE 6-4
SMWD PAST, CURRENT AND PROJECTED WATER DEMAND BY WATER USE SECTOR

	Water Demand by Water Use Sectors (AFY)				
Fiscal Year Ending	**Single Family**	**Multi-Family**	**Commercial /Industrial**	**Landscape**	**Total Demand**
2005	16,295	2,768	9,936	3,862	**32,861**
2010	17,702	2,936	1,948	11,583	**34,169**
2015	18,617	3,130	2,052	12,206	**36,006**
2020	20,499	3,419	2,257	13,424	**39,599**
2025	23,599	3,573	2,564	15,251	**44,987**
2030	24,458	3,573	2,645	15,733	**46,409**
2035	24,458	3,573	2,645	15,733	**46,409**

SOURCE: Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-5, Table 2-4.

25 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-13.
26 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-13.

The residential sector accounts for approximately 60 percent of the existing water demand within SMWD. Commercial/Industrial, including dedicated landscape, consumes approximately 40 percent of SMWD's water supply. SMWD's water demands include recycled and domestic irrigation accounts. SMWD's total water demand includes up to 70 percent for irrigation purposes. Existing centralized irrigation demands are 33.9 percent of SMWD's total water demands, with 17.9 percent of total irrigation demands provided by the recycled water system.[27]

Water Supply

SMWD's main source of water supply is imported water from Metropolitan through purchases from MWDOC. Today, SMWD relies on approximately 82 percent imported water, 18 percent recycled water, and 0.2 percent local groundwater supply from the San Juan Basin.[28]

Tables 6-5 and **6-6** show current and projected supply and demand, by water supply source, under normal year conditions. SMWD's 25-year demand projections for imported water are based on the projections provided by SMWD to MWDOC. Additional water supplies from Metropolitan that have been listed as available in Metropolitan's 2010 RUWMP are not included in this table because of reliability issues and availability concerns (see further discussion o Metropolitan supplies and reliability issues in Section 6.2.7, below). In addition, SMWD intends to supplant these potential supplies from Metropolitan using water from the other/new sources shown in the table.[29]

TABLE 6-5
CURRENT AND PROJECTED WATER DEMANDS (AFY)

	Fiscal Year Ending					
Water Supply Sources	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
MWDOC (Imported Treated/ Untreated Full Service (non-int.))	28,077	19,067	20,480	23,121	24,033	24,033
Baker Treatment Plant (Imported Untreated Full Service (non-int.))	–	9,400	9,400	9,400	9,400	9,400
San Juan Basin	65	100	116	116	116	116
Recycled Water	6,027	7,439	9,603	12,350	12,860	12,860
Total	**34,169**	**36,006**	**39,599**	**44,987**	**46,409**	**46,409**

SOURCE: Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-14, Table 2-9.

27 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-6.
28 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 3-10.
29 Metropolitan Water District of Southern California, *2010 Integrated Water Resources Plan*, 2010.

TABLE 6-6
PROJECTED NORMAL WATER SUPPLY AND DEMAND (AFY)

	Fiscal Year Ending				
	2015	**2020**	**2025**	**2030**	**2035**
Total Demand	**36,006**	**39,599**	**44,987**	**46,409**	**46,409**
San Juan Basin	100	116	116	116	116
Recycled Water	7,439	9,603	12,350	12,860	12,860
Imported	28,467	29,880	32,521	33,433	33,433
Total Supply	**36,006**	**39,599**	**44,987**	**46,409**	**46,409**

SOURCE: Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 3-21, Table 3-13.

By 2015, SMWD's water supply portfolio is expected to shift to 79 percent imported water (53 percent imported treated water, 26 percent potable water from the Baker Water Treatment Plant (WTP) from untreated imported water), 21 percent recycled water, and 0.3 percent local groundwater.[30] Local groundwater from the San Juan Basin is expected to remain at around 100 AFY.

Imported Water. Imported water from Metropolitan (via MWDOC) currently fulfills more than 80 percent of SMWD's demand. Metropolitan's supply projections indicate that it will be able to meet full service demands under wet, normal, and dry years through the year 2035, as does MWDOC.[31] However, these projections are based on several assumptions, including the assumption that uncertainties in the availability of imported water due to environmental, legal, and hydrologic factors will be resolved to Metropolitan's satisfaction and benefit.

Local Groundwater. There is one operating well, Well 6, in the southeast corner of SMWD's service area that provides 65 AFY, or 0.2 percent of SMWD's total water supply.[32] Extractions from the San Juan Basin are anticipated to increase to 116 AFY, or 0.3 percent of SMWD's total water supply, by 2015.

Recycled Water. SMWD provides additional treatment to a portion of its secondary treated wastewater, rather than discharging it to the ocean, and uses it for landscape irrigation. Recycled water is considered a highly reliable water supply since it is generated from relatively constant and predictable wastewater flows that are not subject to seasonal variations. The current combined recycled water production from the Oso Creek Wastewater Reclamation System and the Chiquita Water Reclamation Plant is about 6,600 AFY, and by 2035, recycled water use is expected to more than double, compared to existing conditions.[33]

30 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2.
31 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 3-19.
32 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, pages 3-12, 3-13.
33 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-13.

Water Supply Reliability

SMWD continues to explore opportunities for augmenting and shoring up the reliability of their water supplies to ensure that they meet projected customer demand through 2035. Understanding that the availability of future imported supplies is tentative and dependent on factors outside of its control, SMWD is participating in numerous planned projects, including the Chiquita WRP expansion and the Baker WTP, to decrease SMWD's reliance on imported treated water from MWDOC and Metropolitan. These are briefly summarized below. For more information on these projects, refer to SMWD's 2010 UWMP.[34]

Baker Water Treatment Plant. The Baker WTP will treat untreated water from the Santiago Lateral and Irvine Lake through the Baker Pipeline. It is expected to come online in FY 2012-13. SMWD expects to receive its full capacity right of 9,400 AFY beginning in 2015. Untreated imported water from the planned Baker WTP is expected to decrease the reliance of SMWD on imported treated water from MWDOC and Metropolitan, as shown in Table 6.5. The Project is intended to provide increased water supply reliability to south Orange County by increasing local treatment capability for multiple water supply sources, including imported water and local surface water from Irvine Lake. It will also help provide a reliable local potable water supply in the event of emergency conditions or scheduled maintenance on the Metropolitan's delivery system and increase operational flexibility by creating redundancy within the water conveyance system.[35]

Upper Chiquita Reservoir Project. SMWD is constructing the Upper Chiquita Reservoir, which will have a capacity of 244 MG (750 AF) and will act as a large-scale emergency potable water supply during planned or unplanned service disruptions. Construction was completed in Fall 2011.

Chiquita Water Reclamation Plant Expansion. SMWD's planned Chiquita Water Reclamation Plant (WRP) expansions will provide an additional 3,000 AFY of recycled water by 2015 and another 2,000 AFY by 2025, The expansion will reduce SMWD's dependency on imported water and provide recycled water for irrigation purposes.

Los Alisos Water Reclamation Plant. SMWD has an agreement to purchase up to 1,500 AFY from IRWD through 2030 and additional water on an as-available basis. The Oso/Los Alisos and Chiquita system interconnections increase the reliability of the recycled supply throughout the SMWD service area.

IRWD Interconnection Project. SMWD is working with neighboring agencies to expand a permanent interconnection and pumping facilities between the IRWD potable water distribution systems.

Rancho Mission Viejo Riparian Non-Potable Water. Rancho Mission Viejo (RMV) holds riparian water rights for its ranching, agriculture and tenants uses. RMV and SMWD are

34 Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, pages 2-13.
35 Irvine Ranch Water District, Baker Water Treatment Plant, http://www.irwd.com/your-water/construction-projects/baker.html, accessed October 2011.

contemplating an agreement whereby RMV leases a portion of the riparian water to SMWD for use as supplemental water to offset in part the non-domestic water demand generated by the previously-approved Ranch Plan development, which represents the build-out of the remaining open space within SMWD.[36] SMWD is proposing to use the leased water to provide for non-domestic irrigation water to the HOA parcels and to the RMV-related investment properties in the event that recycled water is not available. A portion of the leased water could also be used during grading and construction activities for dust control, trench backfill, and similar uses.

Supplemental Dry Year Water Supplies. SMWD has two water purchase agreements with Cucamonga Valley Water District and Golden State for water in the Chino Basin. When supplies from Metropolitan are limited, Cucamonga Valley Water District and Golden State will utilize groundwater in lieu of taking delivery of imported water from Metropolitan. This will further augment supply reliability under normal, dry, or multiple dry-year water years. The purpose of these transfer agreements is to ensure that demands on SMWD's water resources from The Ranch Plan do not reduce water supplies for existing customers or prevent other approved developments.

SMWD/Cucamonga Valley Water District Agreement – Cucamonga Valley Water District will provide 4,250 AF of water to SMWD, which will provide 88 percent redundancy to The Ranch Plan's projected Year 2025 potable water demand of 4,840 AF during normal years and augment Metropolitan's conservative projected supply reliability. Expected increased demand during dry and multiple dry years will be met by increasing recycled water production, enabling a 50 percent margin of potable water supply redundancy in addition to meeting non-potable demands for The Ranch Plan.

SMWD/Golden State Water Company Agreement – The 2,000 AF of stored water from Golden State was acquired in contemplation of augmenting Metropolitan water supplies for The Ranch Plan. The water may be called if necessary to supplement the Cucamonga Valley Water District supplemental supply.

Cadiz Valley Water Conservation, Recovery and Storage Project.[37] SMWD is pursuing participation in the proposed Project as part their efforts to address the uncertainties arising over the long-term reliability of, and to offset the need for, imported water. As described in Chapter 3, Project Description, SMWD would acquire 5,000 AFY with an option for an additional 10,000 AFY, totaling up to 15,000 AFY. Conserved water would be collected and delivered via the CRA. A new conveyance pipeline would be constructed from the Cadiz Property to the CRA. From there, SMWD would receive water deliveries via existing infrastructure and through water transfers or exchanges with MWDOC, a Metropolitan member agency, for use throughout their service area. SMWD is also exploring possibilities for water storage at the Project site that in wet years would store water from the CRA into the aquifer. The CRA would also be used under the Imported Water Storage Component to convey stored water to Metropolitan's CRA. This water

[36] The proposed residential development associated with The Ranch Plan will consist of 14,000 units with 6,000 of the units being age-restricted units which have a lower water demand because of lower occupancy. The proposed commercial development is estimated to be 5.2 million square feet.

[37] Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 7-13.

could be used when needed in dry years. If implemented, the proposed Project would diversify SMWD's water portfolio and help drought-proof the District to ensure its water demands are met regardless of the status of the region's imported supply.

Project Growth Inducement Potential for SMWD

Between 2010 and 2035, water demand in SMWD's service area is expected to increase by 36 percent, from 34,169 to 45,409 AFY and population is expected to increase by 40 percent. SMWD has identified opportunities for improving water supply reliability to meet projected demands through 2035. SMWD's planned and possible future projects could provide up to 37,900 AFY of supplemental water supply. The largest of these are the proposed Project, which could provide up to 15,000 AFY, and the Baker WTP, which will deliver 9,400 AFY of imported water to SMWD beginning in 2015. If SMWD exercises its option to acquire a total of 15,000 AFY from the proposed Project (5,000 AFY plus an option for an additional 10,000 AFY), then Project water would represent up to 32 percent of SMWD's projected 2035 supply portfolio.

There is one major remaining development within the SMWD service area, the Ranch Plan that involves 14,000 residential units and 5.2 million square feet of commercial space for which SMWD has already secured adequate water supply. [38] The Project is not needed to meet the demands of this new planned growth. Water acquired by SMWD under the Project primarily would be used to bolster the reliability of the District's existing imported supply, which currently represents 82 percent of its total supply. In years when imported supply deliveries from the Colorado River and Bay-Delta systems are restricted, SMWD could make use of supplemental supply from the Project to make up for imported supply shortfalls.

Although Project water would be used primarily to improve the reliability of SMWD's existing water supplies, by contributing to the District's overall water supply portfolio it is possible that some of the Project water could be used to support some of the remaining incremental growth planned within SMWD's southern Orange County service area. The Project has limited growth potential within the SMWD service area.

It is possible that in select years, SMWD could make some of its Project water available to other neighboring agencies within the MWDOC service area. Water would be provided to another agency on a short-term basis only and, as such, would not represent a firm, permanent supply for any other agency. This action would provide additional supply reliability support within MWDOC and broader Metropolitan service area but would not result in growth inducement outside of SMWD's service area.

6.2.3 Golden State Water Company

Golden State is engaged in the distribution and sale of water and power to over 275,000 customers in 10 counties across California. In Southern California, Golden State serves customers

38 Santa Margarita Water District, *Water Supply Assessment for "The Ranch Plan" General Plan Amendment/Zone Change (PA 01-113) Rancho Mission Viejo,* June 2003.

in cities throughout San Bernardino, Riverside, Los Angeles, Orange, and Ventura counties. Its statewide service area network is divided into three regions with Southern California service systems constituting a small portion of Region I, and all of Regions II and III. Within the Project Water Area of Use, Golden State services 17 water systems in three counties: Los Angeles, Orange and Ventura. Golden State's water supply sources for customers in these areas include imported water purchased from Metropolitan, groundwater pumped from local underground aquifers, and recycled water.

Land Use and Population

Golden State proposes to use Project water in 17 water systems of its Southern California water systems located in three counties: Los Angeles, Orange and Ventura (see Figure 1-3). As shown on **Table 6-7,** current population within these 17 water systems totals 863,355 and is projected to increase approximately 12.5% between 2010 and 2035, to 970,856 people.

TABLE 6-7
PROJECTED POPULATION GROWTH FOR APPLICABLE SOUTHERN CALIFORNIA WATER SYSTEMS IN GOLDEN STATE REGIONS I, II AND III[39]

Water System	2010	2035	% Increase
Artesia	52,974	54,899	3.6%
Bell-Bell Gardens	69,119	70,848	2.5%
Claremont	35,248	39,015	11.0%
Cowan Heights	5,353	5,551	4.0%
Culver City	36,704	37,679	3.0%
Florence Graham	62,451	69,809	12.0%
Hollydale	Covered under "Central Basin", no UWMP		
Norwalk	43,683	47,638	9.0%
Placentia	49,342	55,779	13.0%
San Dimas	54,416	76,769	36.0%
Simi Valley	38,676	42,489	10.0%
South Arcadia	3,395	4,815	42.0%
South San Gabriel	28,715	31,932	11.0%
Southwest	271,861	311,135	23.0%
West Orange	111,418	122,498	10.0%
Willowbrook	Covered under "Central Basin", no UWMP		
Yorba Linda	Covered under Placentia System		
TOTAL	**863,355**	**970,856**	**12.5%**

SOURCE: Golden State Water Company, *2010 Urban Water Management Draft Plan*, *Multiple Water Systems*, 2010, Table 2-2.

39 Statistics for projected and historic population growth include only information for those Water Systems with Urban Water Management Plans, and those with more than 3,000 service connections or supplying more than 3,000 AFY.

Water Supply and Demand - Golden State

Golden State uses two main methods to obtain water for distribution within its service area. Groundwater is pumped to water systems that have access to local groundwater sources, and water is imported from wholesale water suppliers. Wholesale water suppliers that import water to Golden State's Region I, II, and III systems are member agencies of Metropolitan.

Demand projections for 2035 for Golden State's 17 water systems are shown in **Table 6-8**. Demand increases are projected in all customer use categories: Single Family, Multi-Family, Commercial, Industrial, Institutional, Government, and Landscape.

TABLE 6-8
PROJECTED WATER SUPPLY / DEMAND FOR APPLICABLE SOUTHERN CALIFORNIA WATER SYSTEMS IN GOLDEN STATE REGIONS I, II AND III[40]
(acre-feet)

Water System	AFY 2010	AFY 2035	% Increase
Artesia	5,613	7,124	27%
Bell-Bell Gardens	5,333	6,409	20%
Claremont	10,620	14,872	34%
Cowan Heights	2,557	3,299*	29%
Culver City	5,454	6,975	28%
Florence Graham	5,163	6,666	29%
Hollydale	Covered under "Central Basin", no UWMP		
Norwalk	4,986	6,913	39%
Placentia	7,522	9,830	31%
San Dimas	11,922	18,107	52%
Simi Valley	6,513	10,028*	54%
South Arcadia	3,395	4,815	42%
South San Gabriel	2,689	3,748	39%
Southwest	29,886	40,885	37%
West Orange	15,287	19,645	29%
Willowbrook	Covered under "Central Basin", no UWMP		
Yorba Linda	Covered under Placentia System		
Total	**116,940**	**159,316**	**36%**

SOURCE: Golden State Water Company, *2010 Urban Water Management Draft Plan, Multiple Water Systems*, 2010, Tables 3-14, 4-1.

As shown in Table 6-8, all Golden State water systems that could receive water under the proposed Project are projected to have demand increases of 20 percent or greater by 2035; in two water systems demand increases are projected to be approximately 50 percent. For example, the San Dimas Water System anticipates demand to increase by almost 52 percent, from 11,922 AFY in 2010 to 18,107 AFY in 2035. The demand increases projected between 2010 and 2035 for San

40 Statistics for projected and historic water supply/demand include only information for those Water Systems with Urban Water Management Plans, and those with more than 3,000 service connections or supplying more than 3,000 AFY.

Dimas in particular and many of Golden State's water systems in general, are abnormally high but not because accelerated growth is projected for this next 25 year period. Rather, the projected future increases in demand reflect the fact that water demand declined in many service areas between 2008 and 2010 and is expected to recover to previous levels for existing customers in the years ahead on top demand increases associated with new development and customers.

For example, for Golden State's San Dimas water system, water use began declining in 2007 with an approximate 18 percent decline from 2008 to 2010. Review of similar data from other systems suggests that the decline in water use has been widespread and is not isolated to the San Dimas system. The recent decline in water use is not fully understood, but may be the result of several factors including: several years of cool summers, a statewide drought that forced mandatory water reductions and conservation in many areas, and an economic downturn that has resulted in business closures and increased housing vacancies.[41]

Golden State projects adequate supplies to meet the future needs of its water systems included in the Project Water Area of Use, as shown in Table 6-8, based on Metropolitan's projection in its 2010 Regional Urban Water Management Plan that it will be able to deliver imported supplies under all conditions and year types. For example, San Dimas expects to meet this increased demand by increasing the amount of water purchased from Metropolitan through Three Valleys by 79 percent.[42] Golden State specifies in numerous UWMPs that increased demands across Southern California will be met through purchasing additional water from Metropolitan through individual wholesalers, through additional groundwater and surface water transfers,[43] and through conservation practices such as reduced water use commensurate with the requirements of SBx7-7. Golden State plans to reduce per capita water use within each water system by implementing water conservation BMPs (which correspond to the 14 Demand Management Measures under the UWMP Act). However, the demand projections presented in the UWMP, in most cases, do not yet reflect compliance with required water use reductions as defined by SBx7-7.

Water Supply Reliability

Water reliability issues for Golden State are related to the imported water supplies it attains through Metropolitan. Like all water providers receiving imported supplies from the Colorado River system and/or the Sacramento-San Joaquin Delta system via the SWP, Golden State must be prepared to manage during import supply shortage periods due to drought and/or other regulatory restrictions on supply. Golden State has not yet incorporated potential participation in the Project into its current Urban Water Management Plans for the water systems that could be served by the Project but acquisition of up to 5,000 AFY of Project water is one step Golden State is considering, along with proposed surface water transfers, increased groundwater pumping, and increased demand management, to improve the reliability of its supply and meet the future needs of its customers.

41 Golden State Water Company, *2010 Urban Water Management Plan San Dimas Draft Report*¸ August 2011, page 3-2.
42 Golden State Water Company, *2010 Urban Water Management Plan San Dimas Draft Report*¸ August 2011, page 4-3.
43 Golden State Water Company, *2010 Urban Water Management Plan Placentia Draft Report*¸ August 2011, page 4-2.

Growth Inducement Potential for Golden State Water Company

Between 2010 and 2035, the population within Golden State's 17 water system service areas is projected to increase 12.5 percent. Water demand is projected to increase 36 percent but, as discussed above, this reflects an increase in water use by existing users back to prior use levels plus projected new demands. The new demand projection does not reflect additional conservation that will be implemented in compliance with current regulations. Thus, the projected 36 percent increase overstates what is attributable to new demands.

Golden State would receive up to 5,000 AFY of Project water, which represents a small percentage of Golden State's water supply portfolio for the 17 water systems with the Project Water Area of Use (4 percent of current and 3 percent of projected future supply, respectively). As noted above, imported surface water supply makes up a substantial portion of Golden State's water portfolio, thus Golden State has to be prepared for cutbacks in imported supply deliveries in drought years and other periods of restriction. In years when imported supply deliveries from the Colorado River and Bay-Delta systems are restricted, Golden State could make use of the supplemental supply provided by the Project to make up for imported supply shortfalls.

Although Project water would be used primarily to improve the reliability of Golden State's existing water supplies and while it constitutes only a small percent of total supply, by contributing to Golden State's overall water supply portfolio it is possible that some of the Project water could be used to support some of the growth projected in the communities served by Golden State. Therefore, the Project has some, albeit limited, growth inducement potential within the Golden State service area.

6.2.4 Three Valleys Municipal Water District (Three Valleys)

Three Valleys distributes water for beneficial uses within a 133-square-mile area in eastern Los Angeles County that includes Azusa, City of Industry, Covina, Claremont, Diamond Bar, Glendora, Hacienda Heights, La Puente, La Verne, Pomona, Rowland Heights, San Dimas, Walnut, and West Covina. Three Valleys is a member agency of Metropolitan and delivers water purchased from Metropolitan to its 14 member agencies. Three Valleys' typically receives just over half of its total supply from Metropolitan; the rest comes from local groundwater, surface water and recycled water.

Land Use and Population

Three Valleys provides water to a total population of over 573,800. Land use in the service area is primarily urban, with limited open space. **Table 6-9** lists the cities and counties in Three Valleys' service area; those in italics are partially within the service area. At present, Three Valleys has no plans to expand its service area.

Three Valleys' service area is in the planning area of the San Gabriel Valley Council of Governments, a subregional organization within SCAG. Table 6-9 shows the existing (2010) and projected (2035) population and the net and percent change in population, by city. Of the cities

served, Pomona has the largest existing population and projects the largest increase in population between 2010 and 2035, while the City of San Dimas projects the greatest percent change in population (42.6 percent increase) over that period. Overall population growth through 2035 is 24.1 percent.

TABLE 6-9
PROJECTED POPULATION GROWTH IN THREE VALLEYS SERVICE AREA BY CITY

	Population		Change (2010-2035)	
City	**2010**	**2035**	**Net**	**Percent**
Azusa	*1,230*	*1,412*	*182*	*14.8*
Claremont	37,608	40,405	2,797	7.4
Covina	*16,541*	*20,217*	*3,676*	*22.2*
Diamond Bar	61,019	68,570	7,551	12.4
Glendora	*51,773*	*57,959*	*6,186*	*11.9*
Industry	*442*	*445*	*3*	*0.7*
La Puente	*434*	*553*	*119*	*27.7*
La Verne	34,051	40,249	6,198	18.2
Pomona	163,683	208,558	44,875	27.4
San Dimas	36,946	52,694	15,748	42.6
Walnut	32,659	37,339	4,680	14.3
West Covina	*16,934*	*21,074*	*4,140*	*24.4*
Unincorporated	*120,480*	*162,778*	*42,298*	*35.1*
Total Three Valleys Service Area	**573,800**	**712,253**	**138,453**	**24.1**

SOURCE: Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011, Table 2-2, page 11.

Water Supply and Demand – Three Valleys

Water Supply

Three Valleys' water supply portfolio includes a mix of local and imported water supplies. During a normal year, local sources have historically fulfilled 49 percent of the demand and imported supplies have fulfilled 51 percent of the demand. Supply availability can vary from year to year and depends on a variety of environmental, legal, and hydrological factors. **Table 6-10** shows historic and projected/planned sources of supply for the Three Valleys service area, from 2005 to 2035. Additional information on individual supply components is provided below.

Imported Water. Imported supply from the SWP and CRA purchased from Metropolitan typically fulfills slightly over half of the total water demand. By 2035, use of imported water is expected to increase by about 30 percent relative to existing (2010) levels.

TABLE 6-10
HISTORIC WATER USE (2005 – 2009) AND PROJECTED WATER SUPPLY (2010 – 2035)
IN THE THREE VALLEYS SERVICE AREA
(Acre-Feet)

Year	Local Groundwater	Local Surface Water	Recycled Water	Imported Water	Total[d]
2005	48,596.6	10,538.8	6,478.6	64,523.9	130,137.9
2006	51,862.8	11,126.8	6,690.8	63,178.9	132,859.3
2007	52,921.0	8,952.7	4,320.5	72,318.5	138,512.7
2008	49,536.8	11,304.2	3,957.9	69,242.9	134,041.7
2009	45,483.5	6,020.5	3,797.8	59,135.3	114,437.0
2010	46,056	6,500	5,317	69,748	127,621.0
2015	46,137	6,500	7,272	77,343	137,252.0
2020	46,141	6,500	8,185	83,864	144,690.0
2025	46,146	6,500	8,937	86,499	148,082.0
2030	46,151	6,500	9,623	89,498	151,772.0
2035	46,155	6,500	10,292	91,197	154,144.0

SOURCE: Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011, page 16 Table 3-2, and page 18 Table 3-4.

Local Groundwater. Groundwater sourced from several basins underlying the service area makes up the majority of local supply, historically satisfying about 37 to 40 percent[44] of demand. In the future, expansion of groundwater production within the service area may provide added supply, by accessing available local resources that have not yet been tapped or that have been inactive (potential quantities associated with such projects are not currently reflected in water supply forecasts; further details are available in Three Valley's 2010 UWMP).

Local Surface Water. Local surface water supply quantities, which currently satisfy about 5 to 8 percent of total water demand, are expected to remain the same in the future. Surface water is sourced from the San Gabriel Mountain foothills. Surface water availability is dependent upon local precipitation and snowmelt; because annual fluctuations are common, this is not considered a reliable supply during periods of drought.

Recycled Water. Recycled water from the Pomona Water Reclamation Plant and San Jose Creek Water Reclamation Plant is used primarily for irrigation purposes in the southern portion of the service area. Recycled water use in the Three Valleys service area is still limited, making up approximately 3 to 5 percent of total demand. The main objective of future recycled water projects will be to expand the recycled water infrastructure system. As new infrastructure is constructed, the use of recycled water may offset up to 8,000 to 10,000 AFY of potable water demand.

44 Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011, page 15, Table 3-1.

Three Valleys and its member agencies are exploring other opportunities to address the uncertainties arising over the long-term reliability of, and to offset the need for, imported water. As part of these efforts, Three Valleys is pursuing participation in the proposed Project which could supply up to 5,000 AFY of water to offset imported demand. Investigations into other water transfer and conjunctive use opportunities are still in their early stages. Three Valley's 2010 UWMP contains more detail on these projects. The agency's efforts to improve supply reliability are discussed further below under the Water Supply Reliability subsection.

Water Demand

The primary water demands within Three Valley's service area come from the municipal and industrial sectors. Due to the urban character of the region, the municipal and industrial sectors are expected to continue to be the primary water users in the future. Total water use from 2005 to 2009 is shown in the right-hand column of Table 6-10. **Table 6-11** provides a breakdown of current and projected demand between 2010 and 2035, by customer type, based on modeling by Metropolitan. As shown, demand is projected to increase by about 21 percent (from 127,621 AF to 154,144 AF), with Retail Municipal/Industrial accounting for over 96 percent of the projected increase.

TABLE 6-11
TOTAL RETAIL DEMAND IN THREE VALLEYS SERVICE AREA
WITH CONSERVATION - AVERAGE YEAR
(Acre-Feet)

Use Type	2010	2015	2020	2025	2030	2035
Retail Municipal/Industrial	122,367	131,999	138,437	141,829	145,519	147,891
Retail Agricultural	253	253	253	253	253	253
Groundwater Replenishment	5,000	5,000	6,000	6,000	6,000	6,000
Total	**127,621**	**137,252**	**144,690**	**148,082**	**151,772**	**154,144**

SOURCE: Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011, page 18 Table 3-4.

Water Supply Reliability

Because imported water makes up more than half of its water supply portfolio, Three Valleys relies heavily on the availability of Metropolitan supplies to gauge reliability. In an attempt to address reliability issues associated with imported water supply, Three Valleys is promoting water conservation within its service area and pursuing opportunities to develop alternative water supplies, including participating in the proposed Project. Conjunctive use/cyclic storage, groundwater recovery/expansion, and additional resource development are avenues being explored.

Water Conservation. Water conservation across all customer groups is a key component of Three Valleys' long-term water supply strategy. Efforts include public education regarding

efficient water use, conservation research and increased coordination of funding for retail-agency sponsored projects. Three Valleys is a charter signatory to the 1992 Memorandum of Understanding Regarding Urban Water Conservation Best Management Practices, and encourages its member agencies to implement conservation measures. Three Valleys has taken steps to implement applicable BMPs and provide technical, financial and managerial support to member agencies' conservation projects. Long term savings from conservation measures is projected to range from 19,200 AFY in 2020 to 27,300 AFY in 2035.

Conjunctive Use. Three Valleys and its member agencies have developed three conjunctive use projects in recent years, in partnership with Metropolitan. The Live Oak Basin Conjunctive Use Project has the potential to store 3,000 AFY of conjunctive use water with a withdrawal of 1,000 AFY. The City of LaVerne's WTF has the capacity to treat 2,500 AFY on average of additional recovered groundwater. Upper Claremont Heights Basin has averaged 800 AFY production but the storage amount is 3,000 AFY with a withdrawal potential of 1000 AFY; there is also the potential to add 5,000 AFY. Chino Basin has a total program storage capacity of 100,000 AFY with 33,000 AFY annual extraction capabilities in dry years.

Local Groundwater Recovery. The recovery or expansion of groundwater production within the TVMWD service area may provide on the order of 20,000 to 25,000 acre-feet per year of added supplies. The idea behind groundwater recovery is to utilize available local resources that have never been tapped or have been inactive for an extended period due to physical or water quality restrictions. In addition to completed and online projects, the UWMP for Three Valleys lists four planned projects with estimated yield 29,000 AFY.

Recycled Water. Presently, recycled supplies into the TVMWD service area are sufficient to meet current demands, and projected non-potable demands are not expected to outgrow recycled water availability to the region for at least the next 10 years. In the future, recycled water development by the retail agencies within the TVMWD service area may offset another 8,000 to 10,000 AFY of firm potable water demand.

Project Growth Inducement Potential for Three Valleys

Three Valleys is anticipating a 24 percent increase in population between 2010 and 2035 and projecting a water demand increase of 21 percent, mostly due to Retail Municipal/Industrial use. Three Valleys is promoting water conservation within its service area and pursuing opportunities for conjunctive use/cyclic storage, groundwater recovery/expansion, and additional resource development, including participating in the proposed Project, to improve water supply reliability and meet projected demands through 2035. Together these planned and future projects could add 48,000 AFY to Three Valleys' total water supply, including long-term savings from conservation measures projected to range from 19,200 AFY in 2020 to 27,300 AFY in 2035; planned local groundwater recovery projects yielding 29,000 AFY; and recycled water projects offsetting up to10,000 AFY of potable water demand.

The 5,000 AFY of Project water that Three Valleys would acquire under the Project represents a small percentage of its total water supply portfolio (4 percent of current and 3 percent of projected

future supply, respectively). As with other Metropolitan member agencies, Three Valleys may need to use its Project water in some years to maintain its supply reliability and compensate for imported water delivery restrictions. For instance, in years when imported supply deliveries from the Colorado River and Bay-Delta systems are restricted, Three Valleys could make use of the supplemental supply provided by the Project to make up for imported supply shortfalls.

Although Project water would be used primarily to improve the reliability of Three Valleys existing water supplies and while it constitutes only a small percent of total supply, by contributing to Three Valley's overall water supply portfolio it is possible that some of the Project water could be used to support some of the growth projected in the communities served by Three Valley's. Therefore, the Project has some, albeit limited, growth inducement potential within the Three Valleys service area.

6.2.5 Suburban Water Systems (Suburban)[45]

Suburban provides water and water service to a population of approximately 293,000 people in Los Angeles and Orange counties, including all or portions of Glendora, Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, and Buena Park. Suburban's 42-square-mile service area is divided into two regions: the San Jose Hills Service Area and the Whittier/La Mirada Service Area (see Figure 1-2). The two service areas are about 3 miles apart, separated by the La Puente Hills. Suburban's water supply primarily comes from local groundwater (80 percent).

Land Use and Population

Suburban's service area encompasses portions of the cities and counties listed in **Table 6-12**, below. These areas consist primarily of urban residential land uses. Within the service area, population has been relatively steady over the past 15 years and is projected to remain steady in the future (see Table 6-13). The Suburban service area is within the planning area of the San Gabriel Valley Council of Governments and SCAG.

Water Demand and Supply – Suburban

Water Demand

Current water use within Suburban's service area is about 72 percent residential, 21 percent commercial, and 6 percent public agency, with less than 1 percent industrial and other uses. The Suburban service area has almost reached full build-out, and future demand is not expected to significantly change. **Table 6-13** indicates actual water use for 2005 and 2010 and projects water demand for 2015 through 2035.

[45] The following sources were used as the basis for the discussion and analysis of Suburban Water Systems:

- Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011.
- SouthWest Water Company, *Suburban Water Systems*, www.swwc.com/suburban/about-our-water/, accessed February 2011.

TABLE 6-12
PROJECTED POPULATION GROWTH IN SUBURBAN WATER SYSTEMS SERVICE AREA

		Population		Change (2010-2035)	
Service Area	**Cities**	**2010**	**2035**	**Net**	**Percent**
San Jose Hills	West Covina				
	La Puente				
	Walnut				
	Glendora	178,500	178,900	400	0.22
	Industry				
	Covina				
	Unincorporated Los Angeles County				
Whittier/La Mirada	La Mirada				
	Whittier				
	La Habra	115,000	115,300	300	0.26
	Buena Park				
	Unincorporated Los Angeles County				
	Unincorporated Orange County				
Total Suburban Service Area		**293,500**	**294,200**	**700**	**0.24**

SOURCE: Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011, page 2-3, Table 2-1.

Water Supply

Suburban's water supply portfolio includes local groundwater, purchased groundwater and surface water, recycled water, and imported SWP and CRA water from Metropolitan purchased from several different wholesalers. **Table 6-14** shows current and projected water supplies for Suburban's service area.

TABLE 6-13
TOTAL RETAIL WATER USE AND PROJECTED DEMAND IN SUBURBAN'S SERVICE AREA
(Acre-Feet)

Use Type	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Residential	37,700	33,300	34,120	34,120	34,120	34,120	34,120
Commercial	10,700	9,000	9,580	9,580	9,580	9,580	9,580
Industrial	800	1,600	1,570	1,570	1,570	1,570	1,570
Public Authority	2,800	2,800	3,390	3,390	3,390	3,390	3,390
Other	100	0	30	30	30	30	30
Sales to Other Agencies	0	0	10	10	10	10	10
Unaccounted for Water	3,700	2,800	2,870	2,870	2,870	2,870	2,870
Total	**55,800**	**49,500**	**51,570**	**51,570**	**51,570**	**51,570**	**51,570**

SOURCE: Suburban Water Systems, 2010 *Urban Water Management Plan*, June 2011, page 3-8, Table 2-8.

TABLE 6-14
SUBURBAN WATER SYSTEMS: EXISTING AND PROJECTED WATER SUPPLY SOURCES[46]
(Acre-Feet)

Year	Groundwater	Purchased Groundwater and Surface Water	Imported Water[a]	Recycled Water	Total
2010	36,079	11,712	10,333	0	58,124
2015	36,079	11,712	10,333	1,406	59,530
2020	36,679	11,712	10,333	1,406	60,130
2025	36,679	11,712	10,333	1,406	60,130
2030	36,679	11,712	10,333	1,406	60,130
2035	36,679	11,712	10,333	1,406	60,130

a Suburban purchases water from Metropolitan via the Upper San Gabriel Municipal Water District and Central Basin Municipal Water District.

SOURCE: Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011, page 3-3 Table 3-1, and page 3-6 Table 3-2.

Local Groundwater. Suburban historically drew between 45 percent and 76 percent of its supply in each service area from wells in the Main San Gabriel and Central groundwater basins, both of which are adjudicated.[47] A significant portion of Suburban's purchased supply from other agencies is also sourced from these basins. The Main and Central Basins are expected to support the same levels of pumping in the future and are intended to be the primary sources of water through the UWMP planning horizon of 2035.[48]

Studies identifying widespread volatile organic compounds contamination of the groundwater basin led the US Environmental Protection Agency to place the San Gabriel Valley Basin on the National Priorities List, or Superfund Program, in 1984 and subsequently led to the development of groundwater cleanup projects. Suburban's *2010 Urban Water Management Plan* indicates that "problems with groundwater pollution in the Main Basin are being addressed by the Watermaster and San Gabriel Basin Water Quality Authority and these problems, while not completely solved, are being proactively addressed and solutions are being developed."[49]

Imported Water. Suburban obtains imported SWP and CRA water from Metropolitan, mainly through its wholesale agencies (Upper San Gabriel Valley Municipal Water District and Central Basin Municipal Water District), with smaller portions coming from agreements with other Metropolitan member agencies. Additionally, the wholesale agencies provide replenishment water for the Main San Gabriel and Central Basins.

46 Totals are for the San Jose Hills and Whittier/La Mirada service areas combined
47 Suburban is party to the Main San Gabriel Judgment and is entitled to 12.58 percent of the Operating Safe Yield of the Main Basin. Suburban is also a party to the Central Basin Judgment and has an allowed pumping allocation of 3,721 AFY. Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011, page 3-7, Table 3-5.
48 Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011, pages 6-1, 3-2.
49 Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011, page 5-1.

Recycled Water. Although Suburban has not historically used recycled water within its service area, it is participating in the City of Industry Regional Recycled Water Project, currently under construction. The Regional Recycled Water Project will contribute 1,406 AFY of recycled water supplies to the service area, to be used mainly for irrigation, beginning in late 2011. The recycled water will offset potable water use and aid in meeting Suburban's conservation requirements. Recycled water use is expected to remain steady through 2035.

Water Supply Reliability

Suburban has the same concerns about imported supply water reliability from Metropolitan as discussed for the other Project Participants, and has some reliability issues associated with its local groundwater supply, as noted above, related to planned but not yet active implementation of contamination clean up. Suburban expects local groundwater and imported water supplies to remain constant through 2035 and future demand projections shows a relatively stable to decreasing trend. Based on its projections, Suburban's existing water supply capabilities would be sufficient to meet projected demand through 2035 under normal, single dry year, and multiple dry year conditions. Suburban is pursuing water conservation to manage future demand within its service area.

Water Conservation. Suburban is a signatory to the 1992 MOU Regarding Water Conservation in California and implements a variety of demand management measures though its own programs and through collaboration with is wholesale agencies. Suburban's water conservation efforts include a water waste prevention program, retail conservation pricing, public education regarding efficient water use, and participation in high efficiency appliance rebate programs. Long term savings from conservation measures is projected to range from 180 AF in 2015 to 2,670 AF in 2035, which are the levels of conservation needed to meet SBx7-7 targets by 2020.

Project Growth Inducement Potential for Suburban

Between 2010 and 2035, water demand in Suburban's service area is projected to decrease by 7.6 percent, while population is expected remain close to existing levels (0.24 percent decrease). The Suburban service area has almost reached full build-out, and future demand is not expected to significantly change over existing levels.

Under the proposed Project, Suburban would receive up to 5,000 AFY of Project water to be used anywhere within its service area. Suburban has three current connections with Metropolitan and could therefore take Project water directly into their system or into a spreading basin for recharge. Project water would represent about 10 percent of Suburban's projected future water demand in 2035 and Suburban indicates that Project water would replace or be a substitute for imported water supplies. Because there is essentially no growth projected within Suburban's service area and water demand is projected to slightly decline, the Project would improve the reliability of existing supplies but would have no growth inducement potential within the Suburban service area.

6.2.6 Jurupa Community Services District (JCSD)

JCSD provides water, sewer, and street light services to about 102,000 people in and around the Jurupa Valley area of western Riverside County. JCSD's service area, which encompasses 48 square miles, generally extends southward from the San Bernardino County line to the Santa Ana River and eastward from South Milliken Road, Bellgrave Avenue, and Hellman Avenue to points just east of Armstrong Road and Camino Real (see Figure 1-2). Communities and cities in the service area include Sunnyslope, Indian Hills, Glen Avon, Pedly, Mira Loma, Jurupa Valley, and Eastvale; the new cities of Eastvale and Jurupa Valley have both just incorporated in the last two years.

Land Use and Population

JCSD provides water service to residential, commercial, industrial, institutional, recreational, and agricultural customers and for environmental and other uses, such as fire protection and pipeline cleaning. Land use in the service area is predominantly residential. Residential demand accounted for over 70 percent of JCSD's water use in 2009.[50]

JCSD's customer base grew rapidly between1995 and 2009; population in the service area increased by 151 percent in that 15-year period, as depicted in **Table 6-15.** Growth centers included Eastvale and Jurupa Valley, which incorporated as cities in 2010 and 2011, respectively. Currently, JCSD maintains 35,355 service connections. JCSD anticipates continuing to expand its service connections until ultimate build-out is reached (which is projected to occur in 2035). In 2035, JCSD expects 41,689 connections, serving a total population of 137,000. Projections indicate that the population in JCSD's service area will increase by about 35 percent between now and 2035.

TABLE 6-15
HISTORIC AND PROJECTED POPULATION IN JCSD SERVICE AREA

1995	2000	2005	2009	2015	2020	2025	2030	2035
40,512	51,172	84,294	101,700	113,800	130,400	132,500	134,800	137,000

SOURCE: Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011, page 15, 23.

Water Demand and Supply – JCSD

Water Demand

While some decreases in demand have occurred because of rate increases and the nationwide economic downturn, the overall use of and demand for water in JCSD's service area increased over the last 15 years, along with the local population. For example, water use in 1995 was 10,000 AFY and in 2009 was 23,660 AFY. **Table 6-16** summarizes current and projected water demand, by customer service class. Generally, water demand is expected to increase in all

[50] Jurupa Community Services District, *2010 Urban Water Management Plan,* May 2011, page 20.

customer classes, with the largest increases in the single family, commercial, and landscape customer classes. JCSD does not currently use imported water to satisfy demand, though they do plan on integrating imported water into their supply portfolio by 2020, via water transfers from Metropolitan or Western WMD.

TABLE 6-16
CURRENT AND PROJECTED WATER DEMAND BY CUSTOMER CLASS
(Acre-Feet)

Customer Class	2009	2015	2020	2025	2030	2035
Single Family	14,069	17,081	20,118	20,469	20,838	21,190
Multi-Family	851	947	1,109	1,128	1,148	1,166
Commercial	1,916	2,757	3,227	3,281	3,339	3,393
Industrial	851	1,182	1,383	1,407	1,431	1,454
Institutional / Governmental	639	802	939	955	971	987
Landscape	2,556	2,841	3,326	3,382	3,442	3,497
Agricultural (non-potable)	626	720	720	720	720	720
Subtotal	**21,509**	**26,330**	**30,822**	**31,341**	**31,888**	**32,407**
Unaccounted for Water (UAW) 10%[51]	2,151	2,633	3,082	3,134	3,189	3,241
Total Water Demand	**23,660**	**28,962**	**33,905**	**34,476**	**35,077**	**35,648**

SOURCE: Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011, page 15, Table 2-1.

Water Supply

Table 6-17 summarizes JCSD's current and planned water supply. Local groundwater is JCSD's sole source of water at present, and the Chino Basin supplies most of JCSD's groundwater. JCSD operates 16 wells, 8 booster stations, and 15 reservoirs with 53.7 million gallons of storage capacity. JCSD also participates in a Joint Powers Authority (JPA) with neighboring water purveyors, the Chino Basin Desalter Authority (CDA). CDA manages the production, treatment, and distribution of treated water within the region; they own and operate the Chino I and II Desalters, which remove nitrates and TDS from the Chino Basin at a rate of 12 MGD (per plant).[52] JCSD's contractual agreement with CDA requires that they purchase 8,200 AFY, and this contractual amount will increase by 3,300 AFY upon completion of the Chino II Desalter Expansion Project. There are also two small irrigation water systems located in JCSD (one in Sunnyslope and one in Eastvale).

[51] The California Department of Water Resources defines "Unaccounted-for-Water" as follows: Unaccounted-for-water is a misleading term long used by the water industry. Unaccounted-for-water includes unmeasured water put to beneficial use as well as water losses from the system. Better terms distinguish between authorized unmetered uses and water losses. Authorized unmetered uses include firefighting, main flushing, process water for water treatment plants, landscaping of public areas, etc. Water losses include all water that is not identified as authorized metered water use or authorized unmetered use. Water losses are lost from the distribution system, do not produce revenue, and are unavailable for other beneficial uses. Examples of water losses are: illegal connections, accounting procedure errors, reservoir seepage and leakage, reservoir overflow, leaks, theft, evaporation, and malfunctioning distribution system controls. (Source: Department of Water Resources, *Water Use Efficiency / Leak Detection,* http://www.water.ca.gov/wateruseefficiency/leak/, accessed October 2011.)

[52] Jurupa Community Services District, *2010 Urban Water Management Plan,* May 2011, page 5.

TABLE 6-17
SUMMARY OF CURRENT AND PLANNED WATER SUPPLIES IN JCSD
(Acre-Feet)

Water Supply Sources	2009	2015	2020	2025	2030	2035
Supplier Produced Potable Groundwater from Chino Basin	13,586	13,805	13,748	12,819	11,920	10,491
Desalination – Existing CDA Purchase	8,676	8,200	8,200	8,200	8,200	8,200
Desalination – Future CDA Purchase	-	3,300	3,300	3,300	3,300	3,300
Future Transfer from Metropolitan / Western MWD	-	-	5,500	6,500	8,000	10,000
Supplier Surface Diversions	0	0	0	0	0	0
Current Transfers from Rubidoux	679	500	500	500	500	500
Future Transfers from Rubidoux	-	1,000	1,000	1,000	1,000	1,000
Exchanges in or out	0	0	0	0	0	0
Total Potable	**22,941**	**26,805**	**31,748**	**32,319**	**32,920**	**33,491**
Chino Basin – Existing Non-Potable Groundwater	212	200	200	200	200	200
Groundwater – Non-Potable (Riverside Basin)	507	600	600	600	600	600
Non-Potable Groundwater (Future Chino Basin)	-	857	857	857	857	857
Recycled Water (projected use)	-	500	500	500	500	500
Total Non-Potable	**719**	**2,157**	**2,157**	**2,157**	**2,157**	**2,157**
Total Water Supply	**23,660**	**28,962**	**33,905**	**34,476**	**35,077**	**35,648**

SOURCE: Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011, page 28, Table 3-1.

Groundwater. Groundwater from three sources is used to meet both potable and non-potable water demand in the JCSD service area:

- **Groundwater pumping from the Chino Basin for potable and non-potable use.** The Chino Basin is an adjudicated basin, and JCSD has rights to groundwater pumping through the adjudication. There are approximately 2,720 acres of remaining agricultural land in the Chino Basin region of JCSD that are available for future development / conversion to urban uses. Upon conversion, JCSD will receive about 5,440 AF of additional groundwater production rights in the Basin. The Chino Basin Watermaster (Watermaster) is the overseeing agency for recharging and preventing overdraft within the Basin. The Watermaster replenishes groundwater in the Basin using a combination of natural stormwater recharge, SWP water from Metropolitan, and recycled water.
- **Groundwater extracted from the Chino Basin and treated by Chino I and II Desalters.** As a member of the CDA, JCSD is currently entitled to 2,700 AFY from the Chino I Desalter and 5,500 AFY from the Chino II Desalter, for a total of 8,200 AFY.
- **Groundwater pumping from the Riverside Basin for non-potable use.** The Riverside Basin water supply for JCSD is a relatively minor portion of the overall supply portfolio. The Riverside Basin is not adjudicated and not identified or projected to be overdrafted by DWR.

As part of its plans for meeting future water demand, over the next 25 years, JCSD plans to decrease its reliance on groundwater by diversifying its water supply portfolio. Currently,

groundwater accounts for 93 percent of the water supply. JCSD plans to reduce the prominence of groundwater so that by 2035, it accounts for 66 percent of total supply.

Water Supply Reliability

JCSD continues to explore ways to increase water reliability and protect its water supplies against circumstances that are beyond their control. An important component of long-term reliability is a diverse water supply portfolio. JCSD is exploring future diversification of its water supply and plans to reduce dependence on local groundwater supplies by implementing transfers, exchanges, and groundwater banking programs and by initiating a recycled water program to meet up to 4,300 AFY of existing and future irrigation demand that could be satisfied with non-potable water. To ensure reliability, JCSD also intends to increase its water supply portfolio by pursuing water from Western MWD via the Riverside Corona Feeder, the Riverside Basin, and recycled water. If one supplier reduces deliveries, then additional supply can be acquired through other supply sources. The following projects would add reliability to JCSD's existing water supply portfolio and robustness to its system:

Water Conservation. JCSD practices water conservation throughout their service area. Encouraging water conservation is another way of managing against increased demands, particularly for non-potable uses. JCSD implements conservation BMPs (DMMs under the UWMP Act) and is working towards meeting the requirements of SBx7-7.

Chino Desalters. JCSD's participation in the CDA and development of Chino I and II Desalters, which are the main desalination opportunities in the vicinity of the JCSD, also helps ameliorate the reliability issues associated with poor water quality in the lower Chino Basin. Once treated at the Desalters, nitrates and TDS (primarily from historic dairy and agricultural users) in groundwater no longer exceed drinking water standards.

CDA Expansion. The proposed CDA expansion will increase the capacity of the Chino II Desalter by 10,600 AFY of which JCSD will receive approximately 3,300 AFY. Water is projected to be available from this project expansion in 2014. The expansion will provide additional water supplies for JCSD, the City of Ontario, and Western MWD.

JCSD-Rubidoux CSD Interconnection. JCSD has been purchasing water from Rubidoux CSD since 2000 and is planning a second interconnection to Rubidoux CSD, which extracts water from the Riverside South basin. Currently, JCSD transfers 697 AFY of water from Rubidoux via the Riverside South Basin. In addition to the 500 AFY that is currently available, JCSD has opened negotiations for purchasing an additional 1,000 AFY. This supply is anticipated to be available by 2015.[53]

JCSD-IEUA Interconnection. Inland Empire Utilities Agency (IEUA) has indicated that distribution facilities currently exist to deliver water from IEUA's recycled water distribution system to JCSD from a connection within 6,300 feet of JCSD's northern boundary in the Eastvale Area. IEUA's current recycled water master plan contemplates delivering a total of 1,850 AF of

[53] Jurupa Community Services District, *2010 Urban Water Management Plan,* May 2011, page 28.

reclaimed water to the JCSD each year. Construction of an interconnection and related distribution facilities would help JCSD meet the water demands associated with projected population growth and anticipated build-out in 2035.

Budgeted or Planned Water Wells. JCSD is developing four new groundwater wells that will provide 9 to 11 MGD of supply. Collectively, these wells will provide increased supply capacity and reliability of production and will accommodate projected growth.

Riverside-Corona Feeder Project. JCSD is considering a connection to Western MWD facilities that would provide an additional 10,000 AFY source of water for distribution within JCSD's service area by 2035. Connection to Western MWD's proposed Riverside Corona Feeder is expected to be constructed by 2020.

JCSD's Roger D. Teagarden Ion Exchange Plant. Feasibility and planning was recently completed to evaluate the potential existing raw water sources and transmission facilities to JCSD's Roger D. Teagarden Ion Exchange Plant. As currently configured and operating, the Teagarden Ion Exchange Plant has a treatment capacity of 10 MGD and a blending capacity of 14 MGD. The treatment plant has excess blending capacity and could increase capacity by implementing process improvements and expanding the facility. The Ion Exchange Plant could produce an additional 4 MGD or 2,800 gpm if the raw water supply is available.

Metropolitan and/or Western MWD Projects. JCSD has expressed interest in the following additional water supply projects that could increase the reliability and robustness of JCSD's water supply:

- **SWP water purchased from Metropolitan via the Etiwanda or Rialto Feeder.** This would require the construction of a water treatment plant and conveyance facilities.
- **Water from the Santa Ana Watershed Project Authority's existing Arlington Desalter.** JCSD has an interest in acquiring available production from the Arlington Desalter and from a proposed Expanded Arlington Desalter. Currently, there are 1,800 AFY of available product water for sale. Western MWD has funded a reconnaissance-level investigation of the feasibility of expanding the Arlington Project from 7.4 to 10.7 MGD.
- **Construction of a water treatment plant via Metropolitan's Upper Feeder.** Since the Upper Feeder conveys Colorado River water, the treatment plant would require the construction of a reverse osmosis plant in addition to a conventional treatment facility. JCSD may be able to treat the water conventionally and then blend with CDA water to lower the TDS limit of the water supply, in order to meet the RWQCB – SAR wastewater discharge limits at the City of Riverside Regional Water Quality Control Plant.

Project Growth Inducement Potential for JCSD

Between 2010 and 2035, water demand in JCSD's service area is expected to increase by 51 percent, from 23,660 to 35,648 AFY, and population is expected to increase by 35 percent, due in part to the incorporation of two new cities within the last two years, Jurupa Valley and Eastvale. JCSD has identified numerous opportunities for improving water supply reliability and meeting

projected demands through 2035. Its planned and possible future projects could provide at least 17,950 AFY of additional water supplies. The largest of these is the Riverside-Corona Feeder Project, which would provide up to 10,000 AFY water for distribution within JCSD's service area by 2035.

The proposed Project, which would deliver 5,000 AFY of Project water to JCSD for use throughout its service area, represents 14 percent of its projected 2035 supply portfolio. This additional 5,000 AFY would help increase reliability by diversifying JCSD's water supply portfolio, which is one of the District's goals.

Although Project water would be used primarily to improve the reliability of JCSD's existing water supplies, by contributing to JCSD's overall water supply portfolio it is possible that some of the Project water could be used to support some of the growth projected in the communities within JCSD's service area. Therefore, the Project has some, albeit limited, growth inducement potential within the JCSD service area.

6.2.7 California Water Service Company (Cal Water)

Cal Water distributes and provides water service to 1.7 million customers in 63 communities from Chico in the North to the Palos Verdes Peninsula in Southern California. California Water Service Group, Cal Water's parent company, also serves communities in Washington, New Mexico and Hawaii.

Within the Project Water Area of Use, Cal Water provides service to the Westlake District in eastern Ventura. Cal Water's rates and operations are regulated by the California Public Utilities Commission (CPUC). Rates are set separately for each of the systems. Cal Water's water supply sources for customers within the Westlake District include imported water purchased from Metropolitan and recycled water. It has served this community since 1983.[54]

Land Use and Population

Cal Water proposes to use Project water in the Westlake District, which is located in the eastern section of Ventura County within the City of Thousand Oaks. The Westlake District service area encompasses 8,200 acres, which were part of the historic Russell Valley Ranch. This area consists primarily of urban residential land uses. Within the service area, population growth has been relatively slow since 1990 and is projected to remain slow. Growth in total services has averaged 0.07 percent in the past five years, and 0.16 percent for the past 10 years. As shown on **Table 6-18**, current population within this service district is 16,880 and is projected to increase approximately 2.25 percent between 2010 and 2035, to 17,260. This growth rate is expected to remain low due to the limited available land within the Westlake District's service area that can sustain development.[55] Any housing growth would probably be a result of redevelopment, which may also be limited due to growth restrictions imposed by the City of Thousand Oaks. Therefore,

[54] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 11.
[55] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 20

Cal Water does not anticipate any significant growth in the future, except for in-fill development.[56]

TABLE 6-18_
PROJECTED POPULATION GROWTH FOR CAL WATER'S WESTLAKE DISTRICT

Water System	2010	2035	% Increase
Westlake	16,880	17,260	2.25%

SOURCE: California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, Table 2-2, page 23.

Water Supply and Demand – Cal Water

The water supply for the customers of the Westlake District is a combination of purchased imported water and recycled water. Purchased water provides the majority of the total supply while recycled water makes up the remaining portion. CMWD supplies imported water to Cal Water and is a member agency of Metropolitan. Cal Water has a purchase agreement with CMWD that began in 2003 and has a ten year term. Cal Water has an initial base demand of 9,481 AFY and a ten-year purchase order commitment of 56,887 AF.[57] Cal Water estimates that it will need to purchase less than its contracted volume from CMWD over the next 25 years. The recycled supply is also delivered by CMWD. The Westlake District began serving recycled water to its customers in 1995 and now delivers approximately 400 AFY.

Demand projections by water use sectors for Cal Water's Westlake District are shown in **Table 6-19**. Demand is expected to decrease in the following customer use categories: Single Family, Multi-Family, and Institutional/Government. Demand is projected to increase slightly in the Commercial/Industrial sector.

Cal Water's projected recycled water sales and system losses are summarized in **Table 6-20**.

Actual and projected water demands and supplies through 2035 are shown in **Table 6-21**. The values represent the total target demand projection based on SBx7-7 gpcd targets, including recycled water and unaccounted for water. Only purchased water, recycled water, and conservation are included as sources of supply. Metropolitan's supply projections indicate that it will be able to meet full service demands under wet, normal, and dry years through the year 2035, as does CMWD.[58] However, these projections are based on several assumptions, including the assumption that uncertainties in the availability of imported water due to environmental, legal, and hydrologic factors will be resolved to Metropolitan's satisfaction and benefit.

[56] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 20.
[57] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 43.
[58] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 43.

TABLE 6-19_
CAL WATER, CURRENT AND PROJECTED WATER DEMAND BY WATER USE SECTOR

	Water Demand by Water Use Sectors (AFY)					
Fiscal Year Ending	**Single Family**	**Multi-Family**	**Commercial /Industrial**	**Institutional/ Government**	**Other**	**Total Demand**
2005	5,815	212	2,075	318	**1**	**8,483 (actual)**
2010	4,954	228	1,685	251	**12**	**7,130 (actual)**
2015	4,928	225	2,374	323	**14**	**7,864**
2020	4,386	201	2,118	288	**13**	**7,005**
2025	4,402	202	2,132	290	**13**	**7,039**
2030	4,415	203	2,145	292	**13**	**7,068**
2035	4,432	205	2,158	293	**13**	**7,101**

SOURCE: California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, pages 33-34.

TABLE 6-20
ADDITIONAL WATER USE AND LOSSES (AFY)

	Fiscal Year Ending				
	2015	**2020**	**2025**	**2030**	**2035**
Recycled Water	421	422	424	425	427
Unaccounted for System Losses	552	492	493	495	497
Total Supply	**973**	**914**	**917**	**920**	**924**

SOURCE: California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 41.

TABLE 6-21
TOTAL DEMAND AND SUPPLY COMPARISON IN A NORMAL YEAR IN WESTLAKE SERVICE DISTRICT WITH CONSERVATION TARGETS (AFY)

Water Use	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Demand	8,052 (actual)	8,837	7,919	7,956	7,988	8,025
Supply	8,052 (actual)	8,837	7,919	7,956	7,988	8,025

SOURCE: California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 41.

Water Supply Reliability

Cal Water has the same concerns about imported supply water reliability from Metropolitan as discussed for the other Project Participants. Like all water providers receiving imported supplies from the Colorado River system and/or the Sacramento-San Joaquin Delta system via the SWP, Cal Water must be prepared to manage during import supply shortage periods due to drought and/or other regulatory restrictions on supply. Cal Water has not yet incorporated potential participation in the Project into its current Urban Water Management Plan for the Westlake District that could be served by the Project but acquisition of up to 5,000 AFY of Project water is one step Cal Water is considering, along with continued use of recycled water, and increased demand management, to improve the reliability of its supply and control future costs. Cal Water expects imported water supplies to remain fairly constant through 2035 and future demand projections show a relatively stable to slightly decreasing trend. Cal Water is pursuing water conservation to manage and reduce future demand within its service area. Based on its projections and CMWD's UWMP, Cal Water's existing water supply capabilities would be sufficient to meet projected demand through 2035 under normal, single dry year, and multiple dry year conditions.[59] Because of this Cal Water assumes that its total imported supplies will equal its projected demand minus the projected recycled water use.

Water Conservation. Cal Water is a signatory to the 1992 MOU Regarding Water Conservation in California and implements a variety of demand management measures though its own programs and through collaboration with its wholesale agencies. Cal Water is in the process of expanding current conservation programs and developing new programs for its 24 service districts, which includes a Conservation Plan for the Westlake District. Cal Water's water conservation efforts within this district include retail conservation pricing, public education regarding efficient water use, and participation in high efficiency appliance rebate programs. Long term savings from conservation measures is projected to range from 1,312 AF in 2015 to 2,670 AF in 2035, which are the levels of conservation needed to meet SBx7-7 targets by 2020 and MOU requirements.[60]

Project Growth Inducement Potential for Cal Water

Between 2010 and 2035, water demand in Cal Water's service area is projected to decrease by approximately 0.3 percent, while population is expected increase slightly (2.25 percent increase). Cal Water's Westlake District service area has almost reached full build-out, and future demand is not expected to significantly change over existing levels.

Under the proposed Project, Cal Water would receive up to 5,000 AFY of Project water to be used within the Westlake District service area and possibly the Dominguez and East Los Angeles Districts. Cal Water has current connections with Metropolitan and could therefore take Project water directly into their system. Project water could represent up to 62.3 percent of Cal Water's projected future water demand in 2035 and Cal Water indicates that Project water would replace or be a substitute for imported water supplies. Because there is essentially no growth projected

[59] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, pages 52-54.
[60] California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011, page 76.

within Cal Water's service area and water demand is projected to slightly decline, the Project would improve the reliability of existing supply levels but would have no significant growth inducement potential within the Westlake District service area. As noted above, imported surface water supply makes up the majority of Cal Water's Westlake District's water portfolio, thus Cal Water has to be prepared for cutbacks in imported supply deliveries in drought years and other periods of restriction. In years when imported supply deliveries from the Colorado River and Bay-Delta systems are restricted, Cal Water could make use of the supplemental supply provided by the Project to make up for imported supply shortfalls.

Cal Water may also utilize Project water to serve its Dominguez District located at the southern portion of the Los Angeles coastal plain, in the area known as the "South Bay," and its East Los Angeles District located east of downtown Los Angeles with a western boundary approximately three miles from LA's Civic Center. Between 2010 and 2035, water demand in these two service areas is projected to remain relatively stable or decrease slightly, while population is expected to increase slightly.[61] Like Cal Water's Westlake District service area, these two areas have almost reached full build-out, and future demand is not expected to significantly change over existing levels. Both of these service districts utilize imported water from Metropolitan (through Central Basin Municipal Water District and West Basin Municipal Water District)[62] and groundwater.

6.2.8 Future Project Participants

Not all of the Project participants have been identified yet. There is 15,000 to 25,000 AFY of unsubscribed water supply available from the Groundwater Conservation and Recovery Component of the Project (See Table 6-1) that other entities are expected to pursue in the future. In addition, the Imported Water Storage Component of the Project is still in development and participants have not yet been identified. It is expected that future participants in either or both components of the Project would be located in the Southern California region, and most likely would be located within the area covered by the Metropolitan service area. Therefore, for purposes of this analysis, the Metropolitan service area serves as the broadest definition of the Project Water Area of Use. Metropolitan's service area covers six counties in Southern California region: Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties. This section reviews the growth trends and the water demand and supply plans for Metropolitan and discusses the growth inducement potential of the remaining increment of Project water from the Groundwater Conservation and Recovery Component being used within the Metropolitan service area and of the storage capacity provided by the Imported Water Storage Component of the Project.

Metropolitan member agencies in each county and the type of water service they provide (wholesale or retail) are shown in **Table 6-22**.

[61] California Water Service Company, *Dominguez District 2010 Urban Water Management Plan*, June 2011; California Water Service Company, *East Los Angeles District 2010 Urban Water Management Plan*, June 2011.
[62] California Water Service Company, *Dominguez District 2010 Urban Water Management Plan*, June 2011, page 43; California Water Service Company, *East Los Angeles District 2010 Urban Water Management Plan*, June 2011, page 46.

TABLE 6-22
METROPOLITAN WATER DISTRICT MEMBER AGENCIES BY COUNTY

Member Agency	Retail or Wholesale
Los Angeles County	
Beverly Hills, City of	Retail
Burbank, City of	Retail
Central Basin Municipal Water District	Wholesale
Compton, City of	Retail
Foothill Municipal Water District	Wholesale
Glendale, City of	Retail
Las Virgenes Municipal Water District	Retail
Long Beach, City of	Retail
Los Angeles, City of	Retail
Pasadena, City of	Retail
San Fernando, City of	Retail
San Marino, City of	Retail
Santa Monica, City of	Retail
Three Valleys Municipal Water District	Wholesale
Torrance, City of	Retail
Upper San Gabriel Valley Municipal Water District	Wholesale
West Basin Municipal Water District	Wholesale
Orange County	
Anaheim, City of	Retail
Fullerton, City of	Retail
Municipal Water District of Orange County	Wholesale
Santa Ana, City of	Retail
Riverside	
Eastern Municipal Water District	Retail & Wholesale
Western Municipal Water District of Riverside County	Retail & Wholesale
San Bernardino County	
Inland Empire Utilities Agency	Wholesale
San Diego County	
San Diego County Water Authority	Wholesale
Ventura County	
Calleguas Municipal Water District	Wholesale

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-8, Table 1-2.

Regional Planning by SCAG and SANDAG

The SCAG region is one of the largest and most complex metropolitan areas in the nation, and its growth trends and travel patterns pose difficult challenges for the multimodal transportation system. As the planning authority for the six-county area, SCAG is the lead agency in developing and updating the long-range RTP based on growth forecasts and economic trend data projected for a 20-year planning period.

This section uses growth forecasts and economic trend data from 2007 that were published in SCAG's 2008 RTP and represent the most up-to-date SCAG forecasts. SCAG is currently preparing the 2012 RTP update, which it expects to adopt in April 2012. When SCAG compared the 2008 RTP projections against actual population data as part of the update process, they observed unstable/uncertain economic-demographic behaviors (unemployment rate, migration, labor force participation rate, etc) in the short-term framework; shortcomings in the currency and reasonableness of population projections (and assumptions) by the U.S. Census Bureau and the California Department of Finance (DOF); a lack of relevant statistical data delivered in a timely manner; and a significant gap in population estimates between the U.S. Census Bureau and DOF. Further analysis revealed that the 2008 RTP projections had been prepared during the early stages of a recession that worsened over time, including the housing and financial market fallouts and state budget deficits that deepened as a result of the developing global recession.[63] The economic downturn was particularly bad in Southern California, which lost 3,000 businesses and 800,000 jobs across the region, and population grew at much slower rates than had been predicted. U.S. Census data confirmed that population growth *slowed* between 2000 and 2010 by about 135,000 fewer residents annually (-30 percent).[64]

Despite the inaccuracies in the magnitude and rate of population growth in the 2007 data, the projections accurately predicted where growth would occur. That is, growth occurred more slowly, but in the cities where growth was predicted to be highest, growth was highest. **Table 6-23** shows SCAG population projections through 2035 for counties in the Project Water Area of Use. Los Angeles County had been expected to grow the most in terms of total population, followed by Riverside and San Bernardino Counties. In terms of percent increases in population, Riverside County was expected to grow at the fastest rate, followed by San Bernardino County.

63 Applied Development Economics, Inc., *2010 California Regional Progress Report, 2007-2010*, http://www.scag.ca.gov/publications/pdf/2010/CARegionalProgress2010.pdf, accessed October 2010.

64 Levy, Steve, *California's Changing Demography: Implications for Housing, Center for the Continuing Study of the California Economy*, http://www.scag.ca.gov/events/pdfs/demo23/p4Levy.pdf, accessed September 2011.

TABLE 6-23
SCAG POPULATION PROJECTIONS IN STUDY AREA COUNTIES[a]

County	2010	2035	Population Growth 2010-2035	Percent Increase 2010-2035	Average Annual Percent Increase 2010-2035
Los Angeles	10,615,730	12,338,620	1,722,890	16%	0.6%
Orange	3,314,948	3,653,990	339,042	10%	0.4%
Riverside	2,242,745	3,596,680	1,353,935	60%	4.7%
San Bernardino	2,182,049	3,133,801	951,752	44%	1.9%
Ventura County	860,607	1,013,753	153,146	18%	0.7%

[a] Includes entire county.

SOURCE: Southern California Association of Governments, *Integrated Growth Forecast, Adopted 2008 RTP Growth Forecast, by City,* http://www.scag.ca.gov/forecast/downloads/excel/RTP07_CityLevel.xls, accessed October 2011; ESA, 2011.

The jurisdictions that were expected to grow the most between 2010 and 2035 (in terms of population) were the City of Los Angeles, unincorporated Riverside County (both subregions), unincorporated North Los Angeles County, the cities of Palmdale and Ontario, and unincorporated San Bernardino County, as depicted in **Table 6-24**. The areas projected to grow the fastest over the 25-year period (in terms of percent increase) were the Coachella Valley in unincorporated Riverside County, which was expected to grow by more than 300 percent, and the cities of Adelanto, Barstow, and Coachella, which were expected to grow by more than 150 percent. Some of the fastest growing areas in these five counties, including the cities of Beaumont, Calimesa, Coachella, Hesperia, Victorville, and Adelanto and the unincorporated Coachella Valley area, are outside Metropolitan's service area.

Two sets of growth forecasts are available for San Diego County. SANDAG's 2030 Regional Growth Forecast Update, released in 2006, provides projections through 2030, based on 2004 conditions.[65] SANDAG jurisdictions projected to grow the most between 2004 and 2030 are shown in **Table 6-25**, along with projected growth for unincorporated areas and the County as a whole. The City of San Diego was projected to grow the most, followed by unincorporated San Diego County and the City of Chula Vista. Unincorporated areas and Chula Vista were also projected to grow the fastest.

[65] San Diego Association of Governments, *Info: 2030 Regional Growth Forecast Update No. 2*, July 2008 (which includes information from the SANDAG Regional Growth Forecast Update that was released in September 2006).

TABLE 6-24
AREAS WITH GREATEST PROJECTED POPULATION GROWTH IN STUDY AREA COUNTIES, BY COUNTY[a]

County	Subregion	City	Population 2008/2010[c]	Population 2035	Population Growth 2008/2010 - 2035 [c]	Percent Increase 2008/2010 - 2035 [c]	Average Annual Percent Increase 2010 - 2035
Los Angeles County	City of Los Angeles	Los Angeles	4,057,484	4,415,772	358,288	9%	0.3%
	North Los Angeles County	Unincorporated	194,704	434,773	240,069	123%	3.3%
		Palmdale	182,663	363,252	180,589	99%	2.8%
	San Gabriel Association of Cities	Unincorporated	389,266	525,960	136,694	35%	1.2%
		Pomona	170,229	216,899	46,670	27%	1.0%
	Gateway Cities	Long Beach	503,251	572,614	69,363	14%	0.5%
	South Bay Cities Association	Hawthorne	94,042	116,312	22,270	24%	0.9%
	Arroyo Verdugo	Burbank	112,103	133,391	21,288	19%	0.7%
	Las Virgenes	Unincorporated	21,926	32,888	10,962	50%	1.6%
		Calabasas	23,750	28,472	4,722	20%	0.7%
	Westside Cities	Unincorporated	31,779	40,949	9,170	29%	1.0%
		Beverly Hills	36,433	38,508	2,075	6%	0.2%
Riverside	Western Riverside Council of Governments	Unincorporated	526,517	845,959	318,959	61%	1.9%
		Riverside	300,523	385,794	85,271	28%	1.0%
		Moreno Valley	189,700	258,350	68,650	36%	1.2%
		Beaumont [b]	33,951	77,438	43,487	128%	3.4%
		Calimesa [b]	11,605	28,831	17,226	148%	3.7%
	Coachella Valley Association of Governments	Unincorporated	90,725	398,158	307,433	339%	6.1%
		Coachella [b]	46,981	119,383	72,402	154%	3.8%
San Bernardino	San Bernardino Associated Governments	Ontario	187,060	337,095	150,035	80%	2.4%
		Unincorporated	346,523	487,697	141,174	41%	1.4%
		Hesperia [b]	102,895	211,108	108,213	105%	2.9%
		Victorville [b]	106,649	182,275	75,626	71%	2.2%
		Adelanto [b]	40,742	114,368	73,656	181%	4.2%
		Barstow [b]	31,972	69,533	37,561	117%	3.2%
San Diego	San Diego County	San Diego	1,333,617	1,756,621	423,004	32%	1.0%
		Unincorporated	489,958	646,108	156,150	32%	1.0%
		Chula Vista	230,397	237,211	70,318	42	1.4
Orange	Orange County	Anaheim	365,985	438,645	72,660	20%	0.7%
		Unincorporated	166,893	237,211	70,318	42%	1.4%
Ventura	Ventura Council of Governments	Oxnard	205,462	274,266	68,804	33%	1.2%

[a] Where the unincorporated area is projected to experience the greatest amount of growth in a county, it is shown in the table in addition to the city or cities having the greatest projected growth. The city or cities with the greatest projected growth in each subregion are shown for Los Angeles and Riverside counties.

[b] Located outside the Metropolitan service area.

[c] Estimates for San Diego cities and unincorporated County are for 2008; estimates for all other areas are for 2010.

SOURCES: Southern California Association of Governments, *Integrated Growth Forecast*, *Adopted 2008 RTP Growth Forecast, by City,* http://www.scag.ca.gov/forecast/downloads/excel/RTP07_CityLevel.xls, accessed October 2011; San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010, page 13; ESA, 2011.

TABLE 6-25
SANDAG 2030 POPULATION PROJECTIONS

Jurisdiction	2004	2030	Population Growth 2004-2030	Percent Increase	Average Annual Percent Increase 2004-2030
San Diego	1,295,147	1,656,257	361,110	28%	1.0%
Unincorporated	467,728	723,392	255,664	55%	1.7%
Chula Vista	208,675	316,445	107,770	52%	1.6%
Oceanside	172,866	207,237	34,371	20%	0.7%
Carlsbad	92,695	127,046	34,351	37%	1.2%
Escondido	140,328	169,929	29,601	21%	0.7%
San Marcos	66,850	95,553	28,703	43%	1.4%
Entire County	**3,013,014**	**3,984,753**	**971,739**	**32%**	**1.1%**

SOURCE: San Diego Association of Governments, *Info: 2030 Regional Growth Forecast Update*, July 2008, No. 2, which presents information from the SANDAG 2030 Regional Growth Forecast Update that was released in September 2006; ESA 2011.

In February 2010, the SANDAG Board of Directors accepted for planning purposes the Series 12: 2050 Regional Growth Forecast. This forecast, which was developed in collaboration with 18 cities and the County of San Diego, tribal governments, and other land use agencies, represents a combination of economic and demographic projections, local land use data, including information on existing development, general plans, constraints to development, and permitted projects currently in the development process, and potential land use changes that may occur in the region between 2030 and 2050.[66] SANDAG is using the Series 12: 2050 forecast in the development of its 2050 RTP; and in 2011, an official final forecast for 2050 will be brought before the SANDAG Board of Directors, along with the 2050 RTP.[67] In general, growth projections for 2008 through 2030 were based on adopted land use plans and policies, while growth projections for 2030 through 2050 included alternatives that may, in some cases, reach beyond existing adopted plans.[68]

Although it is not SANDAG's official final forecast for 2050, information from Series 12: 2050 is included because it incorporates substantial demographic and land use inputs, provides the most current near-term data (estimates for base year 2008), provides projections for 2035 (which are considered in conjunction with the projections to that year developed by SCAG and Metropolitan), and has been deemed suitable for planning purposes by the SANDAG Board of Directors. Projected growth is shown in **Table 6-26**, including the jurisdictions projected to grow the most between 2008 and 2035. This analysis focuses on the forecast to 2035 because that is the forecast horizon used in current SCAG and Metropolitan documents and in 2010 UWMPs. As

66 San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010, page 2.
67 San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010, page 3.
68 San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010, page 13.

TABLE 6-26
SANDAG 2050 POPULATION PROJECTIONS[a]

Jurisdiction	2008	2035	2050	Population Growth 2008-2035	Percent Increase 2008-2035	Average Annual Percent Increase 2008-2035	Population Growth 2035-2050	Percent Increase 2035-2050
San Diego	1,333,617	1,756,621	1,945,569	423,004	32%	1.0%	188,948	11%
Unincorporated	489,958	646,108	694,464	156,150	32%	1.0%	48,356	7%
Chula Vista	230,397	301,324	330,381	70,927	31%	1.0%	29,057	10%
El Cajon	97,555	138,506	144,515	40,951	42%	1.3%	6,009	4%
Oceanside	178,102	212,213	217,364	34,111	19%	0.7%	5,151	2%
Escondido	143,259	168,141	177,586	24,882	17%	0.6%	9,445	6%
Vista	95,400	117,471	144,536	22,071	23%	0.8%	27,065	23%
Carlsbad	103,406	125,293	129,381	21,887	21%	0.7%	4,088	3%
San Marcos	82,419	103,110	105,708	20,691	25%	0.8%	2,598	3%
Entire County	**3,131,552**	**4,026,131**	**4,384,867**	**894,579**	**29%**	**0.9%**	**358,736**	**9%**

[a] Table is based on SANDAG's Series 12: 2050 Regional Forecast, which is being used in the development of SANDAG's 2050 Regional Transportation Plan; the final 2050 regional forecast will be adopted in conjunction with the Regional Transportation Plan.

SOURCE: San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010, page 13.

with the 2030 forecasts, the City of San Diego is expected to grow the most between 2008 and 2035, followed by unincorporated areas and the City of Chula Vista; in contrast to the 2030 forecast, the City of El Cajon is projected to grow the fastest (from 2008 to 2035), followed by the City of San Diego and unincorporated areas.

Growth Trends and Water Demand in the Metropolitan Service Area

The Metropolitan service area covers approximately 5,200 square miles and includes the greater Los Angeles and San Diego metropolitan areas (see Figure 6-1). The service area encompasses 14 percent of the geographic area, but nearly 90 percent of the population of the six member counties (see **Table 6-27**). The service area is largely urbanized, with municipal and industrial uses accounting for about 93 percent of water use and agriculture uses accounting for about 7 percent.[69] The area includes three climate zones: coastal, inland valley, and desert.[70]

[69] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-13.

[70] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-16, Figure 1-6.

TABLE 6-27
HISTORICAL POPULATION GROWTH IN THE METROPOLITAN SERVICE AREA, BY COUNTY

	Population			Change 1990-2010	
County	**1990**	**2005**	**2010**	**Net**	**Percent**
Los Angeles	8,268,000	9,364,000	9,567,000	1,299,000	16%
Orange	2,412,000	3,057,000	3,205,000	793,000	33%
Riverside	851,000	1,381,000	1,559,000	708,000	83%
San Bernardino	565,000	792,000	832,000	267,000	47%
San Diego	2,407,000	2,934,000	3,109,000	702,000	29%
Ventura County	451,000	588,000	624,000	173,000	38%
Total Metropolitan Service Area	**14,954,00**	**18,116,000**	**18,896,000**	**3,942,000**	**26%**

NOTE: Population figures for 1990 and 2005 represent actual population; figures for 2010 were estimated by Metropolitan.

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.1, Demand Forecast, Table A.1-2, page A.1-8.

Urban Growth within the Metropolitan Service Area

The population in Metropolitan's service area has grown by nearly 4 million since 1990 (see Table 6-27) and the service area is projected to grow by another 3.5 million people by 2035 (see **Table 6-28**), with the most growth, in numbers of people, forecasted in Los Angeles County, followed by San Diego and Riverside Counties. Between 1990 and 2010, Los Angeles County experienced the most growth, followed by Orange and San Diego counties. Riverside County grew the fastest, followed by San Bernardino County.

TABLE 6-28
PROJECTED POPULATION GROWTH IN METROPOLITAN SERVICE AREA BY COUNTY

	Population		Change 2010-2035	
County	**2010**	**2035**	**Net**	**Percent**
Los Angeles	9,567,000	10,781,000	1,214,000	13%
Orange	3,205,000	3,654,000	449,000	14%
Riverside	1,559,000	2,292,000	733,000	47%
San Bernardino	832,000	1,117,000	285,000	34%
San Diego	3,109,000	3,899,000	790,000	25%
Ventura County	624,000	731,000	107,000	17%
Total Metropolitan Service Area	**18,896,000**	**22,474,000**	**3,578,000**	**19%**

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.1, Demand Forecast, Table A.1-2, page A.1-8.

Water Demand and Supply within the Metropolitan Service Area

Demand

Metropolitan estimates future municipal and industrial (M&I) demand in its service area using a forecasting model that has been adapted for conditions in Southern California. M&I demand represents residential, commercial, industrial, institutional, and unmetered uses. The model incorporates demographic and economic information developed by SCAG and SANDAG into statistical water demand models to produce a forecast of gross retail M&I demand. This estimate is then adjusted to account for expected conservation savings, which are calculated using a conservation model that estimates savings due to plumbing codes, active conservation programs funded by member agencies, conservation savings expected as a result of passage of SBx7-7, and other factors. Estimated 2035 demand assumes savings of 1,156,000 acre-feet from conservation and 380,000 acre-feet from SBx7-7 conservation.[71] **Table 6-29** shows retail M&I water demand adjusted for conservation and SBx7-7 conservation savings, and **Table 6-30** shows estimated agricultural water demand. Between 2010 and 2035, with projected population growth at 19 percent, total M&I demand is expected to increase by 7 percent and agricultural demand is projected to decline by 16 percent. Combined, M&I and agricultural demands are projected to increase by 6 percent between 2010 and 2035.

TABLE 6-29
TOTAL RETAIL M&I DEMAND IN METROPOLITAN'S SERVICE AREA
WITH CONSERVATION AND SBX7-7
(Acre-Feet)

County	1980	1990	2000	2010	2020	2035
Los Angeles	1,522,000	1,732,000	1,728,000	1,761,000	1,664,000	1,704,000
Orange	481,000	646,000	643,000	613,000	630,000	634,000
Riverside	141,000	279,000	357,000	454,000	532,000	641,000
San Bernardino	120,000	172,000	221,000	242,000	245,000	279,000
San Diego	365,000	548,000	556,000	596,000	604,000	675,000
Ventura	77,100	118,000	125,000	151,000	149,000	158,000
Metropolitan Total	2,706,000	3,495,000	3,640,000	3,817,000	3,824,000	4,091,000

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A, Table A.1-6.

Demand in the Metropolitan service area also includes water to maintain a seawater intrusion barrier, which is estimated to be 72,000 AF in 2035, and water for groundwater replenishment, which is estimated to be 191,000 AF in 2035. Thus, based on projected M&I, agricultural, seawater barrier, and groundwater replenishment demands, overall average-year demand in the Metropolitan service area in 2035 is projected to be approximately 4,534,000 AF.

[71] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Table 2-8, page 2-14.

TABLE 6-30
TOTAL RETAIL AGRICULTURE DEMAND IN METROPOLITAN'S SERVICE AREA
(Acre-Feet)

County	1980	1990	2000	2010	2020	2035
Los Angeles	6,300	3,800	5,000	500	400	700
Orange	40,000	26,900	17,300	10,900	3,800	2,900
Riverside	207,000	200,800	134,100	89,600	94,200	94,200
San Bernardino	46,100	37,200	29,800	26,500	7,100	7100
San Diego	116,200	138,600	105,600	72,000	78,300	52,300
Ventura	19,400	27,400	7,500	14,700	21,300	22,900
Metropolitan Total	435,300	433,700	294,800	214,200	205,100	179,800

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.1, Table A.1-7, p. A.1-10.

Supply and Reliability

Table 6-31 lists the sources of water to the Metropolitan service area over the past 10 years. Current (2010) and projected supply (2035) is shown in **Table 6-32**. The projected supply for 2035 reflects a 27 percent increase over 2010. Metropolitan's supply situation is considered to be in surplus as long as net annual deliveries can be made to water storage programs.

TABLE 6-31
SOURCES OF WATER SUPPLY USED IN THE METROPOLITAN SERVICE AREA, 2000-2010[a]
(Acre-Feet)

Year	Local Supplies	Los Angeles Aqueduct	Colorado River Aqueduct	State Water Project	Total[d]
2000	1,768,000	255,000	1,217,000	1,473,000	4,714,000
2001	1,708,000	267,000	1,245,000	1,119,000	4,340,000
2002	1,706,000	179,000	1,198,000	1,415,000	4,498,000
2003	1,659,000	252,000	676,000	1,561,000	4,148,000
2004	1627,000	203,000	741,000	1,802,000	4,373,000
2005	1,590,000	369,000	685,000	1,525,000	4,168,000
2006	1,710,000	379,000	535,000	1,695,000	4,319,000
2007	1,852,000	129,000	696,000	1,648,000	4,326,000
2008	1,842,000	147,000	896,000	1,037,000	3,922,000
2009[b]	1,801,000	137,000	1,043,000	908,000	3,890,000
2010[c]	1,832,000	243,000	1,150,000	1,500,000	4,725,000

a Does not include system losses.
b 2009 local supplies are based on 2006-08 averages
c 2010 Colorado River Aqueduct and State Water Project are best estimates as of May 2010; Los Angeles Aqueduct is based on actual supplies from January through April plus projections for May through December; Local Supplies are averages of prior years.
d Totals as provided in source document; discrepancies between components and totals assumed to be due to rounding.

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.2, Table A.2-1, page A.2-3.

TABLE 6-32
EXISTING (2010) AND PLANNED (2035) WATER SOURCES
IN THE METROPOLITAN SERVICE AREA
(Acre-Feet)

Source	Existing (2010)[a]	Planned (2035)[b, c]
Local Supplies	1,832,000	2,373,000
Los Angeles Aqueduct	243,000	230,000
Colorado River Aqueduct	1,150,000	954,000
SWP (California Aqueduct)	1,500,000	2,449,000
Total	**4,725,000**	**6,006,000**

[a] 2010 Colorado River Aqueduct and SWP are best estimates as of May 2010; Los Angeles Aqueduct is based on actual supply from January through April plus projections for May through December; Local Supplies are averages of prior years.

[b] Planned SWP/California Aqueduct supply includes Central Valley transfers and storage program supplies conveyed by the aqueduct.

[c] Planned Colorado River Aqueduct supply includes water management programs and accounts for total aqueduct capacity less non-Metropolitan supplies conveyed through it, including Imperial Irrigation District/San Diego County Water Agency transfers and canal linings projects.

SOURCE: Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010; 2010 data: Appendix A.2 page A.2-3 Table A.2-1; 2035 data: page 2-14 Table 2-8 (Local and LAA), pages A.3-47 and A.3-52 Table A.3-7 (CRA and SWP).

Five surplus management stages guide the storage of surplus supplies in Metropolitan's portfolio. When Metropolitan must make net withdrawals from storage to meet demands, it is considered to be in a shortage condition. For shortage stages 1 through 4, Metropolitan will meet demands by withdrawing water from storage. At shortage stages 5 through 7, Metropolitan may undertake additional shortage management steps, including issuing public calls for extraordinary conservation, considering curtailment of Interim Agricultural Water Program deliveries in accordance with their discounted rates, exercising water transfer options, or purchasing water on the open market. Under most of these stages, it is still able to meet all end-use demands for water.[72] Metropolitan's 2010 RUWMP concludes that Metropolitan will be able to meet 100 percent of full-service demands from 2015 through 2035 during normal years, a single dry year, and multiple dry years, even under a repeat of the worst drought.

There are different ways of defining supply and demand, surplus, and shortage that yield different results. Metropolitan's RUWMP assumes 100 percent efficiency, 100 percent capability, and 100 percent delivery conditions. In other words, Metropolitan equates "capability of the current programs" to "supply." That is why a small surplus is shown even after total demand is subtracted from capable supply. Similarly, Metropolitan adds planned and potentially planned supplies to the capable supply (minus demand), the 1.5 MAF result of which they call a "surplus." However, there is some uncertainty in whether Metropolitan can meet full capabilities, receive full allocations, and experience no losses. The reliability issues associated with supplies are well-documented and water providers commonly increase diversity of supply by identifying alternate sources in case one or more sources of water is unavailable for reasons beyond their control.

72 Metropolitan Water District of Southern California, *2010 Integrated Water Resources Plan* 2010, page 2-21.

Local Supplies

Local supplies include groundwater, local surface water, groundwater recovery (treatment of degraded groundwater to acceptable water quality standards), recycled water, and water transfers that are available within the Metropolitan service area;[73] desalinated water is also expected to be an important component of future supply.[74] Estimates of local supplies (including the Los Angeles Aqueduct, which Metropolitan considers as local) were developed by Metropolitan based on local agencies' urban water management plans, Metropolitan's annual production surveys, and communication between Metropolitan and staff of member agencies. Local supplies currently make up 44 percent of Metropolitan's total supply portfolio, and Metropolitan projects that 43 percent of its total water supply in 2035 will come from local supplies, which would require an increase of 541,000 AF of local supply.

Imported Supplies

Los Angeles Aqueduct. The Los Angeles Aqueduct is owned and operated by the City of Los Angeles and imports surface water and groundwater from the Mono Basin and Owens Valley of California. The amount of water from this source has been affected by court decisions and other actions related to environmental concerns in the Mono Basin and Owens Valley.[75] The Los Angeles Aqueduct is estimated to provide approximately 256,000 AFY on average, which may be reduced to approximately 106,000 AF during a historical dry period.[76] Metropolitan projects that 3.8 percent of its total future supply in 2035 will come from the Los Angeles Aqueduct.

Colorado River. Metropolitan projects that 16 percent of its total water supply in 2035 will come from the Colorado River. As described in Section 2.6.2, Metropolitan owns and operates the CRA, which was built to convey Colorado River water to Southern California to supplement local water supplies and meet growing demand. Metropolitan's entitlement to Colorado River water is based on interstate compacts, federal laws, agreements, court decrees, and guidelines collectively known as "The Law of the River," which govern the distribution and management of Colorado River water. Of California's 4.4 MAF apportionment from the Colorado River, 3.8 MAF, or 86 percent, is delivered to the Imperial Valley and, to a much lesser extent, the Palo Verde Irrigation District near Blythe, the Yuma Project, and the Coachella Valley Irrigation District. The water rights held by these irrigation districts are called "present perfected" rights – they predate the 1922 Colorado River Compact and thus entitle them to receive their water allocation in all years – dry or wet – over other lower priority users, including Metropolitan.

---

73 For example, the San Diego County Water Authority (SDCWA) and Imperial Irrigation District (IID) currently have an agreement under which IID water is transferred to SDCWA. The transferred water is made available by land fallowing; additional future increases in transferred water will be made possible by additional fallowing and implementation of new irrigation efficiency measures. The transfer is implemented via Metropolitan infrastructure, whereby Metropolitan receives the IID water and conveys the same amount of CRA water to SDCWA. ([RUWMP p. 1-22]

74 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages 1-22, 2-10, 2-11.

75 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.2, pages A.2-16 - A.2-17.

76 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-22.

California has historically drawn more than its basic apportionment of Colorado River water; its annual use has varied between 4.5 and 5.3 MAF over the last ten years[77,78] with water supplies above California's entitlement of 4.4 million acre-feet typically coming from unused portions of Arizona's apportionment and surplus water on the River in wet years. However, in recent years, increased use by upstream water users (within their allocated rights) has reduced the amount of surplus Colorado River water formerly available to Metropolitan, a 10-year drought in the Colorado River watershed has decreased storage levels in Lake Mead and Lake Powell below 50 percent, record dry conditions in Southern California have reduced groundwater basins and local reservoirs, and consecutive dry years in northern California reduced Lake Oroville (at the starting point of the SWP) in 2008 and 2009 to its lowest and third lowest operating level since the reservoir was filled.[79] Thus, while California's apportionment of water has priority over Arizona and Nevada, there are increasing concerns about diminished supplies and the reliability of Colorado River water over the long term.

Over the years, Metropolitan has helped implement and fund programs to increase the reliability of CRA supply, including farm and irrigation district conservation programs, improved reservoir operations, land management programs, and water transfers and exchanges.[80] The estimated 2035 supply from the CRA assumes that the total capacity of the aqueduct (1.25 million AFY) will be used; total non-Metropolitan water conveyed through the CRA (296,000 AF) is subtracted from this number to calculate estimated supply for the Metropolitan service area.[81]

Basic Contracts. Metropolitan's basic contracts permit the delivery of 1.212 MAF per year when sufficient water is available. Metropolitan's 1987 surplus flow contract with Reclamation permits the delivery of water to fill the remainder of the CRA when water is available.

1931 Seven Party Agreement. Metropolitan holds a fourth priority right to 550,000 AF of Colorado River water (its basic apportionment). In addition, Metropolitan has access to up to 662,000 MAF and 38,000 AF of additional water through fifth and sixth priority rights in the California apportionment. Metropolitan may receive this additional water from unused apportionments, water supplies unused by agricultural districts, supplies unused by the states of Arizona and Nevada classified as Priority 6, and as Intentionally Created Surplus or supplies stored from previous years' extraordinary conservation and efficiency improvements to the operations of the Colorado River system, which are classified as Priority 3(a). Subject to the terms of agreements, this stored water may be withdrawn as needed during years in which insufficient supplies are available.

77 Aquifonia, *The Colorado River*, http://aquafornia.com/where-does-californias-water-come-from/the-colorado-river, accessed October 12, 2011.

78 San Diego County Water Authority, *News Release: QSA remains most reliable path for California's Colorado River Supplies*, http://www.sdcwa.org/qsa-remains-most-reliable-path-californias-colorado-river-supplies, accessed October 2011.

79 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-18.

80 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 1-19.

81 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, Appendix A.3, Table A.3-7 (table notes 4 and 5); page A.3-47, page 1-19, page 2-15.

Metropolitan's Priority 4 apportionment has been available and delivered every year since 1939, and they use the full apportionment annually. Although this amount is reasonably expected to be available over the next 20 years, water supply reliability is an increasing concern due to increased water use by other states and persistent drought conditions, which are reducing available supply to lower-priority users such as Metropolitan.

2003 Quantification Settlement Agreement (QSA). The QSA is a set of agreements among IID, CVWD, San Diego County Water Authority (SDCWA), Metropolitan and others intended to reduce California's reliance on the Colorado River. Essentially, the QSA calls for Imperial Valley farmers to make voluntary efficiency and conservation improvements and transfer the conserved water to San Diego. In consideration for this, SDCWA will pay for conservation and efficiency improvements and provide mitigation funds to help with economic losses. As part of the agreement, the State has agreed to bear responsibility for the restoration of the Salton Sea. Specifically, the QSA committed the parties to implementing eight long-term transfer and supply agreements that will shift up to 36 MAF from agricultural to urban use over the life of the agreement and authorize the All American Canal and Coachella Canal Lining Projects. Numerous lawsuits have been filed against the QSA on various grounds, including questioning the constitutionality of the QSA JPA Agreement to which IID, CVWD, and SDCWA agreed to commit $133 million toward mitigation, and the State agreed to fund mitigation in excess of this amount, if any. On February 11, 2010, a Superior Court judge held that the State's commitment in the QSA JPA was unconstitutional and violated its debt limitation. The judge also held that eleven other agreements, including the QSA, were invalid because they were linked to the QSA JPA. An appeal was filed and a temporary stay immediately granted, which was later made permanent pending outcome of the appeal. The stay allows the QSA water transfers to continue while the QSA parties appeal its invalidation.

Sacramento/San Joaquin River Delta. As described in detail in Section 2.6.1, Metropolitan imports water from California's SWP, which transports Feather River water stored in and released from Oroville Dam and unregulated flows diverted directly from the Sacramento-San Joaquin Bay-Delta (Bay-Delta) south via the California Aqueduct to four delivery points near the northern and eastern boundaries of Metropolitan's service area. The SWP is operated by DWR. The California Aqueduct is capable of transporting Metropolitan's full contracted Table A amount of 1,911,500 AFY. However, actual deliveries have never reached this amount because they depend on the availability of supplies as determined by DWR. The quantity of water available for export from the SWP through the California Aqueduct can vary significantly year to year. The amount of precipitation and runoff in the Sacramento and San Joaquin watersheds, system reservoir storage, regulatory requirements, and contractor demands for SWP supplies impact the quantity of water available to Metropolitan. The SWP provided between 25 and 50 percent of Metropolitan's total water supply through 2001, after which it provided as much as 70 percent. The historical record shows significant accomplishments by DWR in providing its contractors with SWP water supplies. Through 2008, the SWP delivered nearly 80 MAF to its contractors. The maximum annual water supply was delivered in 2005, and totaled 3.75 MAF. In

2006 the project delivered 3.7 MAF. DWR has continued to invest in SWP facilities to deliver water to its contractors.[82]

The availability of SWP supplies for delivery through the California Aqueduct over the next 18 years is estimated according to the historical record of hydrologic conditions, existing system capabilities as may be influenced by environmental permits, requests of the State Water Contractors and SWP contract provisions for allocating Table A, Article 21 and other SWP deliveries including San Luis carryover to each contractor. Metropolitan estimates future SWP supplies based on DWR's draft 2009 SWP Delivery Reliability Report and takes into account restrictions on SWP and Central Valley Project (CVP) operations resulting from the USFWS and National Marine Fisheries Service (known as the NOAA Fisheries Service) biological opinions that were issued in 2008 and 2009.[83] Collaborative efforts by Metropolitan and other SWP contractors have increased supplies received from the SWP water during dry and below-normal water conditions. These efforts include numerous voluntary Central Valley storage and transfer programs intended to increase supply that can be conveyed through the California Aqueduct during dry hydrologic conditions or regulatory restrictions.[84] Metropolitan's estimate of future SWP supply assumes that current restrictions resulting from environmental concerns about the Delta are resolved with completion of a new Delta conveyance that would be fully operational by 2022 and would return supply reliability to a 2005 condition (i.e., a condition comparable to those prior to restrictions from the 2008 and 2009 Biological Opinions).[85] Accordingly, although the SWP currently provides 32 percent of Metropolitan's water supply, it is expected to provide up to 41 percent of the total supply in 2035.

Factors Impacting Supply Reliability

The amount of imported water available to Southern California fluctuates widely each year due to hydrologic conditions (including annual snowpack, flood management needs, changing weather-temperature conditions, water quality) as well as conservation, economic conditions, and regulatory restrictions. [86] These variables have an impact on the reliability of Metropolitan supplies. **Table 6-33** shows which reliability factors affect the consistency of supply from the CRA and SWP, respectively.

82 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page A.3-15.
83 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 2-15.
84 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, page 2-15.
85 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages ES-4 - ES-5.
86 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages ES-1 - ES-4, 2-9 - 2-16, Appendix A.2.

TABLE 6-33
FACTORS RESULTING IN INCONSISTENCY OF SUPPLY

Name of Supply	Legal	Environmental	Water Quality	Climatic
State Water Project	X	X		
Colorado River			X	X

SOURCE: ESA 2011.

Environment – Endangered species protection needs in the Sacramento-San Joaquin River Delta (through which about 30 percent of Southern California's water flows) have resulted in operational constraints to the SWP system. The Bay-Delta's declining ecosystem caused by agricultural runoff, operation of water pumps and other factors has led to historical restrictions in SWP supply deliveries. SWP delivery restrictions due to the biological opinions resulted in the loss of about one-third of the available SWP supplies in 2008. Recent environmental concerns in the Owens Valley have also affected supply availability in the Los Angeles Aqueduct system.[87] Endangered fish species are also a concern in the Lower Colorado River.

Legal – Listings of additional species under the Endangered Species Act and new regulatory requirements could impact SWP operations by requiring additional export reductions, releases of additional water from storage or other operational changes impacting water supply operations. Additionally, the QSA, described above, has been challenged in courts and may have impacts on the water transfer between IID and SDCWA. If there are negative impacts, San Diego could become more dependent on Metropolitan supplies. Meanwhile, higher-priority users are beginning to take their full apportionment of Colorado River water, which could eventually reduce the amount of water available to Metropolitan to 550,000 AF, which is its fourth priority right, plus what water can be made available from conservation programs with the IID and other agricultural-to-urban water transfers.

Water Quality –Water imported from the CRA contains high level of salts. The operational constraint is that this water needs to be blended with SWP supplies to meet the target salinity of 500 mg/L of TDS. Another water quality concern is related to the quagga mussel. Controlling the spread and impacts of quagga mussels within the CRA requires extensive maintenance and results in reduced operational flexibility.

Climate Change – Changing climate patterns are expected to shift precipitation patterns and affect water supply. Unpredictable weather patterns will make water supply planning even more challenging. Climatic conditions have been projected based on historical patterns; however, severe pattern changes may occur in the future. The areas of concern for California include the reduction in Sierra Nevada snowpack, increased intensity and frequency of extreme weather events, and rising sea levels causing increased risk of levee failure in the Bay-Delta. Climate

87 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010,* November 2010, pages 1-18 - 1-19.

Change is also expected to impact the Colorado River Basin. Currently, it is believed that climatic factors would have more of an impact than others on long-term water reliability.

Water Surplus and Drought Management Planning

Metropolitan's water supply planning includes development of its Water Surplus and Drought Management (WSDM) Plan which guides operations during both shortage and surplus conditions. The guiding principle of the WSDM Plan is to encourage storage of water during periods of surplus and work with its member agencies to minimize impacts of water shortages during periods of shortage. Under the WSDM Plan, Metropolitan considers its supply situation to be in surplus as long as net water deliveries can be made to storage. Depending on the amount of surplus, water may be stored in Diamond Valley Lake and/or the SWP terminal reservoirs during any surplus stage if storage capacity is available. It is assumed that the surplus indicated by the projected demands and supplies for 2035, if realized, would be delivered to storage, consistent with the WSDM Plan. Metropolitan considers a shortage condition to be in effect anytime it needs to make a net withdrawal from storage to meet demands.[88]

The Uncertainty Buffer

Total water supply deliveries within the Metropolitan service area vary from year to year due to factors such as individual water agencies' demands, economic conditions, rainfall, conservation, challenges associated with the Delta and the Colorado River, regulatory restrictions, and climate change. The quantities used from different sources also vary from year to year due to the relative availability of the particular supply components, which in turn may be affected by snowpack, reservoir storage, operational constraints, and environmental water requirements.[89]

Metropolitan's Integrated Water Resources Plan (IRP) 2010 Update recognizes that future water conditions may fall outside of projected conditions assumed in Metropolitan's baseline demand and supply planning due to these uncertainties and challenges. Therefore, the 2010 IRP Update includes goals for a range of buffer supplies to respond to possible shortages. Buffer supplies are planned to initially come from actions to improve efficiency beyond State mandates, and later will include collaborating with member agencies to develop additional local supplies.[90]

Summary

SCAG and SANDAG project continuing growth in the region and Metropolitan's RUWMP and the UWMPs of water providers in the region reflect these expectations and project increasing water demands to serve that growth. Based on information presented in Section 6.2.2, between 2010 and 2035, the population in Metropolitan's service area is projected to grow by 19 percent, water demand in Metropolitan's service area is projected to increase by 6 percent, and Metropolitan's total water supply is projected to increase by 27 percent. In addition to meeting

88 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages 2-20 - 2-23.

89 Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages ES-1 - ES-4, 2-9 - 2-16, Appendix A.2.

90 Metropolitan Water District of Southern California, *Integrated Water Resources Plan 2010 Update: Executive Summary*, 2010, pages 3, 5. http://www.mwdh2o.com/mwdh2o/pages/yourwater/irp/IRP2010ExecutiveSummary.pdf, accessed October 2011.

full-service demands from 2015 through 2035, Metropolitan projects reserve and replenishment supplies to refill system storage. This assumes projections prove accurate, Metropolitan and MWDOC are not in shortage, and zero allocations are imposed for imported supplies. The relatively minor increase in demand relative to population growth indicates an assumption that gains in conservation and demand management and reductions in per capita consumption are expected to be realized over this period. It is uncertain whether these goals can be realized.

The projected breakdown of the water supply sources in Table 6-28 reflects Metropolitan's efforts to maximize the reliability of supplies by diversifying Metropolitan's supply portfolio and creating surpluses to ensure that projected demands can be met despite the inherent uncertainties. Thus, Colorado River deliveries, which currently contribute 24 percent of the total, are only expected to contribute 16 percent of the total supply in 2035. Local supplies are expected to increase slightly but their overall contribution is expected to remain relatively constant. And Metropolitan projects that SWP deliveries will increase substantially and the SWP contribution to total supply, currently at 31 percent, would increase to 41 percent. This projection is predicated on the resolution of environmental concerns about the Delta and the completion of a new Delta conveyance that would be fully operational by 2022.[91] There remains some uncertainty regarding the nature and timing of remedies to the SWP water supply reliability issues associated with the Bay-Delta system such that Metropolitan's assumption about the SWP deliveries may not be fulfilled. As described above, Metropolitan is pursuing several actions to buffer the uncertainty of its main imported supplies that include additional demand management and development of supplemental supplies.

Growth Potential within Metropolitan Service Area

Metropolitan projects that, in addition to meeting 100 percent of their member agencies' full-service demands from 2015 through 2035, reserve and replenishment supplies will be available to refill system storage. However, there remains some uncertainty regarding Metropolitan's main imported sources of supply from the Colorado River and the Bay-Delta. These include the assumptions regarding resolution of Delta issues, construction of a new Delta conveyance by 2022, and that that Metropolitan and MWDOC won't experience significant shortages during this period of time.

SCAG and SANDAG project continuing growth in the region and Metropolitan's RUWMP and the UWMPs of water providers in the region reflect these expectations and project increasing water demands to serve that growth. The Urban Water Management Planning Act requires water suppliers, as part of their long-range planning activities, to make every effort to ensure the appropriate level of reliability in their water service sufficient to meet the needs of their customers during normal, dry, and multiple dry water years. Because of the uncertainties in water supplies in general, and the uncertainty in supplies from Metropolitan in particular, participating water providers are pursuing a variety of projects, programs, and strategies, including participating in the proposed Project, to improve water supply reliability in their water service areas, as described in Section 6.3. Considered collectively, these projects, programs, and

[91] Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010, pages ES-4 - ES-5.

strategies will improve reliability and decrease the reliance on imported water supplies by increasing water conservation efforts and the use of recycled water for landscaping and other non-potable needs, developing additional water supplies local to the Southern California region (such as the proposed Project) and diversifying potential water supply sources and opportunities, and enhancing delivery flexibility through infrastructure interties and improvements such as adding storage facilities and capacity.

As discussed in Section 6.2, Project water from the Groundwater Conservation and Recovery Component (Phase 1) would provide some additional water supply to the known Project Participants as well as to future Project Participants within the Project Water Area of Use. Together with other identified sources of potential future water, a portion of the Project water would be used by participating water providers to replace a portion of the imported supply while meeting existing and projected future demand. In some cases, in addition to enhancing reliability, water from the proposed Project could be used to support new population growth and new planned infill development within the Project Participants' service areas, and/or for as yet-to-be identified future Project Participants within the Project Water Area of Use.

6.3 Secondary Effects of Growth

6.3.1 Introduction

The growth inducement potential of the Cadiz Valley Water Conservation, Recovery and Storage Project is assessed in Section 6.2, above, for each of the known participating water providers and for potential future water providers that would be located within Metropolitan' six-county Southern California service area. The Project has no direct growth inducement potential in that no housing is proposed as part of the Project or required as a result of the Project. Project construction would create many jobs but an adequate labor pool already exists in the Southern California region such that new housing is not needed to accommodate an imported labor force. It is expected that workers would commute from neighboring communities on the weekends but stay on site during the work week in existing worker housing areas on the Project site. The on-site housing is sufficient to support the construction effort needed for both components of the Project.

The Project has only indirect growth inducement potential, which is limited at that, related to the fact that the water and storage capacity made available by the Project to participating water providers would contribute to augmenting and improving the reliability of each water provider's water supply portfolio. This contribution to the improving the water supply portfolio of participating water providers would help remove water supply reliability as a potential obstacle to growth, which in accordance with the *CEQA Guidelines*,[92] meets one definition of growth inducement. In summary, the growth inducement potential of the Project by water provider is determined to be as follows (See Section 6.2 for a discussion of each water provider):

- SMWD: Project has limited growth inducement potential.
- Golden State: Project has limited growth inducement potential.

[92] *CEQA Guidelines*, California Code of Regulations Title 14, Chapter 3, §15126.2(d).

- Three Valleys: Project has limited growth inducement potential.
- Suburban: Project has no growth inducement potential.
- JCSD: Project has limited growth inducement potential.
- Cal Water: Project has no growth inducement potential.
- Future Participating Water Providers within the Metropolitan Service area: Project has limited growth inducement potential.

Pursuant to Section 15126.2(d) of the *CEQA Guidelines*, growth per se is not assumed to be beneficial or detrimental; it is the secondary, or indirect, effects of population and/or economic growth (e.g., increased traffic, noise, degradation of air and water quality, and loss of agricultural land and open space) that can result in significant adverse changes to the physical environment, which are the focus of the discussion below.

In all cases, the Project's contribution to each water provider's supply portfolio would help support planned growth that is reflected in the adopted General Plans for each community served and growth that is projected to occur in the region by SCAG. The Project would not stimulate growth beyond planned and projected levels.

The cities and counties in the Project Water Area of Use have adopted comprehensive, long term general plans for land uses and physical development within their jurisdictions, and regional planning agencies have prepared projections of future growth in the area, as discussed in Section 6.2 for each Project Participant. The growth and development allowed by these city and county General Plans can result in environmental impacts and, consistent with CEQA, cities and counties have prepared EIRs for their general plans and general plan updates to identify and address the adverse physical effects expected to result from their adopted land use and development plans.

To characterize potential secondary effects of planned growth within the Project Water Area of Use, the General Plans and associated EIRs for cities and counties throughout the Southern California region were reviewed, as listed in **Table 6-34**. The general plan documents selected and reviewed for this analysis include those prepared by the six counties, those from representative jurisdictions within the service areas of the participating water providers, and those prepared by representative jurisdictions projected to grow the most by 2035. The selected EIRs cover a broad range of environmental conditions (in terms of geography, existing levels of development, climate, and ecosystems) in the Project Water Area of Use. Appendix J presents the summary table that reviews the findings of the General Plan EIRs with respect to significant and unavoidable impacts associated with planned growth in the respective communities.

TABLE 6-34
DOCUMENTS THAT HAVE ANALYZED GROWTH IN THE PROJECT WATER AREA OF USE

Document	Lead Agency
Los Angeles County General Plan EIR	Los Angeles County
Orange County Environmental Determination for Orange County General Plan Technical Update	Orange County
Riverside County General Plan EIR	Riverside County
San Bernardino County General Plan EIR	San Bernardino County
San Diego County General Plan EIR	San Diego County
City of Los Angeles General Plan EIR	City of Los Angeles
City of Ontario General Plan EIR	City of Ontario
City of Anaheim General Plan EIR	City of Anaheim
City of Riverside General Plan EIR	City of Riverside
City of Rancho Santa Margarita General Plan EIR	City of Rancho Santa Margarita

SOURCE: ESA, 2011.

6.3.2 Impact and Mitigation

Although the Project has limited growth inducement potential, for purposes of this CEQA analysis and full disclosure of potential indirect effects, the significant and unavoidable impacts associated with planned growth in the Project Water Area of Use are summarized below and identified as potential indirect effects of Project implementation.

Significance Criteria

The EIRs prepared for the local general plans by the cities and counties within the Project Water Area of Use (Metropolitan Service Area) evaluate the environmental effects associated with planned land uses and growth in accordance with impact significance criteria established by those local jurisdictions. This section summarizes the impact findings from those General Plan EIRs based on the impact significance criteria used by the local jurisdictions.

Impacts

Impact 6.1: Secondary Effects of Growth. The Project would contribute to provision of adequate water supply and improved reliability for the participating water providers (SMWD, Golden State, Three Valleys, Suburban, JCSD, and Cal Water) as well as within the broad Metropolitan service area covering portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties. No appreciable growth in population or employment would occur as a direct result of construction or operation of the proposed Project. However, as intended, the water supply and supply reliability benefits of the Project would help participating water providers meet the supply needs of both existing and future customers. Therefore, indirectly the Project would

support planned growth, which, in turn, could result in secondary environmental effects. As determined by the local city and county land use jurisdictions within the service area of the participating water providers and within the Metropolitan service area in the General Plan EIRs, some of the secondary environmental effects of planned growth were determined to be less than significant with mitigation in some communities, and some were determined to be significant and unavoidable.

Table J-1, included in Appendix J, summarizes the effects that have been identified as significant and unavoidable in the majority of EIRs reviewed for this analysis. Secondary effects of growth typically found to be significant and unavoidable include:

- Effects to or loss of agricultural resources;
- Air quality degradation;
- Hydrology and water quality modification and degradation;
- Traffic congestion;
- Transportation demand increase;
- Increased noise; and
- Increased demand on public services and utilities.

Most communities in Southern California and within the services areas of the participating water providers adopted their General Plans and completed the associated EIR prior to current CEQA requirements to analyze greenhouse gas emissions. It is expected that planned growth and development within the Project Water Area of Use could result in a significant and unavoidable contribution to increased greenhouse gas emissions as well.

Pursuant to CEQA, the local lead agencies that have adopted their General Plans have also adopted statements of overriding consideration for the anticipated significant unavoidable effects.

Mitigation Measures

Measures to mitigate secondary impacts of growth have been identified in the general plan EIRs of jurisdictions in the Project Water Area of Use. As summarized in 6-35 at the end of the chapter, some impacts would not be reduced to a less than significant level and remain significant and unavoidable. As described in Section 6.1.3, participating water providers do not have the authority to control land use within their service area or mitigate for the secondary effects of those land use decisions; that authority to regulate growth resides primarily with the cities and counties through the land use planning and development approval process. **Table 6-35** identifies other agencies with the authority to implement measures to reduce or mitigate the environmental impacts of growth in the area.

TABLE 6-35
AGENCIES HAVING AUTHORITY TO IMPLEMENT MAJOR MITIGATION MEASURES FOR GROWTH-RELATED IMPACTS

Agency	Authority
Counties within the Study Area	Responsible for planning, land use, and environmental protection of unincorporated areas. Of particular importance is development of presently undeveloped lands, provision of regional solid waste management facilities, and regional transportation, air quality and flood control improvement programs.
Cities within the Study Area	Responsible for adoption of the *General Plan* and various planning elements and local land use regulations. Responsible for managing some wastewater treatment facilities. Adopts and implement local ordinances for control of noise and other environmental concerns. Participates in regional air quality maintenance planning through adoption of local programs to control emissions via transportation improvements. Responsible for enforcing adopted energy efficiency standards in new construction.
Local Agency Formation Commissions	Empowered to approve or disapprove all proposals to incorporate cities to form special districts or to annex territories to cities or special districts. Also empowered to guide growth of governmental service responsibilities.
Councils of Government	Under State and federal law, have authority and responsibility over transportation planning and funding. Allocate transportation infrastructure and housing.
Regional Water Quality Control Boards, Los Angeles, Santa Ana, San Diego, Colorado River	Share responsibility with SWRCB to coordinate and control water quality. Formulates and adopts water quality control plans. Implements portions of the Clean Water Act when EPA and SWRCB delegate authority, as is the case with issuance of NPDES permits for waste discharge, reclamation, and storm water drainage.
State Department of Health	Responsible for the purity and potability of domestic water supplies for the State. Assists SWRCB and RWQCBs in setting quality standards.
California Air Resources Board	Responsible for adopting and enforcing standards, rules, and regulations for the control of air pollution from mobile sources throughout the State.
South Coast Air Quality Management District, San Diego Air Pollution Control District, and Ventura County Air Pollution Control District	Adopt and enforce local regulations governing stationary sources of air pollutants. Issue Authority to Construct Permits and Permits to Operate. Provide compliance inspections of facilities and monitors regional air quality. Developed the Clean Air Plan in compliance with the Clean Air Act.
U.S. Fish and Wildlife Service	Requires consultation under Section 7 or Section 10 of the Endangered Species Act for projects which could potentially impact endangered or threatened species. Prepares biological opinions on the status of species in specific areas and potential effects of proposed projects. Approves mitigation measures to reduce impacts and establishes Habitat Conservation Plans.
U.S. Army Corps of Engineers	Issues permits to place fill in waterways pursuant to Section 404 of the Clean Water Act.
California Department of Fish and Game	Issues Stream Bed Alteration Agreements for projects potentially impacting waterways.

SOURCE: ESA, 2011.

Significance after Mitigation: Significant and Unavoidable. As determined by the appropriate local city and county land use jurisdictions, some of the effects of planned growth within the Project Water Area of Use are significant and unavoidable. To the limited extent that the Project would help create adequate and reliable water supply to support planned growth, it would indirectly result in the secondary effects of planned growth, including those effects determined in some communities to be significant and unavoidable.

CHAPTER 7
Alternatives Analysis

7.1 Introduction

This Chapter describes alternatives to the project pursuant to *CEQA Guidelines* (Section 15126.6(a)) that may avoid or lessen significant environmental impacts of the proposed Project and meet most or all of the Project Objectives. The analysis below compares a range of alternatives to the proposed Project to evaluate whether impacts would be greater, lesser, or similar to those resulting with the proposed Project. The Chapter restates the Project Objectives and lists the significant and unavoidable impacts of the project as identified in Chapters 4, 5, and 6 of this EIR. Project Alternatives are then described that may avoid or lessen those significant and unavoidable impacts. The analysis in this Chapter then compares each of the Alternatives including the No Project Alternative and identifies the Environmentally Superior Alternative for both the Groundwater Conservation and Recovery Component and the Imported Water Storage Component.

As described in Chapters 4, 5, and 6, of this Draft EIR, the proposed Project's Groundwater Conservation and Recovery Component would have less than significant impacts after mitigation to aesthetics, agricultural resources; biological resources; cultural resources; geology, soils and seismicity; hydrology and water quality; land use and planning; noise; public services and utilities; and traffic. As described below in Section 7.3, significant and unavoidable impacts would occur with regard to construction air emissions and cumulative air emissions for NOx, as well as secondary effects of growth in the water agency service areas.

With respect to the proposed Project's Imported Water Storage Component also described in detail in Chapters 4, 5, and 6, less than significant impacts after mitigation are identified for aesthetics, biological resources; cultural resources; geology and soils; green house gas emissions; hazards and hazardous materials; hydrology and water quality; public services and utilities; and traffic. As described below in Section 7.3, significant and unavoidable impacts would occur with regard to construction air emissions and cumulative air emissions for NOx.

7.1.1 CEQA Guidance for Alternatives Analysis

According to the *CEQA Guidelines* (Section 15126.6(a)), an EIR must describe a reasonable range of alternatives to a proposed project that could feasibly attain most of the basic project objectives, and would avoid or substantially lessen any of the proposed project's significant environmental effects. Section 15126.6(b) of the *CEQA Guidelines* states that:

> "...the discussion of alternatives shall focus on alternatives to the project or its location which are capable of avoiding or substantially lessening any significant effects of the project, even if these alternatives would impede to some degree the attainment of the project objectives, or could be more costly."

Section 15126.6(f) of the *CEQA Guidelines* provides direction on the required alternatives analysis:

> "The range of alternatives required in an EIR is governed by a "rule of reason" that requires the EIR to set forth only those alternatives necessary to permit a reasoned choice. The alternatives shall be limited to ones that would avoid or substantially lessen any of the significant effects of the project. Of those alternatives, the EIR need examine in detail only the ones that the lead agency determines could feasibly attain most of the basic objectives of the project. The range of feasible alternatives shall be selected and discussed in a manner to foster meaningful public participation and informed decision making."

"Feasible" means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social and technological factors. Section 15126.6(d) of the *CEQA Guidelines* provides further guidance on the extent of alternatives analysis required:

> "The EIR shall include sufficient information about each alternative to allow meaningful evaluation, analysis, and comparison with the proposed project. A matrix displaying the major characteristics and significant environmental effects of each alternative may be used to summarize the comparison. If an alternative would cause one or more significant effects in addition to those that would be caused by the project as proposed, the significant effects of the alternative shall be discussed, but in less detail than the significant effects of the project as proposed."

The range of feasible alternatives is selected and discussed in a manner to foster meaningful public participation and informed decision-making. Among the factors that may be taken into account when addressing the feasibility of alternatives (as described in CEQA Section 15126.6(f)) are site suitability, economic viability, availability of infrastructure, general plan consistency, regulatory limitations, jurisdictional boundaries, and whether the proponent could reasonably acquire, control, or otherwise have access to the alternative site.

The EIR must briefly describe the rationale for selection and rejection of alternatives and the information the lead agency relied on when making the selection. It also should identify any alternatives considered, but rejected as infeasible by the lead agency during the scoping process and briefly explain the reasons for the exclusion. Alternatives may be eliminated from detailed consideration in the EIR if they fail to meet most of the basic project objectives, are infeasible, or do not avoid any significant environmental effects.

Section 15126.6(e)(1) of the *CEQA Guidelines* also requires that the No Project Alternative be addressed in this analysis. The purpose of evaluating the No Project Alternative is to allow decision-makers to compare the potential consequences of the proposed project with the consequences that would occur without implementation of the proposed project.

With respect to the alternatives analysis for programmatic components of a project, there is a broader policy-level focus. *CEQA Guidelines* section 15168(b)(4). The purpose of the broader analysis is to consider potential alternatives early in the process to guide future approvals. *In re Bay-Delta Programmatic Envt'l Impact Report Coordinated Proceedings* (2008) 43 Cal.4th 1143, 1169. Alternatives are considered based on their feasibility and their ability to eliminate or reduce the project's environmental effects while meeting most of the basic project objectives.

Finally, an EIR must identify the environmentally superior alternative. The No Project Alternative may be environmentally superior to the proposed project based on the minimization or avoidance of physical environmental impacts. *CEQA Guidelines* section 15126.6(e)(2). require that if the environmentally superior alternative is the No Project Alternative, the EIR shall identify an environmentally superior alternative from among other alternatives.

7.1.2 Chapter Organization

This chapter presents the alternatives identification and evaluation process and is organized as follows:

- Section 7.2 – Project Objectives
- Section 7.3 – Significant Impacts of the Project
- Section 7.4 – Alternatives Rejected from Further Consideration
- Section 7.5 –Alternatives to the Groundwater Conservation and Recovery Component
- Section 7.6 – Alternatives Evaluation – Groundwater Conservation and Recovery Component
- Section 7.7 – Comparison of Alternatives and Identification of the Environmental Superior Alternative – Groundwater Conservation and Recovery
- Section 7.8 – Alternatives to the Imported Water Storage Component
- Section 7.9 – Comparison of Alternatives and Identification of the Environmental Superior Alternative – Imported Water Storage

7.2 Project Objectives

Project Alternatives are evaluated against their ability to meet the Project Objectives. *CEQA Guidelines* Section 15126.6(c) identifies factors that can be used to eliminate Project Alternatives including an Alternative's inability to meet most of the basic Project Objectives. This Chapter evaluates each Alternative's ability to meet the Project Objectives. For clarity, the Project Objectives are repeated below:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to the brine zone and evaporation;

- Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought;
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;
- Enhance dry-year water supply reliability within the service areas of SMWD and other Southern California water provider Project Participants;
- Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of carry-over and, for Phase 2, imported water storage;
- Support operational water needs of ARZC in the Project area;
- Create additional water storage capacity in Southern California to enhance water supply reliability;
- Locate, design, and operate the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

7.3 Significant Impacts of the Proposed Project

The proposed Project would result in two significant and unavoidable impacts: construction air emissions would exceed thresholds of significance for NOx directly and cumulatively, and secondary effects of growth in the water agency service areas. No other significant impacts have been identified.

7.4 Alternatives Rejected from Further Consideration

An EIR must briefly describe the rationale for selection and rejection of alternatives. The lead agency may make an initial determination as to which alternatives are potentially feasible and, therefore, merit in-depth consideration, and which are clearly infeasible. Alternatives that are remote or speculative, or the effects of which cannot be reasonably predicted, need not be considered (*CEQA Guidelines*, Section 15126.6(f)(3)). This section identifies alternatives considered by the lead agency, but rejected as infeasible, and provides a brief explanation of the reasons for their exclusion. As noted above, alternatives may be eliminated from detailed consideration in the EIR if they fail to meet most of the basic Project objectives, are infeasible, or do not avoid any significant environmental effects (*CEQA Guidelines*, Section 15126.6(c)). The following paragraphs describe those alternatives.

Five alternatives were analyzed in the 2001 Cadiz Groundwater Storage and Dry-Year Supply Program EIR/EIS: The Eastern Alternative, the Western Alternative, The Combination Alternative, The Eastern/Canal Alternative, and the No Project Alternative. Three of these alignments are considered but rejected: Western Alternative, Combination Alternative and

Eastern/Canal Alternative. All three alternatives are pipeline alignment alternatives that are outside the ARZC easement and traverse previously undisturbed open space.

7.4.1 The Western Alternative

The Western Alternative includes construction of a 33.3-mile pipeline beginning at the Cadiz Property and joining the CRA at the western portal of the Iron Mountain Tunnel. The pipeline would proceed three miles south along the ARZC easement to a point located just south of the Cadiz Dunes Wilderness area. At this point, the pipeline would turn south-southwest and would run along the western boundary of the Kilbeck Hills and Iron Mountains for approximately 20 miles to the CRA.

The Western Alternative would impact 10 linear miles of undisturbed open space area within a wildlife movement corridor between the Iron Mountains and Calumet Mountains. The alignment is considered occupied desert tortoise territory. The alignment would also require approximately 484 acres of temporary construction right-of-way and 323 acres of permanent right-of-way for construction and operation of facilities on BLM land. In addition, due to the amount of previously undisturbed open space affected, this alternative would have a high potential to impact archaeological or paleontological resources. The alignment would not eliminate any impacts associated with the proposed Project.

This alternative would meet the objectives of the proposed Project. However, due to the increased impacts to biological resources and cultural resources, and due the need for an easement from BLM, this alternative was rejected from further consideration.

7.4.2 The Combination Alternative

The Combination Alternative includes construction of a 34-mile pipeline beginning at the Cadiz Property to the CRA at the western portal of the Iron Mountain Tunnel. The pipeline would be identical to the Western Alternative except that it would continue an additional 10 miles within the ARZC easement and proceed west on the eastern side of the Kilbeck Hills. At southern end of the Kilbeck Hills, the alignment would re-join the Western Alternative alignment and proceed approximately 10 miles to the CRA.

The Combination Alternative would have impacts similar to the Western Alternative. Previously undisturbed biological and cultural resources could be affected, and the alignment would require an easement from BLM. The alignment would not eliminate any impacts associated with the proposed Project. This alternative would meet the objectives of the proposed Project. However, due to the increased impacts to biological resources and cultural resources and due the need for an easement from BLM, this alternative was rejected from further consideration.

7.4.3 The Eastern/Canal Alternative

The Eastern/Canal Alternative would construct a 34.6-mile water conveyance facility that would include a pipeline with an approximately 10-mile canal segment on the western edge of the Danby Dry Lake. The water conveyance facilities would connect with the CRA at the Iron Mountain Pumping Plant.

Similar to the other two alignments, the Eastern/Canal Alternative would traverse previously undisturbed open space that would substantially increase acres of effect to biological resources and cultural resources. In addition, the alignment would require an easement from BLM and would not eliminate any impacts associated with the proposed Project. This alternative would meet the objectives of the proposed Project. However, due to the increased impacts to biological resources and cultural resources and due the need for an easement from BLM, this alternative was rejected from further consideration.

7.4.4 Water Conservation Alternative

The Water Conservation Alternative would eliminate the need for the proposed Project through the implementation of conservation policies and Demand Management Measures (DMMs) by each Project Participant that would effectively reduce water demands to levels consistent with the Project water supplies. Under the Water Conservation Alternative, each Project Participant would reduce water demands by 5,000 AFY through implementation of DMMs. While uncertainty in supplies in general have forced water providers to pursue a variety of projects, programs, and strategies to improve water supply reliability including conservation efforts, as described in Section 6.3, this alternative assumes an actual numeric reduction requirement for agencies to reach.

Conservation in general has seen increasing priority by individual agencies since 1991[1] because both the SWP and Colorado River water supplies are experiencing reductions from historic deliveries. Thus, the overall purpose of the proposed Project is to make available a reliable water supply for Southern Californian Project Participants to supplement or replace existing supplies and enhance dry-year supply reliability.

Under the Urban Water Management Planning Act, water providers of a certain size are required to prepare Urban Water Management Plans (UWMPs) that include conservation measures ensuring the efficient use of urban water supplies. In 2010, the California Department of Water Resources (DWR) published the 10x2020 Plan that identifies strategies to reduce per capita water use in the state by 20 percent by the year 2020. DWR outlines strategies to meet this target through a combination of conservation, improved water use efficiencies, increased recycled water

[1]Each of the Project Participants is already subject to water conservation policies adopted by the state to increase water use efficiency. The California Urban Water Conservation Council's (CUWCC) Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) identifies Best Management Practices (BMPs) that include several "Foundational BMPs" that promote water use efficiency. These BMPs have been implemented across the state since the MOU was first established in 1991.

use, and other potable water demand reduction measures and programs, as described below. Additionally, Metropolitan in collaboration with Metropolitan Water District of Orange County (MWDOC) and other Metropolitan member agencies is in the process of developing a Long Term Conservation Plan, which seeks an aggressive water use efficiency target in order to achieve a 20 percent reduction in per capita water use by 2020 for the entire Metropolitan service area. However, to date it is uncertain whether these goals can be realized. See Section 6.2 Growth Inducement Potential.

Each of the water agency Project Participants has prepared UWMPs that outline detailed conservation measures needed to meet aggressive conservation goals. The identification of conservation measures in the UWMPs would occur with or without the proposed Project. As noted in the UWMPs, each water agency's projected water demand already includes aggressive conservation goals. Therefore, even with success in achieving these goals, there would still be the need to participate in the proposed Project which primarily offers water supply reliability and diversity for each of the participants. The water provided by the proposed Project is primarily intended to offset expected declines in existing supplies; in some cases Project water will augment Participant supplies. The Project will reduce each participant's reliance on the SWP and/or California's allotment of Colorado River water. This supply flexibility increases reliability. Availability of imported water supplies in the future in average and dry years continues to be uncertain for Southern California water agencies. Concerns for escalating costs of future water in dry years also affects supply reliability.

As described in each Project Participant's UWMP, water conservation strategies are being implemented in accordance with state laws and local ordinances. Financial incentives and low flow fixtures form the foundation of the efficiency measures. Even with implementation of the conservation goals set out by the state and local jurisdictions, water supply diversity is needed to augment reliability and dry year supply. Reducing demands does not obviate the need for diverse water sources that enhance reliability and protect against declines during dry years.

The Water Conservation Alternative would not meet any of the Project Objectives. The Water Conservation Alternative would avoid the significant and unavoidable impact of NOx emissions during construction. However, the secondary effects of growth would not be avoided. Elimination of the proposed Project would not change any growth patterns or reduce the growth planned for Southern California. Water supplies would be less reliable and subject to shortages in dry years. Therefore, the Water Conservation Alternative is not a feasible alternative to the proposed Project.

The following sections describe the status of the ongoing conservation efforts conducted by each water agency Project Participant as reported in the UWMPs.

Santa Margarita Water District

SMWD is actively participating in many water conservation activities and has made water use efficiency an integral part of its water use planning. As a result, SMWD's 2010 UWMP forecasts that between 2010 and 2035, the population within City limits will increase by 40 percent, while water demand will increase by 36 percent.[2] Future water demands are expected to increase at a lower rate than population growth for several reasons, including the water conservation practices, techniques, and technologies implemented by SMWD to improve water use efficiency in their service area.

The SMWD Board of Directors adopted the Comprehensive Water Conservation Program Ordinance No. 09-07-02 on July 10, 2009, which establishes a comprehensive water conservation program that encourages reduced water consumption within SMWD through conservation, effective water supply planning, reasonable and beneficial use of water, prevention of waste, and efficient use of water within SMWD.

In addition, SMWD has dedicated resources to implementing 13 of the 14 BMPs identified in the California Urban Water Conservation Council's (CUWCC) Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), including all of the "Foundational BMPs." The bulk of the resources are dedicated to high-efficiency appliance replacements and rebate programs, water accounting and metering, incentivizing programs and measures, and public information and school education programs. Due to its water conservation efforts in the past decade, SMWD is on its way to meeting its 20 percent water use per capita goals.

Three Valleys Municipal Water District

Water conservation across all customer groups is a key component of Three Valleys' long-term water supply strategy and essential to meeting the State's goal of reducing per capita water use by 20 percent by 2020. On a regional basis, the baseline water demand is estimated to be 193 gallons per capita per day (GPCD). A 20 percent reduction would lessen this to 154 GPCD. Long term savings from conservation measures is projected to range from 19,200 AFY in 2020 to 27,300 AFY in 2035. Three Valleys is one of the charter signatories to the 1991 CUWCC MOU. A number of Three Valleys' member agencies are also signatories to the CUWCC, including the cities of Covina, Glendora, La Verne, and Pomona, Covina Irrigating Company, Rowland Water District, Golden State, and Walnut Valley Water District. Three Valleys is working with its retail member agencies to develop policies and programs to address individual water reduction targets as part of a concerted effort to meet its conservation target. Three Valleys' past resolutions have encouraged its retail member agencies to adopt ordinances encouraging conservation practices during times of drought. In 2009, the District adopted its own updated ordinance to govern mandatory conservation activities during times of drought and other water shortages and emergencies, which contributed to a decrease in water use in 2009.

[2] Santa Margarita Water District, *2010 Urban Water Management Plan*, June 2010, page 2-13.

Suburban Water Systems

Suburban is a CUWCC member and signatory to the 1991 CUWCC MOU. Since 2007, there has been a significant downward trend in total and per capita water use, likely due to recent recessionary economic conditions, increased emphasis on water conservation and public outreach, and lower than normal summer temperatures. Over the last several years, Suburban has shown a stable to slightly decreasing demand trend. Water use by new customers appears to be offset by the following conservation measures, as well as the effects of new California plumbing and building code requirements.[3]

With its 2010 use at 141 GPCD, San Jose Hills is currently in compliance with its target of 142 GPCD. The DMM goal of 137 GPCD will be achieved by continued program implementation as well as the development of a recycled water program that is expected to reduce potable demand by about 1,400 AFY or 7 GPCD by 2015. The DMM goals for Whittier/La Mirada require reductions of about seven percent by 2020. Suburban will realize these savings by building on and expanding its existing programs, including the high efficiency toilets (HET) direct-delivery and financial incentives. Suburban will work with its wholesale agencies to promote and, where possible, augment available incentive programs. Long term savings from conservation measures is projected to range from 180 AF in 2015 to 2,670 AF in 2035.

Jurupa Community Services District

JCSD has focused its conservation efforts on implementing the water conservation BMPs and DMMs from the 1991 CUWCC MOU throughout their service area. JCSD has experienced a 17 percent decrease in per capita water consumption since 2006 and a reduced water demand since 2008, which has been attributed in part to JCSD's tiered pricing structure, the economic and drought conditions that have affected the region as a whole, and the effectiveness of JCSD's water conservation program. [4] JCSD continues to implement public information and education programs, which are effective in managing against increased demands, particularly for non-potable water users. Residential, commercial, and industrial usage can be expected to decrease as a result of the implementation of more aggressive water conservation practices. As of 2009, JCSD is meeting their target of 199 GCPD, as reported in their 2010 UWMP.[5]

Golden State Water Company

Golden State is progressing towards implementing all Foundational BMPs for each of its water systems, as required in the revised MOU and UWMP Act. Golden State's companywide approach to meeting conservation targets includes accelerating current programs and adding additional programmatic, regulatory and information-based activities. Implementation levels and specific program offerings vary by system, depending on system goals, including existing implementation levels, demographics, and hydrologic characteristics. Chapter 6.0 – Growth Inducement reviews

[3] Suburban Water Systems, *2010 Urban Water Management Plan,* June 2011.
[4] Jurupa Community Services District, *2010 Urban Water Management Plan,* May 2011.
[5] Jurupa Community Services District, *2010 Urban Water Management Plan,* May 2011, Section 2-2.

Golden State's Urban Water Management Plans for service areas that could receive Project water and provides further discussion of conservation and supply management measures.

California Water Service Company

Cal Water is a signatory to the 1991 MOU Regarding Water Conservation in California and implements a variety of demand management measures through its own programs and through collaboration with its wholesale agencies. Cal Water is in the process of expanding current conservation programs and developing new programs for its 24 service districts, which includes a Conservation Plan for the Westlake District. Cal Water's water conservation efforts within this district include retail conservation pricing, public education regarding efficient water use, and participation in high efficiency appliance rebate programs. Long term savings from conservation measures is projected to range from 1,312 AF in 2015 to 2,670 AF in 2035, which are the levels of conservation needed to meet SBx7-7 targets by 2020 and MOU requirements.[6]

7.4.5 Other Supply Sources Alternative

The Other Supply Sources Alternative could result in Project Participants developing other water sources, thereby avoiding impacts of constructing and operating the proposed Project. The significant and unavoidable NOx emissions would be avoided by this Alternative. However, the Other Supply Source Alternative would not eliminate the secondary effects of growth since other sources would likely be developed to support planned growth that results in secondary impacts. In addition, if other water supply projects are implemented, they would likely have similar or greater impacts than the Project.

The UWMPs for each of the Project Participants as well as Metropolitan identify numerous water supply projects that make up a broad portfolio of opportunities to meet water demands and enhance supply reliability. The overall purpose of the proposed Project is to be included as one of many water supply options available to Project Participants. Eliminating one of the water supply options would limit options to enhance reliability, control costs, and reduce reliance on imported CRA and SWP water. Water supply agencies in Southern California including each of the Project Participants are pursuing numerous water supply options as imported water supplies are becoming less reliable. This pursuit of other water supplies would likely occur with or without the proposed Project.

The proposed Project is being implemented by SMWD as Lead Agency in cooperation with Cadiz Inc. which owns land in the Cadiz Valley. Cadiz Inc. would not be available as a project partner for any other water supply Project. Therefore, the Other Water Supply Sources Alternative does not meet fundamental purpose of the Project, which is to develop a local supply by saving substantial quantities of groundwater that are lost each year in the Cadiz Valley to evaporation. Nor does this Alternative meet several other objectives.

Table 7-1 lists water supply projects identified in the Project Participant's UWMPs.

[6] Cal Water, *Westlake District 2010 Urban Water Management Plan,* Adopted June 2011, page 76.

TABLE 7-1
PLANNED AND FUTURE WATER SUPPLY PROJECTS AND PROGRAMS

Santa Margarita Water District	
Baker Water Treatment Plant.	The Baker Water Treatment Plant will be a new 25 MGD plant at the existing Irvine Ranch Water District's (IRWD) Baker Filtration Plant site in Lake Forest. The Baker WTP will treat untreated water from the Santiago Lateral and Irvine Lake through the Baker Pipeline; SMWD expects to receive 9,400 AFY beginning in 2015.[7]
Upper Chiquita Reservoir Project.	SMWD is constructing the Upper Chiquita Reservoir near Oso Parkway and the 241 Toll Road; it will have a capacity of 244 MG (750 AF) and will act as a large-scale emergency potable water supply during planned or unplanned service disruptions. Construction is expected to be completed in Fall 2011.
Rancho Mission Viejo Riparian Non-Potable Water.	Rancho Mission Viejo (RMV) holds riparian water rights for its ranching, agriculture and tenants uses. RMV and SMWD are contemplating an agreement whereby RMV leases a portion of the riparian water to SMWD for use as supplemental water to provide for non-domestic irrigation water to The Ranch Plan properties in the event that recycled water is not available. A portion of the leased water could also be used during grading and construction.
Recycled Water.	Recycled water from the Oso Creek Wastewater Reclamation System is used to meet centralized irrigation requirements and community landscape areas. Recycled water from the Chiquita WRP is used for irrigation purposes. The current combined recycled water production from the Chiquita WRP, Oso Creek WRP, and Nichols Institute is about 6,600 AFA, and by 2035, recycled water use is expected to more than double.
Supplemental Dry Year Water Supplies.	SMWD has two water purchase agreements with Cucamonga Valley Water District (CVWD) and Golden State for water in the Chino Basin that will augment supply reliability under normal, dry or multiple dry year water years. The purpose of these transfer agreements is to ensure that demands on SMWD's water resources from The Ranch Plan do not reduce water supplies for existing customers or prevent other approved developments.
Other Interconnections.	SMWD is working with neighboring agencies to expand a permanent interconnection and pumping facilities between the IRWD potable water distribution systems.
Other Storage.	SMWD purchased 50 percent of the capacity in the El Toro R-6 Domestic Water Reservoir which increased emergency storage within SMWD. In addition, SMWD has a distribution system of storage reservoirs which are designed to supply fire flow and one maximum-day of storage.
Groundwater.	As a member agency of the San Juan Basin Authority, which is responsible for a brackish groundwater desalination plant in the City of San Juan Capistrano, SMWD may consider participation in expansion of the facility.
Desalination.	There are three proposed ocean desalination projects in Orange County, one of which could benefit SMWD. On June 23, 2009, SMWD signed a non-binding Letter of Interest (LOI) for 5,000 AFY of Huntington Beach Seawater Desalination Project supplies.

[7] Irvine Ranch Water District, *Baker Water Treatment Plant,* http://www.irwd.com/your-water/construction-projects/baker.html, accessed October 2011.

Three Valleys Municipal Water District

Transfer Opportunities.	Three Valleys has purchased over 1,300 AF of groundwater stored in the basin, which off sets the need to purchase an equivalent quantity of imported water. In the future, Three Valleys will continue to utilize this transfer opportunity as much as practically possible.
Conjunctive Use.	Three Valleys and its member agencies have developed three conjunctive use projects in partnership with Metropolitan. The Live Oak Basin Conjunctive Use Project, with the potential to store 3,000 AFY, the City of LaVerne's WTF with the capacity to treat 2,500 AFY on average of recovered groundwater, and the Upper Claremont Heights Basin with an averaged 800 AFY with the potential to add 5,000 AFY.
Local Groundwater Recovery.	The recovery or expansion of groundwater production in Three Valleys' service area may provide 20,000-25,000 AFY of added supplies.
Recycled Water.	In the future, recycled water development by the retail agencies within the Three Valleys service area may offset another 8,000-10,000 AFY of firm potable water demand.

Jurupa Community Services District

Recycled Water.	JCSD is exploring the potential of increasing recycled water use. Recycled water is anticipated to come on line in 2015
Groundwater.	JCSD has rights to groundwater pumping in the Chino Basin. Upon conversion of agricultural lands, JCSD will receive about 5,440 AF of additional groundwater production rights in the Basin. JCSD is also developing four new groundwater wells that will provide 9 to 11 MGD of supply.
Desalination.	JCSD's contractual agreement with Chino Desalter Authority requires that they purchase 8,200 AFA, and this contractual amount will increase by 3,300 AFA upon completion of the Chino II Desalter Expansion Project. The proposed CDA expansion will increase the capacity of the Chino II Desalter by 10,600 AFY, of which JCSD will receive approximately 3,300 AFY. Water is projected to be available from this project expansion in 2014.
Imported Water.	The Riverside Corona Feeder Project would allow Western MWD to purchase water from the SWP from Metropolitan and deliver the water to JCSD's service area through future built connections. The Feeder will incrementally increase water supply from 5,000 AFY in 2020 to 10,000 AFY in 2035. JCSD has also expressed interest other imported water supply projects that could increase the reliability and robustness of JCSD's water supply:
Interconnection Projects.	JCSD is planning a second interconnection to Rubidoux Community Services District, which extracts water from the Riverside South Basin. In addition to the 500 AFY that is currently available, JCSD has opened negotiations for purchasing an additional 1,000 AFY by 2015.
Roger D. Teagarden Ion Exchange Plant.	Feasibility and planning was recently completed to evaluate the potential existing raw water sources and transmission facilities to JCSD's Roger D. Teagarden Ion Exchange Plant, which has excess blending capacity and could increase capacity by implementing process improvements and expanding the facility. The Ion Exchange Plant could produce an additional 4 MGD, or 2,800 gpm, if raw water supply is available.

Suburban	
Desalination.	Suburban could develop financial arrangements with SWP contractors in the construction of their seawater desalination facilities in exchange for SWP supplies. Suburban's 2010 UWMP lists seven existing and proposed seawater desalination facilities that would individually yield from 10,000 AFY (Long Beach) to between 56,000 and 168,000 (Camp Pendleton) of water. Together, the seven desalination facilities could yield between 102,000 and 280,000 AFY.
Recycled Water.	To date, Suburban has not used recycled water within its service area, but it is participating in the City of Industry Regional Recycled Water Project that will be coming online in late 2011. Phase I is currently under construction and will contribute 1,406 AFA of recycled water supplies to Suburban's service area to offset potable water use for irrigation and aid in meeting Suburban's conservation requirements. Recycled water use is expected to remain steady through 2035.
Golden State	
Delta Wetlands Place of Use Project.	The Delta Wetlands Place of Use Project would deliver water to 33 Water Systems8 within the Southern California service area, including Barstow, which currently forecasts a supply shortfall in 2035.9 As a designated participant, Golden State would receive a maximum annual delivery of 20,000 AFY that would be used for municipal, industrial and domestic purposes, which would provide additional dry year water supply reliability.
California Water Service Company	
Recycled Water	Recycled water is currently used within Westlake District's service area. Cal Water has signed an agreement for the purchase of water from two recycled water distribution systems operated by CMWD: North Ranch and South Ranch systems, and plans to purchase water as it become available.

SOURCE: Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011; Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011; Santa Margarita Water District, *2010 Urban Water Management Plan*, July 2011; California Water Service Company, *Westlake District 2010 Urban Water Management Plan*, June 2011.

8 Places of use for Delta Wetlands Place of Use Project include all Golden State Water Systems for which proposed Project water could be used, listed in the Growth Inducement Chapter 6, Table 6-7.

9 Semitropic Water Storage District, *Delta Wetlands Project Place of Use Draft EIR,* April 2010, page 6-3.

7.5 Alternatives to the Groundwater Conservation and Recovery Component

Alternatives to be considered in the EIR analysis are those that can avoid or substantially lessen one or more of the significant environmental effects of the proposed Project. An analysis of project alternatives also assists in evaluating options of a project that may reduce or avoid impacts that may not be significant. This Chapter identifies and compares several facilities alternatives that examine Project design modifications or facility locations to evaluate whether different variations of the Project would result in greater, similar, or lesser impacts. This Chapter evaluates two No Project Alternatives, one that compares against the existing baseline condition (Existing Agricultural Operations), and one that assesses the potential future condition based on existing land use development approvals (Expanded Agricultural Operations). This Chapter also evaluates alternative ways to operate the Project (Project Facilities and Project Operations, respectively).

No Project Alternatives

Two No Project scenarios are evaluated. The first assumes that the Project will not be constructed and that Cadiz agricultural operations will continue as they are today. The second scenario assumes that the Project will not be constructed but that Cadiz Inc. will expand its agricultural operations over time in accordance with existing plans and approvals.

1. **No Project Alternative – Existing Agriculture Operations**. The No Project Alternatives analyzed in this Draft EIR includes no construction of any new facilities and no change to existing agricultural operations within the Cadiz Property.
2. **No Project Alternative – Expanded Agriculture Operations.** This alternative assumes that agricultural operations on the Cadiz Property would increase as allowed under existing County approvals and zoning.

Project Facilities Alternatives

1. **Alternative Pipeline Route. West of Danby Pipeline.** This alternative includes a variation of the pipeline alignment from the wellfield to the CRA. The alignment is similar to the pipeline alignment evaluated in the 2001 Draft EIR/EIS by lead agencies Metropolitan and BLM.
2. **Existing Natural Gas Pipeline Alternative Route.** This alternative involves use of an existing, unused natural gas pipeline that runs past the Cadiz Property to Barstow (and on to Wheeler Ridge). This pipeline has capacity for approximately 30,000 AFY of water. The pipeline extends approximately 100 miles between the Project site and Barstow. The pipeline would require rehabilitation and upgrades including construction of up to 5 pump stations between the Cadiz Property and Barstow, installation of air valves at approximately half mile intervals along the pipeline route, and eventual pipeline lining.

3. **Wellfield Location.** This alternative involves a wellfield option located north of the proposed wellfield to evaluate the potential to reduce drawdown effects on brine migration and salt mining operations.

Project Operations Alternatives

1. **Project with Agriculture.** This alternative assumes that the existing or slightly expanded agricultural operations within the Cadiz Property would continue to operate in conjunction with the proposed Project.

2. **Phased Project Alternative.** This alternative assumes that the conveyance pipeline would be constructed similar to the proposed Project, but that the wellfield would be installed in a phased manner, over five (5) years rather than eighteen (18) months, expanding as monitoring data reveals drawdown effects are within expected levels.

3. **Reduced Project Alternative.** Under the Reduced Project Alternative, the duration of the Project would be reduced to 25 years and the total volume of water extracted over the term of the Project would be reduced by 25 percent. To maintain the benefits of conserving water that would otherwise flow to the brine zone and evaporate, the Reduced Project Alternative would pump up to 75,000 AFY of groundwater for a period of 25 years for delivery to Project Participants.

Table 7-2 provides a brief description of these alternatives, highlights how they differ from the Project, and identifies the Project impacts the alternative is intended to address.

7.6 Alternatives Evaluation – Groundwater Conservation and Recovery Component

This section provides a general description of each alternative, followed by its ability to meet the Project objectives and finishes with a qualitative discussion of its comparative environmental impacts. As provided in Section 15126.6(d) of the *CEQA Guidelines*, the significant effects of each alternative are identified in less detail than the proposed Project. **Table 7-3** compares the ability for each alternative to meet the Project objectives. **Table 7-4** compares the environmental impacts for each alternative to the proposed Project.

TABLE 7-2
SELECTED ALTERNATIVES FOR CEQA ANALYSIS –
GROUNDWATER CONSERVATION AND RECOVERY

Alternative / Description	How Does the Alternative Differ from the Proposed Project?	What Project Impact is the Alternative Intended to Avoid or Minimize?
No Project Alternatives		
1: No Project – Existing Agriculture	• No facilities would be constructed and no Project implementation. Existing agricultural activity would continue.	• Included as required by CEQA
2: No Project – Expanded Agriculture	• No facilities would be constructed and no Project implementation. Existing agricultural operations would expand as currently allowed by County.	• Included as required by CEQA assuming approved land uses are implemented
Project Facility Alternatives		
1. Pipeline route alternative – West of Danby Pipeline	• Full Project implementation with alternative alignment for conveyance pipeline, which is shorter, crossing the Danby Dry Lake through previously undisturbed desert to Iron Mountain Pump Station	• Reduces impacts of construction of longer pipeline alignment
2. Pipeline route alternative – Existing Natural Gas Pipeline	• Implementation of the Project with use of existing pipeline, avoids construction of new conveyance pipeline. Reduced operation of 30,000 AFY groundwater extracted versus Project proposed 50,000 AFY due to pipeline capacity restriction.	• Avoids impacts of constructing new conveyance pipeline and CRA tie-in. Conveyance capacity limitations would reduce groundwater pumping thereby reducing groundwater drawdown effects and associated effects on third party wells and salt mining operations.
3: Wellfield location alternative	• Wellfield would be north of proposed Project wellfield configurations	• Reduces migration of saline-freshwater interface and resulting intrusion of lower quality groundwater
Project Operation Alternatives		
1. Project with Agriculture	• Full Project implementation and continued agricultural activity. Would allow agriculture to remain in operation on Cadiz Property along with the Project.	• Avoids loss of agricultural activities
2. Phased Project Operation	• Full Project implementation but over a longer implementation schedule. Would allow for monitoring feedback as Project is implemented	• Ensures drawdown is as expected
3. Reduced Project	• Reduces total groundwater pumping by 25 percent over shorter term. Allows pumping of 75,000 AFY on average over 25 years.	• Reduces total groundwater withdrawal and allows for groundwater levels to recover sooner

SOURCE: ESA, 2011.

TABLE 7-3
ABILITY OF PROJECT ALTERNATIVES TO MEET PROJECT OBJECTIVES

			Project Facility Alternatives			Operational Alternatives		
Project Objectives	**No Project Alternative**	**No Project Alternative with Expanded Agriculture**	**West of Danby Pipeline**	**Existing Natural Gas Pipeline Alternative Route**	**Wellfield Location**	**Project plus Existing Agriculture**	**Phased Project Alternative**	**Reduced Project Alternative**
Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to evaporation;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Enhance dry-year water supply reliability within the service areas of SMWD and other Southern California water provider Project Participants;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of storage;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Support operational water needs of ARZC's railroad operations in the Project area;	**No**	**No**	**No**	**No**	Yes	Yes	Yes	Yes
Create additional water storage capacity in Southern California to enhance water supply reliability;	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes
Locate, design, and operate the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.	**No**	**No**	Yes	Yes	Yes	Yes	Yes	Yes

SOURCE: ESA, 2011

TABLE 7-4
SUMMARY COMPARISON OF PROJECT ALTERNATIVES TO PROPOSED PROJECT

			Project Facility Alternatives			Operational Alternatives		
Impact	**No Project Alternative**	**No Project Alternative with Expanded Agriculture**	**West of Danby Pipeline**	**Existing Natural Gas Pipeline Alternative Route**	**Wellfield Location**	**Project plus Existing Agriculture**	**Phased Project Alternative**	**Reduced Project Alternative**
Aesthetics	Lesser	Lesser	Lesser	Lesser	Similar	Similar	Similar	Similar
Agriculture and Forestry Resources	Lesser	Similar	Similar	Lesser	Similar	Lesser	Similar	Similar
Air Quality	Lesser	Greater	Similar	Lesser	Greater	Greater	Greater	Lesser
Biological Resources	Lesser	Greater	Greater	Greater	Greater	Similar	Greater	Similar
Cultural Resources	Lesser	Greater	Greater	Lesser	Greater	Similar	Similar	Similar
Geology and Soils	Lesser	Similar	Greater	Similar	Lesser	Similar	Similar	Similar
Greenhouse Gas Emissions	Lesser	Greater	Lesser	Lesser	Similar	Greater	Similar	Lesser
Hazards and Hazardous Materials	Lesser	Greater	Similar	Similar	Similar	Similar	Similar	Similar
Hydrology and Water Quality	Lesser	Lesser	Similar	Lesser	Greater	Greater	Similar	Lesser
Land Use and Planning	Lesser	Similar	Greater	Similar	Similar	Similar	Similar	Similar
Mineral Resources	Lesser	Lesser	Greater	Lesser	Lesser	Greater	Similar	Lesser
Noise	Lesser	Greater	Similar	Lesser	Similar	Greater	Greater	Similar
Population and Housing/Growth/Socioeconomics	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
Public Services and Utilities	Lesser	Similar	Similar	Similar	Similar	Similar	Similar	Similar
Recreation	Similar	Greater	Greater	Similar	Similar	Similar	Similar	Similar
Transportation and Traffic	Similar	Greater	Similar	Lesser	Similar	Greater	Greater	Similar

SOURCE: ESA, 2011

7.6.1 No Project Alternatives

No Project Alternative – Current Agriculture Operations

Pursuant to Section 15126.6(e)(2) of the *State CEQA Guidelines*, the No Project Alternative shall:

> …discuss the existing conditions at the time the notice of preparation is published, or if no notice of preparation is published, at the time the environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services.

For the No Project Alternative, construction of facilities identified under the proposed Project would not be implemented. The existing agricultural operations at the Cadiz Property would continue and no new permanent structures would be constructed. There would be no augmentation to the Participating Provider' water supply.

Ability to Meet Project Objectives

The No Project Alternative would not meet any of the Project objectives. Under the No Project Alternative, current agricultural operations would continue, with the potential for increased agricultural production on the 1,140 acres currently fallow and not irrigated. Domestic water supply reliability and storage would not be developed.

Comparison of Environmental Impacts

Aesthetics

The No Project Alternative with Existing Agriculture would not impact scenic vistas and visual character. Since the Project site is already used for agriculture, open views for motorists traveling along National Trails Highway, SR 62, and other local roadways would be preserved. In addition, identifiable increases in light and glare would not occur under this alternative. Thus, the No Project Alternative with Existing Agriculture would result in fewer aesthetic impacts compared to the proposed Project.

Agricultural and Forestry Resources

Implementation of the No Project Alternative with Existing Agriculture would continue agricultural operations at the site. Since the proposed Project would curtail agricultural operations once the program is fully subscribed, the No Project Alternative with Existing Agriculture would result in fewer impacts to agricultural resources than the proposed Project.

Air Quality

The No Project Alternative with Existing Agriculture would not increase air impacts from existing conditions. Therefore, the No Project Alternative with Existing Agriculture would result in fewer impacts to air quality than the proposed Project.

Biological Resources

The No Project Alternative with Existing Agriculture would not alter the existing condition and therefore have fewer biological resource impacts than the proposed Project.

Cultural Resources

The No Project Alternative with Existing Agriculture would not alter the existing conditions and would therefore have fewer impacts than the proposed Project which contemplates new construction.

Geology and Soils

The No Project Alternative with Existing Agriculture would not involve the development of any on-site structures. The potential for subsidence would be reduced under this Alternative. The No Project Alternative with Existing Agriculture would not alter the existing condition and would therefore have fewer impacts than the proposed Project.

Greenhouse Gas Emissions

The No Project Alternative with Existing Agriculture would not increase emissions from existing conditions. Therefore, the No Project Alternative with Existing Agriculture would result in fewer GHG impacts than the proposed Project

Hazards and Hazardous Materials

The No Project Alternative with Existing Agriculture would not involve the use of more hazardous materials than are used under existing conditions. Therefore, the No Project Alternative with Existing Agriculture would not alter the existing condition and, since some mitigation would be required in the proposed Project, would have fewer impacts than the proposed Project.

Hydrology and Water Quality

The No Project Alternative with Existing Agriculture would not result in increased groundwater extraction, and therefore water levels within the Cadiz aquifer would not be lowered more than they are now. Groundwater quality would not be affected by the change in groundwater gradients. Existing operations would be subject to the existing Groundwater Management Plan. No new monitoring features would be installed to monitor the groundwater basin. For the proposed Project, impacts to the hydrology and water quality were found to be less than significant with mitigation. Since some mitigation would be required with the proposed Project, the No Project Alternative with Existing Agriculture would result in fewer impacts on hydrology and water quality.

Land Use and Planning

The No Project Alternative with Existing Agriculture would not alter existing land uses. Therefore, the No Project Alternative with Existing Agriculture would have fewer impacts than the proposed Project.

Mineral Resources

The No Project Alternative with Existing Agriculture would extract less water than would the proposed Project. Since some mitigation would be required, the No Project Alternative with Existing Agriculture would therefore result in fewer impacts to mineral resources than the proposed Project.

Noise

The No Project Alternative with Existing Agriculture would not require additional construction that would generate noise. For the proposed Project, potential impacts from construction noise were found to be less than significant with mitigation. Therefore, since some mitigation would be required, the No Project Alternative with Existing Agriculture would not alter the existing condition and would have fewer impacts than the proposed Project.

Population and Housing

The No Project Alternative with Existing Agriculture would not increase population in the area. Nor would the Alternative include the addition of any new structures. No urban water demands would be met with a new reliable water supply. However, urban demands would be met by other means. Therefore, the No Project Alternative with Existing Agriculture would result in similar impacts to the proposed Project.

Public Services and Utilities

The No Project Alternative with Existing Agriculture would not increase population in the area. Nor would the Alternative include the addition of any new structures. No urban water demands would be met with a new reliable water supply. Therefore, the No Project Alternative with Existing Agriculture would result in similar impacts to the proposed Project.

Recreation

Implementation of the No Project Alternative with Existing Agriculture would not result in any new development and would not impact any recreational resources. Therefore, implementation of the No Project Alternative with Existing Agriculture would have similar effects to recreation-related impacts as the proposed Project.

Traffic and Transportation

Implementation of the No Project Alternative with Existing Agriculture would not alter existing conditions or increase traffic. Therefore, since some mitigation would be required, implementation of the No Project Alternative with Existing Agriculture would have fewer impacts than the proposed Project.

No Project Alternative – Expanded Agriculture Operations

Under the No Project Alternative with Expanded Agriculture, impacts associated with the construction and operation of the 43-mile pipeline and wellfield would be avoided. The existing agricultural operations would be expanded at the Cadiz Property. Some or all of the seven square

miles of agricultural lands that are currently open space could be converted to agricultural uses. To accommodate agricultural water demands, six new extraction wells would be installed with the capacity to extract up to 30,000 AFY to meet agricultural crop demands.

Ability to Meet Project Objectives

The No Project Alternative with Expanded Agriculture would not meet any of the Project objectives.

Comparison of Environmental Impacts

Aesthetics

The No Project Alternative with Expanded Agriculture would increase agriculture on the Cadiz Properties. Six new extraction wells would be drilled. Since the Cadiz land is already being used for agriculture, the No Project Alternative with Expanded Agriculture would not conflict with the existing character of the Project site. The alternative would avoid impacts to vistas and visual character of constructing the wellfield and installing pipeline under the proposed Project. For the proposed Project, potential impacts associated with night lighting were found to be less than significant with mitigation. Therefore, the No Project Alternative with Expanded Agriculture would result in fewer aesthetic impacts compared to the proposed Project.

Agricultural and Forestry Resources

Implementation of the No Project Alternative with Expanded Agriculture would result in the development of up to seven square miles of agricultural land. The site would remain in an agricultural use. The No Project Alternative with Expanded Agriculture would not adversely affect farmland or result in conversion of agriculture to non-agricultural uses. The Alternative would be similar to the proposed Project.

Air Quality

The No Project with Expanded Agriculture would have similar operational emissions associated with pumping 30,000 AFY of water from the ground although approximately forty percent less pumping would be required. The existing wells would be powered with diesel engines as opposed to the cleaner natural gas engines of the proposed Project. The No Project with Expanded Agriculture would result in air emissions from water pumping similar to the proposed Project, but to a lesser degree due to reduced operations. However, the expanded use of farm equipment would substantially increase operational combustion emissions and fugitive dust emissions in the valley. Overall, the No Project Alternative with Expanded Agriculture would result in greater air quality impacts compared to the proposed Project.

Biological Resources

The No Project Alternative with Expanded Agriculture would result in grading up to seven square miles of open desert. The proposed Project would only convert approximately 250 acres of open space desert, or 0.39 square miles. As a result, the No Project with Expanded Agriculture would result in substantially more impacts to biological resources than the proposed Project.

Cultural Resources

The No Project Alternative with Expanded Agriculture would affect a different area that has not been thoroughly surveyed. Because no surveys would be required for the agriculture expansion, potential impacts to cultural resources could be greater under the No Project with Expanded Agriculture.

Geology and Soils

The No Project Alternative with Expanded Agriculture would include significantly fewer structures. Overall, due to the decreased number of structures, the No Project Alternative with Expanded Agriculture would have fewer geological impacts compared to the proposed Project. However, extraction of up to 30,000 AFY could result in subsidence effects similar to the proposed Project, and although the No Project Alternative with Expanded Agriculture would be subject to the existing Groundwater Management Plan, no new monitoring features would be installed to measure its effects. Impacts associated with the No Project Alternative with Expanded Agriculture would be similar but slightly less than the proposed Project.

Greenhouse Gas Emissions

The No Project with Expanded Agriculture would have similar operational emissions associated with pumping 30,000 AFY of water from the ground although less than the 50,000AFY of water for the proposed Project. The existing wells would be powered with diesel engines as opposed to the cleaner natural gas engines of the proposed Project. The expanded use of farm equipment would substantially increase operational combustion emissions in the valley. Overall, the No Project Alternative with Expanded Agriculture would result greater GHG impacts compared to the proposed Project.

Hazards and Hazardous Materials

The No Project Alternative with Expanded Agriculture would not require construction related equipment that would require fuel storage. However, the expanded use of farm equipment would mean a greater use of fuels than would the proposed Project. Impacts would be greater than the proposed Project.

No schools are located within one-quarter mile of the Project area and no airport land use plan or public or public-use airport is located in proximity to the Project area. In addition, the Alternative would not interfere with any roadways or roads listed with an adopted emergency response plan or evacuation route. Thus, no impacts would occur and impacts would be similar to the proposed Project.

Hydrology and Water Quality

The No Project Alternative with Expanded Agriculture would include the construction of six production wells that would be used to irrigate seven square miles of additional agricultural uses. Up to 30,000 AFY of water may be extracted to irrigate this amount of acreage. This is less than the 50,000 AFY associated with the proposed Project. As a result, drawdown impacts to third party wells and brine resources resulting from the No Project with Expanded Agriculture

Alternative would be similar but slightly less than those of the proposed Project. However, no new monitoring features would be installed to measure the effects of extraction and to adaptively manage the groundwater basin under the existing MOU with the County. Therefore, impacts associated with the No Project Alternative with Expanded Agriculture would be similar but slightly less than the proposed Project.

Land Use and Planning

Implementation of the No Project Alternative with Expanded Agriculture would be consistent with existing zoning. Thus, the No Project Alternative with Expanded Agriculture would result in similar impacts to land use compared to the proposed Project.

Mineral Resources

The No Project Alternative with Expanded Agriculture would not affect access to mineral resources. Since the drawdown would be slightly less than the proposed Project, potential impacts on the salt mining operation would be slightly fewer. However no new monitoring features would be installed to assess and actively manage the groundwater basin. Impacts associated with the No Project Alternative with Expanded Agriculture would be similar but slightly less than the proposed Project.

Noise

The No Project Alternative with Expanded Agriculture would avoid construction noise impacts associated with the proposed Project. However, for the duration of the agricultural operations, daily noise generation from farm equipment would be greater than with the proposed Project. Therefore, impacts associated with the No Project Alternative with Expanded Agriculture would be greater than the proposed Project.

Population and Housing

The No Project Alternative with Expanded Agriculture does not include new residential or commercial development, nor would it displace existing housing or substantial number of people. In addition, the No Project Alternative with Expanded Agriculture would not convey water to meet urban demands. However, urban demands would be met by other means. Impacts associated with the No Project Alternative with Expanded Agriculture would be similar to the proposed Project.

Public Services and Utilities

The No Project Alternative with Expanded Agriculture would require new full-time employees during operation; this would generate a permanent population. Therefore, this Alternative would increase demand for fire services, police services, and emergency services in the Cadiz Valley. Impacts associated with the No Project Alternative with Expanded Agriculture would be greater than the proposed Project.

Recreation

The No Project Alternative with Expanded Agriculture would not encroach onto BLM lands. However, it would create additional jobs that could require an increase demand for existing recreational services and facilities. Impacts associated with the No Project Alternative with Expanded Agriculture would be greater than the proposed Project.

Traffic and Transportation

The No Project Alternative with Expanded Agriculture would create additional jobs that could require an increase to existing traffic in the area. Impacts associated with the No Project Alternative with Expanded Agriculture would be greater than the proposed Project.

7.6.2 Project Facility Alternatives

The following sections evaluate Project facility Alternatives including the following:

- West of Danby Pipeline Alignment
- Existing Natural Gas Pipeline
- Northern Wellfield Location

Table 7-4 provides a comparison of environmental effects of each Alternative compared to the proposed Project.

West of Danby Pipeline Alignment Alternative

The West of Danby Pipeline includes a variation of the pipeline alignment from the wellfield to the CRA that is more direct than that of the proposed Project pipeline. This pipeline alignment was evaluated in the 2001 EIR/EIS for the Cadiz Groundwater Storage and Dry-Year Supply Program, referred to as the "Eastern Alternative.” This alignment was the preferred alternative in the 2001 EIR/EIS.

The West of Danby Pipeline begins at the Project wellfield, approximately three miles north of the unimproved Cadiz-Rice Road. The water conveyance facilities route proceeds due south for three miles, then parallels Cadiz Rice Road and the ARZC rail lines in a southeasterly direction toward abandoned Chubbuck Station. Southeast of abandoned Chubbuck Station, the water conveyance facilities turn south, generally following the 820-foot contour for approximately three miles around the west side of Danby Dry Lake. The water conveyance facilities then turn southeast, still generally following the 820-foot contour, between the south side of Danby Dry Lake and along the Iron Mountains for approximately ten miles until crossing Metropolitan's existing power transmission right-of-way. The water conveyance facilities continue around the east side of the Iron Mountains where they connect to an unimproved road. The water conveyance facilities parallel the unimproved road, enter the Iron Mountain Pumping Plant site, and discharge into the existing Iron Mountain Pumping Plant forebay. The total length of the West of Danby Pipeline is approximately 34.6 miles.

Ability to Meet Project Objectives

The West of Danby Pipeline would meet each of the Project objectives. It would provide a similar new pipeline from the wellfield to the CRA, only following a slightly different route.

Comparison of Environmental Impacts

Aesthetics

The West of Danby Pipeline would result in limited short-term impacts resulting from construction activities. The topography of the pipeline route would allow unobstructed views of equipment and construction activities. Portions of the route are already disturbed with existing facilities. Similar to those of the proposed Project, the West of Danby Pipeline would require the construction of air relief valves approximately every 1/2 mile. These relief valves would consist of a five-foot tall "goose-neck" pipe on a concrete pad that would be visible at the surface. Impacts of this pipeline would be similar to the proposed Project, although somewhat reduced due to the shorter length of the pipeline.

Agricultural and Forestry Resources

As with the proposed Project, the potential impact on agricultural resources from the West of Danby Pipeline would be minimal. The soils of the proposed pipeline area are not designated as agricultural soils, nor has it been designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance. The pipeline areas are not zoned for agricultural use, and no existing Williamson Act contract lands would be affected by the construction activities. Impacts of the West of Danby Pipeline would be similar to the proposed Project.

Air Quality

Construction emissions from the West of Danby Pipeline are anticipated to result in significant adverse air quality impacts that cannot be mitigated to below CEQA threshold levels of significance. Construction methods required to implement the West Danby Pipeline Alternative would be similar to the proposed Project. Similar to the proposed Project, emissions of NOx during short-term construction impacts would exceed thresholds of significance and would be significant and unavoidable.

Biological Resources

According to the 2001 EIR/EIS, direct impacts on plant communities and wildlife habitat resulting from the implementation of the West of Danby Pipeline would include the removal of approximately 585.3 acres of Mojave creosote bush scrub (30.1 acres permanent impact), 10 acres of Mojave wash scrub (1 acre of permanent impact), and 148.7 acres of stabilized or partially stabilized desert dunes or desert sand fields (16.5 acres permanent impact). See Table 5.8-3 of the 2001 EIR/S [Eastern Alternative Conveyance Pipeline.] Direct impacts on sensitive communities of Mojave wash scrub and stabilized or partially stabilized desert dunes or desert sand fields resulting from the implementation of the West of Danby Pipeline are expected to be potentially significant. However, with implementation of mitigation measures the impacts would potentially be reduced to a less than significant level. Although potentially mitigable, impacts of

the West of Danby Pipeline on biological resources would be greater than those of the proposed Project.

Cultural Resources

Ten sites of cultural significance could be impacted by the West of Danby Pipeline. In addition, the existing historic Iron Mountain Pumping Plant is at the southern terminus of the West of Danby Pipeline Route and Mining-related features at the town. The West of Danby Pipeline would entail construction of the Pumping Plant at the Iron Mountain Pumping Plant, which is a CRA complex containing structures and a cultural landscape characteristic of the 1930s. The impacts of the West of Danby Pipeline would be greater than those of the proposed Project.

Geology and Soils

The West of Danby Pipeline would have no significant adverse effects related to topography, geology and soils, or faults and seismicity. Local areas of shallow groundwater may exist where the alignment of the water conveyance facilities pass in close proximity to Danby Dry Lake. This is the only segment of the water conveyance facilities alignment that has a significant risk of liquefaction. Mitigation would reduce this risk to a level of insignificance. As compared to the proposed Project, impacts of the West of Danby Pipeline would be greater.

Greenhouse Gas Emissions

Construction and operational emissions from the West of Danby Pipeline would be expected to be less than those of the proposed Project due to the shorter length of the pipeline and therefore generation of fewer Greenhouse Gas Emissions.

Hazards and Hazardous Materials

Similar to the proposed Project, construction of the West of Danby Pipeline would require that equipment fuel lubricants and other potentially hazardous materials be transported to and stored in the pipeline construction staging areas. These activities would be conducted consistent with existing hazardous waste and pollution regulations. Therefore, the potential impacts related to uncontrolled releases of hazardous substances into the environment would be below the level of significance, similar to the proposed Project. There is the possibility that unexploded military ordinance could be located within the West of Danby Pipeline route from prior military operations. However, as with the proposed Project, the impact could be reduced to a less than significant level with mitigation. The West of Danby Pipeline would have potential impacts similar to those of the proposed Project conveyance facility.

Hydrology and Water Quality

Grading for the water conveyance facilities would not create new drainages. However, there is potential for erosion at locations where the water conveyance facility crosses ephemeral arroyos. Based on the depth of pipeline burial erosion protection along existing arroyos may be required for the West of Danby Pipeline. Extraction of groundwater is not part of the water conveyance facility construction and no risk of subsidence or other hydrological effects would occur. The impacts from the West of Danby Pipeline would be similar to those of the proposed Project.

Land Use and Planning

Construction of the West of Danby Pipeline would be constructed on undeveloped land including federal lands administered by the BLM, State owned lands and privately owned lands. The water conveyance and power distribution facilities would cross the railroad lines and oil and natural gas pipelines. These crossings would be coordinated with the railroad and pipeline operators. The pipe would be jacked or tunneled under the rail line. In order to secure temporary and permanent right-of-way easements from BLM, the West of Danby Pipeline would require an amendment of the CDCA Plan. Considering the additional planning approvals needed and the use of BLM land, the West of Danby Pipeline would have impacts greater than those of the proposed Project.

Mineral Resources

None of the existing mineral extraction operations in the vicinity would be directly impacted by construction of the West of Danby Pipeline, although the pipeline passes through or near areas with potential mineral resources. Construction of the pipeline would result in temporary access delays to areas along the water conveyance facilities, including areas identified for potential mineral resources. However, these temporary access delays would only occur if these areas were developed for mineral extraction and would not result in long term access limitations or delays to areas identified for potential mineral resources. The West of Danby Pipeline would have slightly greater impacts than those of the proposed Project.

Noise

Construction for the West of Danby Pipeline would take up to 12 months with additional time for the pump stations. During these construction periods, short term noise would be generated by construction equipment, vehicles, and worker vehicles, as with the proposed Project. The Cadiz Dunes Wilderness Area is closest to the pipeline and would be adjacent to the south side of the pipeline for a distance of approximately five miles. The Old Woman Mountains Wilderness Area would be located north of the water conveyance facilities. Blasting may be necessary during construction at up to three locations along the water conveyance facility alignment. This blasting could occur over a total of eight days during the excavation of the water conveyance facility trench and may result in short-term intermittent noise levels which may be heard in the Cadiz Dunes wilderness area and potentially in parts of the Old Woman Mountains wilderness area. These potential impacts would be similar to those of the proposed Project, as the proposed Project may also require blasting but likely to a lesser extent.

Population/Housing/Socioeconomics

The West of Danby Pipeline would generate short-term employment related to construction of the water conveyance facilities (estimated to be approximately 400 workers) and would generate negligible long-term employment opportunities (1 worker) related to the operations of the pipeline. Neither the long-term nor short-term employment generated by the West of Danby Pipeline would be considered a significant adverse impact under the criteria of inducing substantial growth or concentration of population (in this case, employee population). The West of Danby Pipeline is not expected to result in significant adverse impacts related to population and housing and the level of direct population or employment growth it would generate would be

insignificant relative to the overall level of growth projected for the surrounding area. The impacts would be similar to those of the proposed Project.

Public Services and Utilities

Like the proposed Project, construction of the West of Danby Pipeline would not require additional police and law enforcement services in the Cadiz Project area.. Like the proposed Project, it is not anticipated that a significant increase in demand for fire protection or medical services would be needed in the long term, and any short term increase would be met by temporary provision of emergency medical services. There could be a minor short term increase in the demand for emergency medical services during construction, but the existing fire station at Wonder Valley would be adequate to meet the demand for fire and emergency services. Like the proposed Project, there are no construction-related impacts on school facilities and services, or libraries, because there are no schools or libraries on or in the immediate vicinity of the Project. Overall, impacts on public services and utilities caused by the West Danby Pipeline would be similar to those of the proposed Project.

Recreation

The West of Danby Pipeline conveyance facilities and power distribution facilities would be within several hundred feet of the west boundary of the Old Woman Mountains Wilderness Area for approximately 1.25 miles. The alignment is also within 100 feet of the eastern boundary of the Cadiz Dunes Wilderness Area for approximately five miles, which is closer than the proposed Project. The West of Danby Pipeline would require construction within 500 feet of the Johnson Valley to Parker Race Route. Overall, impacts from the West of Danby Pipeline would be greater than the proposed Project.

Traffic and Transportation

Five hundred and sixteen daily one way traffic trips are estimated to be generated from construction of the West of Danby Pipeline, conservatively assuming construction at the Project site, intermediate staging area, and Iron Mountain pumping plant site occur simultaneously and each employee drives alone. Operational trips would be negligible considering it is estimated that only one employee would be needed for these trips. Similar to the proposed Project, short and long-term traffic trips generated by the West of Danby Pipeline would be less than significant.

Existing Natural Gas Pipeline Alternative

The Existing Natural Gas Pipeline Alternative involves the conversion and use of a portion of an existing 30-inch diameter unused natural gas pipeline that extends through the Cadiz Inc. Property north through Barstow and to Wheeler Ridge near Bakersfield, California. The proposed pipeline in its entirety encompasses approximately 304 miles extending from Ehrenberg, Arizona (near the California/Arizona border) to Wheeler Ridge, California. The pipeline was originally built to convey oil and was recently converted for use to convey natural gas.

Phase 1 of the Alternative includes the upgrading of the 100-mile pipeline segment that extends from the Cadiz Property to Barstow. This pipeline segment would have a capacity of

approximately 30,000 AFY of water and would allow for water deliveries to the City of Barstow. These deliveries would replace water delivered to Barstow via the State Water Project, allowing that water to be delivered to the Project Participants in the Metropolitan service area. The pipeline could also potentially provide more than 5,000 AFY of water to the Golden State Water Company, which provides water service to Barstow.

Under Phase 1 of this Alternative, the pipeline would undergo rehabilitation and upgrades to prepare the natural gas pipeline for water conveyance, including the construction of two pump stations along the pipeline and air valves installed in approximately half-mile segments. With milepost markers located along the pipeline and beginning at "0" at the Cadiz Inc. Property, construction of the proposed pump stations would be located at the 32 and 40 milepost markers at a ridge crossing. The pump station sites would encompass a maximum of two acres but would be located within the pipeline right-of-way. Construction of the air valves would occur along the pipeline in half-mile intervals, totaling approximately 200 air valves along the 100-mile segment. The air valve facilities consist of the installation of a vault marked at the surface by a five foot-by five foot square concrete pad with a "goose neck" air vent protruding up to five feet high. If necessary, the air valve placement can also be moved to avoid potential environmental constraints.

Phase 2 of this Alternative could potentially upgrade and rehabilitate the pipeline from Barstow to Wheeler Ridge, near the City of Bakersfield. In order to prepare the pipeline for water conveyance to Wheeler Ridge, additional pump stations and air valves along the pipeline segment would be required. The entire 220-mile pipeline segment from Cadiz Inc. Property to Wheeler Ridge would require approximately three to five additional pump stations, in addition to the two pump stations proposed under Phase 1 for the Cadiz Property to Barstow pipeline segment. The pump stations would also encompass a maximum of two acres but would be located within the pipeline right-of-way. Additional air valves would be required in half-mile intervals along the pipeline segment, totaling approximately 440 air valves. At Wheeler Ridge, the pipeline could intertie with the State Water Project. This would require construction of a pump station within a two-acre parcel.

Ability to Meet Project Objectives

The Existing Natural Gas Pipeline Alternative would meet most of the Project Objectives, but would not provide the capacity needed to meet the goals of the Project as "fully subscribed." The alternative pipeline would only convey 30,000 AFY. Under this Alternative, objectives to maximize the beneficial use of groundwater through conservation, create new water storage capacity in Southern California, and enhance water supply reliability would be met, but to a lesser extent than the proposed Project. In addition, since water would only be delivered to Barstow, conveyance of water directly to the Project Participants would be more difficult to achieve, requiring agreements with the Mojave Water Agency to accept Project water in lieu of SWP water.

Comparison of Environmental Impacts

For this Alternative analysis, only Phase 1 of the Existing Natural Gas Pipeline Alternative will be analyzed.

Aesthetics

The Existing Natural Gas Pipeline Alternative would result in limited short-term impacts resulting from construction activities. The proposed pipeline traverses arid desert terrain and is currently disturbed with existing right-of-ways along the pipeline route. The topography of the pipeline route would allow unobstructed views of equipment and construction activities. The pipeline is currently equipped with metering facilities, mainline valves, and pressure control valves located along intervals of the pipeline. The proposed Alternative would update the pipeline with two pump stations and approximately 50 air valves with a maximum height of five feet each located every half mile. As the pipeline area are currently equipped with existing facilities, the upgrading and construction of new pump stations and air valves would be less than significant.

If construction activities occur in the night, light and glare would be directed to the Project site. In addition, impacts related to light and glare would be negligible as no sensitive receptors are located in proximity to the pipeline site. Furthermore, there are no designated State Scenic Highways, County-designated scenic routes, or scenic resources such as trees or rock outcroppings in the proposed vicinity that would be negatively impacted by the construction activities. As the proposed site is already disturbed with existing facilities and impacts would be limited and short-term, impacts related to aesthetic and visual resources would be less than significant. For the proposed Project, potential impacts to aesthetics were found to be less than significant with mitigation. Since some mitigation would be required, impacts would be reduced compared to the proposed Project.

Agricultural and Forestry Resources

Under the Existing Natural Gas Pipeline Alternative, no agricultural land or forest resource land would be affected. No areas designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance would be affected. The project would convert an existing pipeline. No areas designated as Williamson Act contract lands would be affected. Impacts would be reduced to those compared to the proposed Project.

Air Quality

Air emissions from construction would be fewer than the proposed Project since the pipeline already exists. Operational air emissions would most likely be less than the proposed Project because fewer wells would be operated to convey the 30,000 AFY.

Biological Resources

Construction activities would be located within the 100-foot right-of-way along the pipeline. However, the construction of the pump stations would require up to a two-acre site of disturbance and a five foot-by-five foot square concrete pad for the air valves. The area is generally undeveloped desert land that consists of numerous vegetation communities and wildlife habitats.

The existing pipeline traverses an area that may have more value for desert tortoise or other sensitive species than the terrain through which the proposed Project pipeline runs. The construction and upgrading activities could encroach on biologically sensitive habitats and resources. The Alternative would have both short-term construction impacts and also small amounts of permanently impacted habitat. Biological surveys would be required to quantify the value of the properties affected. Impacts to desert areas would be fewer than the proposed Project since the construction area would be more limited. However, direct effects to sensitive species could be greater.

Cultural Resources

Cultural and archeological resources along the natural gas pipeline route may be affected. However, with implementation of mitigation measures similar to those of the proposed Project, the Existing Natural Gas Pipeline Alternative impacts to cultural and paleontological resources could be minimized and limited. Since the construction areas would be smaller than those of the proposed Project, impacts would be reduced compared to those of the proposed Project.

Geology and Soils

Major seismic activity along the nearby and active San Andreas or Garlock fault systems, or other associated faults, could affect the proposed site and pipelines through strong seismic ground shaking. In response to this, the existing pipeline was constructed with an increased wall thickness to provide additional protection to the pipeline in the event of seismic activity. The proposed new pipeline components would be designed to withstand strong ground shaking as required by the California Building Code to minimize the potential effects of liquefaction, ground shaking, landslides, and other effects of seismic activity. Trenching and grading would occur that could cause soil erosion or loss of topsoil; however implementation of mitigation measures similar to the proposed Project would ensure impacts are less than significant. As the pipeline and proposed pipeline facilities would be reinforced to withstand seismic activity, impacts related to geology, soils, and seismicity would be less than significant and similar to the proposed Project.

A smaller amount of groundwater would be extracted under this Alternative since the conveyance capacity would be less. This would reduce the potential for adverse effects of subsidence.

Greenhouse Gas Emissions

The Existing Natural Gas Pipeline Alternative would provide the ability to increase water supplies to urban uses in Southern California. Construction and upgrading activities would be limited and short-term and is not anticipated to result in significant GHG emissions. However, pumping water through the alternative pipeline alignment would require additional energy that would emit greenhouse gases**.** Due to the limited capacity of the Existing Gas Pipeline, impacts related to GHG emissions would be less than those of the proposed Project.

Hazards and Hazardous Materials

Construction-related activities would require the use, storage, and transportation of fuels, oils, lubricants, and other potentially hazardous materials that could pose a hazard to people and the

environment, due to the potential for accidental release. Similar to the proposed Project, the Alternative would be required to comply with applicable rules and regulations in the handling, storage, and transportation of the hazardous materials to reduce the risks and hazards to workers, the public, and the environment. Therefore, impacts would be less than significant with implementation of mitigation measures similar to the proposed Project.

The pipeline would be cleaned and retrofitted to accommodate water. Water quality would be monitored and would be required to meet drinking water standards in order for the Project to be feasible.

No schools are located within one-quarter mile of the Project area, no airport land use plan or public or public-use airport is located in proximity to the Project area. In addition, the Alternative would not interfere with any roadways or roads listed with an adopted emergency response plan or evacuation route.

Hydrology and Water Quality

The Alternative would convert the pipeline from natural gas to water conveyance. The pipeline would have a capacity of 30,000 AFY as opposed to the 75,000 AFY of the proposed Project. As a result, the alternative would not fully achieve delivery objectives. Extraction of groundwater would be less under this Alternative since the conveyance capacity would be less. This would reduce the potential for adverse effects on third party users and salt mining operations.

The Alternative does not include the development of housing nor is it located with a 100-year flood zone. The Alternative would not expose workers or structures to seiches, tsunamis, or mudflows. Impacts would be less than significant with the implementation of mitigation measures similar to the proposed Project. Thus, impacts would be less than those of the proposed Project due to the reduced project capacity.

Land Use and Planning

The existing pipeline traverses different land uses including utility lands, rangelands, and BLM lands. Construction and upgrading activities on the pipeline would not divide communities and is not expected to conflict with existing planning goals and policies as the activities would primarily be conducted within the pipeline right-of-way. Improvements along the pipeline route would be within the Western Mojave Planning area and subject to the Western Mojave Plan HCP. Thus, impacts would be less than significant and similar to those of the proposed Project.

Mineral Resources

The Alternative would construct pipeline appurtenances along the existing pipeline route. These appurtenances would not block access to mineral resources in the area. Furthermore, since the Alternative pipeline would extract less water, impacts to salt mining operations on Bristol and Cadiz Dry Lakes would be less than those of the proposed Project.

Noise

Construction of the pipeline appurtenances would generate short-term construction noise. The noise levels would fluctuate depending on the type, number, and duration of uses of various pieces of construction equipment. The pump stations would be insulated to minimize noise. Ground-borne vibrations would also be limited. Noise impacts from the Alternative project would be lesser than those of the proposed Project since the construction efforts would be less.

Population and Housing

The Alternative pipeline would have a lesser capacity to deliver water to Project Participants. Nonetheless, it would provide a reliable water supply that could indirectly support some level of new growth. In this way it would be similar to the proposed Project.

Public Services and Utilities

The Existing Natural Gas Pipeline Alternative would not construct permanent residential development, nor require new full-time employees during operation that would generate a permanent population. Therefore, the proposed Alternative would require a minor short-term demand for fire services, police services, and emergency services during the construction phase as with similar to the proposed Project.

Upgrading and rehabilitation activities on the existing natural gas pipeline would require energy use including electricity and natural gas. Similar to the proposed Project, this Alternative would not substantially increase energy use compared to existing energy demands for importing water to Southern California.

Recreation

The use of the existing natural gas pipeline would not affect recreational facilities. Therefore, no impacts would occur and impacts would be similar to the proposed Project.

Traffic and Transportation

Construction-related traffic would be limited and short-term. Since construction on the Alternative project would be limited, impacts to traffic would be less than the proposed Project.

Northern Wellfield Location Alternative

Under the Northern Wellfield Location Alternative, the wellfield would be located north of the proposed Project wellfield within the Cadiz Property. A condensed wellfield similar to Wellfield Configuration A would be installed with a few “high capacity” wells in the center of the wellfield. The wells would be placed within Cadiz Property only and would not maximize the water conservation potential. The Alternative would be designed to reduce the movement of the saline interface around Bristol Dry Lake.

Ability to Meet Project Objectives

The Northern Wellfield Location Alternative would meet most of the Project objectives, but would not maximize the water conservation potential provided by the other wellfield alternatives.

Comparison of Environmental Impacts

Aesthetics

The location of the northern wellfield may be slightly more visible from Route 66. However, it would result in similar affects to visual resources as the proposed Project since it would use a similar configuration.

Air Quality

The Northern Wellfield Location Alternative would result in air emissions similar to the proposed Project because a similar number of wells would be operated although the water would be pumped a slightly greater distance.

Agriculture and Forestry Resources

The Northern Wellfield Location Alternative would have impacts to agricultural resources similar to the proposed Project.

Biological Resources

The Northern Wellfield Location Alternative would be located within desert tortoise critical habitat and would have a greater effect on desert tortoise as a result. All other biological impacts would be similar to the proposed Project.

Cultural Resources

The Northern Wellfield Location Alternative while not surveyed would have a similar potential to encounter previously unknown cultural resources as the proposed Project.

Geology and Soils

The Northern Wellfield Location Alternative would be similar to the proposed Project, but may result in lesser potential for subsidence due to the location of the wells further from the Dry Lake.

Greenhouse Gas Emissions

The Northern Wellfield Location Alternative would result in GHG emissions similar to the proposed Project because the same number and types of wells would be operated.

Hazards and Hazardous Materials

The Northern Wellfield Location Alternative would result in use of hazardous materials similar to the proposed Project.

Hydrology and Water Quality

The Northern Wellfield Location Alternative would move the deepest part of the wellfield drawdown north of the Fenner gap. This would result in somewhat less saline intrusion toward the wellfield than under the proposed Project. However, the wellfield would not be able to access water supplied by the Orange Blossom Wash. Furthermore, water already through the gap flowing toward the brine sink would not be pulled back into the wellfield and conserved from evaporation. Therefore, the northern wellfield location would not maximize the conservation potential offered by the proposed Project.

Land Use and Planning

The Northern Wellfield Location Alternative would occur on Cadiz Property. Similar to the proposed Project, no impacts to land uses would occur.

Mineral Resources

The Northern Wellfield Location Alternative would result in less drawdown under the Dry Lakes since the wellfield would be situated further away from the Dry Lakes and would therefore draw more from upgradient of the Fenner Gap. As a result, somewhat less impacts to salt mining operations would result.

Noise

Construction and operational noise would be similar to the proposed Project. Essentially, it would vary during construction depending on how many wells were drilled and duration, and operationally the power generators and pump stations would generate noise. However, given remote location, these impacts are less than significant.

Population and Housing

Effects on population and housing would be similar to the proposed Project.

Public Services and Utilities

Effects on public services and utilities would be similar to the proposed Project which because of the minimal infrastructure, it will not generate the need for fire protection, police or emergency services or dispute local and regional utilities. However, during construction, some need for emergency service may arise during the contemplated two year construction period but current service levels would be adequate to meet any anticipated demand.

Recreation

Effects on recreational facilities would be similar to the proposed Project. The Project has been designed to avoid all BLM lands, including Wilderness Areas. Therefore, neither construction nor operation would disrupt recreational opportunities or uses.

Traffic and Transportation

Effects on traffic would be similar to the proposed Project due to similar construction and operational requirements.

7.6.3 Project Operational Alternatives

Proposed Project with Agriculture

The Proposed Project with Agriculture Alternative would provide for the implementation of the proposed Project in addition to the existing or slightly expanded agricultural operations. Under this Alternative, the total amount of water extracted from the groundwater basin is assumed at approximately 55,000 AFY. The additional 5,000 AFY above the proposed Project would supply the agricultural operations.

Ability to Meet Project Objectives

The Proposed Project with Agriculture Alternative would meet all the Project objectives.

Comparison of Environmental Impacts

Because this alternative would involve construction and operation of the full proposed Project in addition to the continuation of the existing agricultural activity on the Cadiz Property, facility construction impacts associated with this alternative would be the same as those for the Project. Similarly, operational impacts for this alternative would largely be the same as for the Project with a few exceptions as described below. Impacts associated with construction of the conveyance pipeline and wellfield would be identical to the proposed Project. The proposed Project as analyzed assumes that the existing agricultural operations would continue initially in addition to the Project operations, but would be eliminated if and when the Project is fully subscribed, in order to limit total groundwater pumping to the 50,000 AFY average annual amount established for the proposed Project operations. Therefore, under the proposed Project, the combined impacts of on-going agriculture in addition to the operation of the wellfield and conveyance facility have been evaluated in terms of overlapping activities.

As shown in Table 7-4, above, impacts in the following environmental areas would be the same or similar under this alternative as those described for the Project due to the fact that the construction footprint would be the same and therefore result in similar effects on these resources:

- Aesthetics
- Biological Resources
- Cultural Resources
- Geology and Soils
- Hazardous Materials
- Land Use and Planning
- Population, Housing, Growth, and
- Public Services and Utilities
- Recreation
- Socioeconomics

Implementation of this alternative would result in less impact to Agricultural Resources and slightly greater impacts in six environmental issue areas described below in comparison to the Project because existing agricultural operations, including groundwater pumping for irrigation up to 5,000 AFY average annual, would occur in addition to construction and operation of the full Project as proposed. This would result in slightly more total groundwater pumping per year on an average annual basis, with associated increases in energy use and air emissions related to this increased pumping, and increases in groundwater extraction and associated effects. Continuing agricultural activities in addition to the Project would also result in slight increases in traffic on the Project site to support operations and maintenance of the agricultural operations (planting, harvesting, and maintenance) in addition to the Project operations.

Agriculture and Forestry Resources

Implementation of Proposed Project with Agriculture alternative would result in less impact to agricultural resources than the Project because the existing agricultural operation would remain active along with the Project rather than phased out over time. Maintaining the existing agricultural operation would avoid the loss of existing agricultural activity that would result as part of the proposed Project.

Air Quality

Allowing for continued agriculture would result in slightly greater air emissions including combustion emissions and dust as a result of increases in groundwater pumping, and the ongoing activities required for agricultural operations, including truck and farm equipment operations and dust-generating field management activities (i.e., plowing, planting). Air Quality impacts from the Proposed Project with Agriculture alternative would be greater than the proposed Project.

Greenhouse Gas Emissions

Allowing for continued agriculture would result in somewhat greater GHG emissions as a result of increases in groundwater pumping, and the ongoing activities required for agricultural operations, including truck and equipment operations. GHG impacts from the Proposed Project with Agriculture alternative would be greater than the proposed Project.

Hydrology and Water Quality

The Proposed Project with Agriculture alternative would allow for increased groundwater extractions of 5,000 AFY on average over 50 years, in addition to the 50,000 AFY average annual pumping proposed under the Project. This ten percent increase in average annual pumping would result in the potential to lower groundwater levels beyond those evaluated in Chapter 4, Section 4.9 of this Draft EIR. It would also result in a slightly increased potential to induce subsidence and to cause the migration of saline water eastward toward the wellfield because 5,000 AFY more would be withdrawn on average each year. The groundwater impact analysis provided in Chapter 4 describes three natural recharge scenarios that have been modeled to predict the effect of extracting 50,000 AFY on average under the Project over 50 years of operation. One scenario assumes that only 5,000 AFY of natural recharge occurs in the valley. The other two scenarios assume greater natural recharge. In each case, the addition of 5,000 AFY

of extraction could increase drawdown slightly. The Draft EIR describes that drawdown effects on salinity, and subsidence would be a less than significant impact with the implementation of mitigation measures. Under the Proposed Project with Agriculture alternative, these impacts would remain less than significant with mitigation since the additional drawdown would be only slightly greater; no new impacts that would not be mitigated with the already identified mitigation measures would occur. The GMMMP would apply to this alternative similar to the proposed Project and would be implemented to ensure that significant impacts were avoided. The Proposed Project with Agriculture alternative would result in similar but slightly greater hydrology and water quality impacts than the proposed Project.

Mineral Resources

As described in the paragraph above for Hydrology and Water Quality, because under this alternative groundwater pumping would increase by 5,000 AFY on average, or up to a 10 percent increase over the proposed Project, groundwater drawdown would be somewhat greater than that described for the proposed Project. Consequently, effects on the existing salt mining operations described in Chapter 4 associated with groundwater drawdown could be slightly greater under this alternative. Mitigation measures identified for the Project (incorporated into the GMMMP) could also be applied to this alternative and reduce this impact to less than significant.

Noise

There would be no change in construction period noise under this alternative as no additional facilities specifically for agriculture beyond the Project facilities would be constructed. However, noise associated with operations for this alternative would be slightly greater than for the proposed Project alone because this alternative includes maintaining active agricultural operations on the site in addition to full Project operations. Additional groundwater pumping would occur and additional vehicle trips would occur to support the agricultural operation, which would result in some additional noise. As with the Project, noise effects would be less than significant.

Transportation and Traffic

There would be no change in construction period traffic under this alternative as no additional facilities specifically for agriculture beyond the Project facilities would be constructed. However, traffic associated with operations for this alternative would be slightly greater than for the proposed Project alone because this alternative includes maintaining active agricultural operations on the site in addition to full Project operations. Additional vehicle trips on the project site and local roadways would occur to support the agricultural operation. As with the Project, these traffic effects would be less than significant.

Phased Implementation Alternative

The Phased Implementation Alternative would include the construction of the pipeline similar to the proposed Project. However, the wellfield would be installed on a phased schedule, allowing for the monitoring features to confirm predicted groundwater reaction to the increased extraction.

The construction and operation of the extraction wells would occur over a five to ten year period rather than over 18 months as proposed by the proposed Project.

Ability to Meet Project Objectives

This alternative would meet each of the Project objectives except that the full implementation of the Project would be delayed.

Comparison of Environmental Impacts

Impacts of installing the wellfield would be similar to the proposed Project but prolong construction impacts to air quality, biological resources, noise and traffic. Prolonging the wellfield construction could convert short-term impacts to these resources to long-term effects over the five to ten years of construction. With respect to groundwater effects, the Phased Implementation Alternative would allow for potential impacts (such as effects on third party wells, salinity migration, and subsidence) to be monitored and confirmed as extractions increased to the full capacity. No new impacts would result, nor would any significant impacts of the proposed Project be avoided or lessened.

Reduced Project Alternative: 25 Percent Reduction in Proposed Groundwater Withdrawal

Under the Reduced Project Alternative, the total volume of water extracted over the term of the Project would be reduced by 25 percent. The term of proposed Project operation would be shortened from 50 years to 25 years. To maintain the benefits of conserving water that would otherwise flow to the brine zone and evaporate, the Reduced Project Alternative would pump up to 75,000 AFY of groundwater for a period of 25 years for delivery to Project Participants. The reduced term of the Project under this Alternative would result in a total maximum withdrawal of 1,875,000 AF over the life of the Project, which represents an approximate 25 percent reduction (625,000 AF) from total pumping compared with the proposed Project. Just as with the proposed Project, the wellfield and manifold (piping) system would be constructed on Cadiz Property to carry pumped groundwater to the conveyance pipeline, which would tie into the CRA and convey water to Project Participants.

Under the Reduced Project Alternative, the Imported Water Storage Component would be available for the full 50-year period. Extractions after the first 25 years would be limited to the amount previously recharged.

Ability to Meet Project Objectives

This alternative would meet each of the Project Objectives including the objective to maximize the beneficial uses of the groundwater basin since the higher initial extractions would allow recovery of groundwater that would otherwise flow to the brine zone but over a shorter period of time.

Comparison of Environmental Impacts

The Reduced Project Alternative would not eliminate any of the significant effects resulting from construction of the proposed Project since the wellfield and 43-mile pipeline would be constructed just as under the proposed Project. As shown in the list below, for most environmental issue areas, the effects of this alternative would be similar to the Project because the Project infrastructure would be the same.

- Aesthetics
- Agriculture and Forestry Resources
- Biological Resources
- Cultural Resources
- Geology and Soils
- Hazardous Materials
- Land Use and Planning
- Noise
- Population, Housing, Growth, and Socioeconomics
- Public Services and Utilities
- Recreation
- Transportation and Traffic

The Reduced Project Alternative would not avoid any impacts of operating the proposed Project but it would lessen some of the impacts associated with the Project.

Air Quality

Reducing the total groundwater withdrawal under the Groundwater Conservation and Recovery Component of the Project would reduce the overall pumping and therefore would reduce total energy use and associated air emissions. In addition, shortening the operational term of this component from 50 to 25 years would reduce operations and maintenance activities, which would, in turn, make a slight reduction in operational vehicle and equipment use and associated air emissions. Therefore, the Reduced Project Alternative would reduce air quality emissions effects of operation (but not of construction, which would be the same as the Project).

Greenhouse Gas Emissions

As described for Air Quality Emissions in the paragraph above, reduced total groundwater pumping under this alternative would reduce energy use and, in turn, reduce the associated GHG emissions. In addition, the shortened operational period would reduce operational activities including vehicle and equipment use, which would also reduce greenhouse gas emissions slightly as compared to the proposed Project.

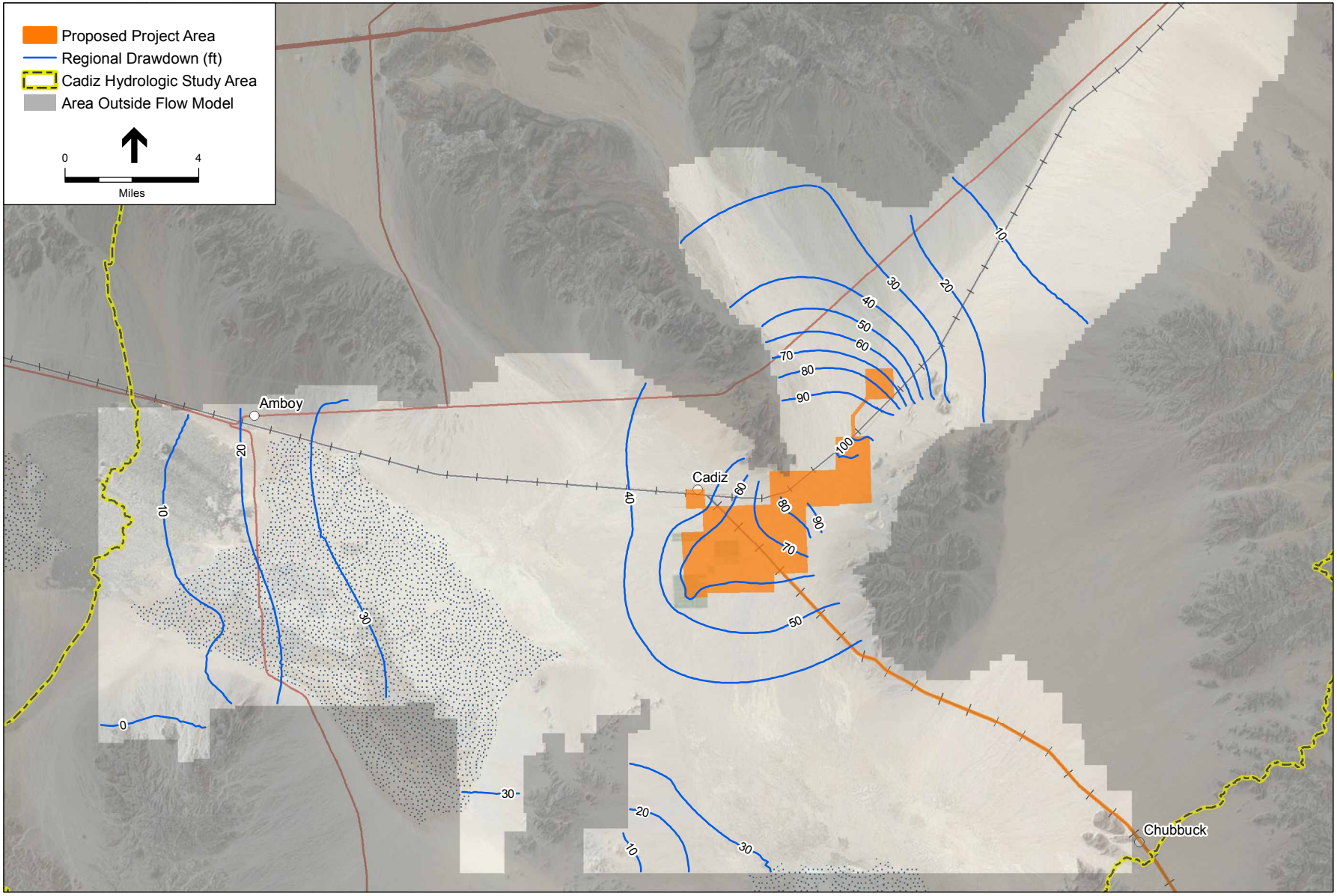
Hydrology and Water Quality and Mineral Resources

With respect to the groundwater basin, because the total groundwater withdrawn under this alternative would be less than under the proposed Project, the effects associated with groundwater withdrawal and associated drawdown, including effects on third party wells or salt mining operations, migration of the saline-freshwater interface, and subsidence, would be similar but somewhat less than for the Project. The effects of pumping groundwater at the higher average

annual rate of 75,000 AFY rather than 50,000 AFY were evaluated as part of the Project analysis.[10] **Figures 7-1** and **7-2** depict projected groundwater level drawdown after 50 years under the 32,000 AFY scenario and 16,000 AFY scenario respectively. The model runs do show that by pumping at 75,000 AFY for 25 years, the maximum groundwater drawdown expected for the Project of approximately 120 feet occurs sooner, as would be expected with a higher pumping rate, and subsequently groundwater levels recover sooner once pumping is stopped. Under the 32,000 AFY scenario (Figure 7-1) groundwater levels under the Bristol Dry Lake could decline by 30 feet. Under the 16,000 AFY scenario (Figure 7-2) groundwater levels under Bristol Dry Lake could decline by 40 feet. These are similar to the proposed Project (see Figures 4.9-12, 13, and 14).Thus, the effects on groundwater levels and associated impacts would be similar but somewhat less under this alternative than the Project because less total water would be withdrawn from the basin and the groundwater levels would fully recover sooner than compared to the Project.

Operation of the proposed Project was found to have less than significant impacts after mitigation for groundwater drawdown, groundwater quality, and subsidence and similarly, effects on hydrology, water quality and mineral resources under this alternative would be reduced to less than significant levels with implementation of applicable mitigation measures identified in Chapter 4.0.

10 Geoscience, *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery Project*, September 20, 2011.

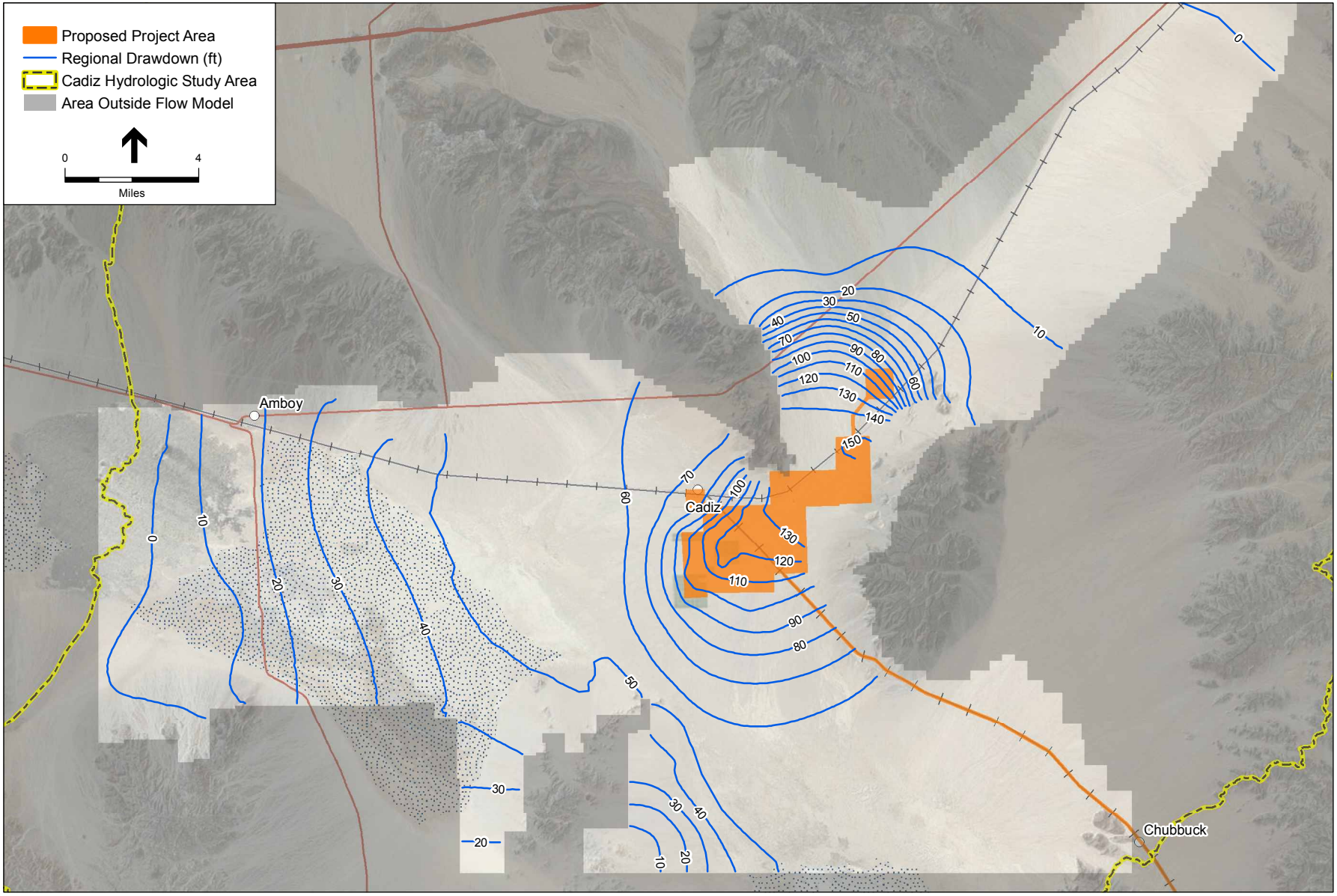


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 7-1

Model-Predicted Regional Drawdown - Reduced Alternative Scenario after 25 Years
(Assumes 32,000 AFY Recharge)
Well Configuration B



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 7-2

Model-Predicted Regional Drawdown - Reduced Alternative Scenario after 25 Years
(Assumes 16,000 AFY Recharge)
Well Configuration B

7.7 Comparison of Alternatives and Identification of the Environmentally Superior Alternative – Groundwater Conservation and Recovery Component

7.7.1 Comparison of Alternatives

Table 7-2 summarizes whether the alternatives meet the Project Objectives. Table 7-3 summarizes the comparison of Project Alternatives with the proposed Project. Neither of the No Project Alternatives would meet any of the Project Objectives. The No Project Alternative Existing Agriculture would result in fewer impacts than the proposed Project. However, the No Project with Expanded Agriculture would result in greater impacts for several resource areas including air quality and noise due to the increase in operational activities in the area.

The West of Danby Pipeline Alternative would meet all of the Project Objectives, but result in greater impacts to biology, cultural resources, and geology since the alignment would traverse open space BLM lands in desert tortoise habitat.

The Existing Natural Gas Pipeline Alternative would meet all of the Project Objectives but to a lesser degree since the capacity of the pipeline is less than the proposed Project requires and the water would not be delivered to an area accessible by the Project Participants. The Existing Natural gas Pipeline Alternative would result in fewer environmental impacts in nearly every resource area.

The Project with Agriculture Alternative would meet all of the Project Objectives and would result in slightly greater impacts to air quality, hydrology, noise and transportation. The Phased Implementation Alternative would meet all the Project Objectives but would result in slightly greater impacts since the construction of the wellfield would be prolonged by five to ten years. The Reduced Project Alternative would meet all the Project Objectives but for a shorter duration and to a somewhat lesser extent.

7.7.2 Environmentally Superior Alternative

CEQA requires that an EIR identify the environmentally superior alternative of a project other than the No Project Alternative (*CEQA Guidelines* Section 15126.6(e)(2)). The No Project Alternative would avoid all construction and operational impacts associated with the proposed Project, but the No Project Alternative would not meet any of the Project objectives.

Of the Project Facility Alternatives, the Existing Natural Gas Pipeline Alternative would be the environmentally superior alternative since it would eliminate the need to construct the 43-mile pipeline to the CRA. However, the alternative would not meet the basic objectives of providing water to the Project Participants, but rather would provide water to Barstow and would need to rely on implementing agreements with the Mojave Water Agency to exchange the water for SWP

water deliveries. In addition, the alternative would not have the capacity needed to fully implement the proposed Project.

Of the Operational Alternatives, the Reduced Project Alternative would be the environmentally superior alternative since groundwater levels would recover more quickly than under the proposed Project, Phased Alternative, or Project with Agriculture Alternative. Overall the Reduced Project Alternative would extract less water than the proposed Project resulting in fewer overall air and GHG emissions. The Reduced Project Alternative would construct all the facilities within 18 months and would not prolong construction impacts to aesthetic, biological, and noise impacts, as would be the case under the Phased Implementation Alternative. The Project with Agriculture Alternative would result in impacts similar to the proposed Project, but with greater impacts to energy use and air emissions resulting from the increased extractions.

7.8 Alternatives to the Imported Water Storage Component

Similar to the Groundwater Conservation and Recovery Component analysis, the selection of policy-level alternatives for the Imported Water Storage Component is determined by their potential to avoid or substantially lessen potentially significant environmental effects of the proposed Project, while meeting most of the basic Project objectives. The first step in identifying what policy-level alternatives should be considered in comparison to the proposed Project is to review the potentially significant environmental impacts associated with the Imported Water Storage Component to determine what strategies or policies should be applied that might avoid or lessen such impacts while accomplishing most of the basic Project objectives, i.e., to create additional water storage capacity in Southern California to enhance water supply reliability and delivery flexibility in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

Table 7-5 summarizes the significant environmental effects associated with the Phase 2 Imported Water Storage Component and frames the alternative strategies to address each impact area. On a policy-level, the Imported Water Storage Component alternatives would focus on reducing or relocating spreading basins and various Project facilities and on modifying wellfield pumping scenarios. Listed below are the policy-level alternatives that may be examined in more detail during future review of Phase 2 implementation:

A. No Project Alternative

The No Project Alternative considers the effects of not proceeding with the Imported Water Storage Component.

B. Spreading Basins Alternatives

The Spreading Basins Alternatives includes relocating or reducing the size of spreading basins.

C. Wellfield Alternatives

The Project Facilities Alternatives include modifying or relocating wellfield configurations.

D. Project Operations Alternative

Project Operations Alternative includes a phased approach to pumping.

E. Conservation/Alternate Storage Alternatives

Conservation/Alternate Storage Alternatives include adopting conservation strategies and alternate storage projects.

TABLE 7-5
STRATEGIES TO AVOID OR LESSEN SIGNIFICANT
ENVIRONMENTAL EFFECTS OF THE IMPORTED WATER STORAGE PROJECT

Phase 1 Project Element	Impact Summary	Potential Strategies that Might Avoid or Lessen Impact
Spreading Basins	Potential impacts to desert tortoise habitat; potential impacts from construction dust, erosion, runoff	• Are alternate sites available for locating spreading grounds to avoid or lessen potential biological effects? • Can the spreading grounds be reduced?
Wellfield	Potential impacts from construction dust, erosion, stormwater runoff, potential impacts to habitat, cultural resources and land use	• Can the extent of the additional wellfield facilities be relocated or reduced? Smaller footprint or fewer facilities?
Project Operations	Potential draw down and recharge effects including subsidence, migration of saline water into freshwater zones and water quality impacts; increased energy use	• Can the proposed groundwater pumping/recharge scenario be modified to reduce potential drawdown/recharge effects?

SOURCE: ESA, 2011.

Each of the alternatives selected for review has the potential to address significant effects of the Imported Water Storage Component of the Project. At this stage in the review process, the Project participants have not been identified and elements of design are still under conceptual development (including the potential quantity and schedule for surface water import and spreading, storage and extraction). Therefore, future implementation of Phase 2 may require additional environmental review.

With the exception of the No Project Alternative, each of the Alternatives selected has the potential to be feasible, to avoid or lessen impacts and meet most of the basis objectives of the Project.

7.8.1 No Project Alternative

For the No Project Alternative, construction of facilities identified under the proposed Project would not be implemented. The existing agricultural operations at the Cadiz Property would continue and no new permanent structures would be constructed. There would be no augmentation to the water supply. Any significant effects caused the Imported Water Storage Component would not occur under the No Project Alternative.

The No Project Alternative would not meet any of the Project objectives. Under the No Project Alternative, current agricultural operations would continue, with the potential for increased agricultural production on the 1,140 acres currently fallow and not irrigated. Domestic water supply reliability and storage would not be developed. Should agricultural production be expanded, additional agricultural water supply would be required.

7.8.2 Spreading Basins Alternatives

As currently conceptualized, the Imported Water Storage Component spreading basins are located in Fenner Gap on Cadiz Property north of the BNSF Railroad (see Figure 3-14). The spreading basins would encompass approximately 400 acres with each individual basin ranging from 10 to 15 acres surrounded by chain link fences. The basins would be designed to allow water to flow by gravity from upstream basins to downstream basins. This location has the potential to impact critical habitat of the desert tortoise. The Spreading Basins Alternatives would relocate to the south or reduce the development footprint of the spreading basins by 20 percent.

Ability to Meet Project Objectives

The alternatives would potentially meet most of the basic objectives of the Imported Water Storage Component including the creation of additional storage capacity but potentially to a lesser extent than the proposed Project.

Comparison of Environmental Impacts

Relocate Spreading Basins to South of BNSF Railroad Alternative

This alternative would relocate the spreading basins to south of the BNSF Railroad within the general area of the Project wellfield. The alternative location would avoid or substantially lessen impacts on the desert tortoise habitat. The basins would be located closer to the Dry Lakes but designed to reduce lateral movement of water toward the Dry Lakes, optimize percolation rates and maintain water quality in the storage and extraction areas. The alternative would continue to site the spreading basins entirely on privately owned land, therefore, the impacts on land use would be similar to the proposed Project.

By placing the spreading basins within the wellfield development area, construction impacts would be reduced and a smaller overall development footprint would be needed. Spreading basins

and the pipeline to the basins would not be developed north of the Railroad tracks. Potential construction impacts and maintenance impacts to aesthetics, air quality, cultural resources, climate change, hazardous materials, runoff, noise and traffic would be less than the proposed Project. Locating the basins within the general area of the wellfield south of BNSF location would reduce or avoid the potential loss of up to 437 acres of critical habitat for the desert tortoise. While the proposed Project would mitigate the impacts through a habitat conservation plan (and other measures) to a less than significant level, this alternative would result in fewer impacts to biological resources.

20 Percent Reduction in Spreading Basin Alternative

This alternative would utilize the conceptual site north of the BNSF Railroad similar to the proposed Project but would reduce the overall size of the spreading basins area by a minimum of twenty percent and design the basin cells to reduce impacts to desert tortoise habitat as well as impacts from construction dust, erosion and runoff. Approximately 80 acres of critical desert tortoise habitat would be avoided under this alternative. Impacts would remain less than significant with mitigation. Construction impacts to aesthetics, air quality, cultural resources, climate change, hazardous materials, noise and traffic would be similar to the proposed Project but somewhat less based on the reduced development footprint of the basins.

7.8.3 Wellfield Alternatives

As currently conceptualized, the Project facilities for the Imported Water Storage Component would involve the expansion of the wellfield, roads and utilities developed for the Groundwater Conservation and Recovery Component, and the potential use of existing natural gas pipelines for water conveyance to the State Water Project. Potential impacts of these facilities include construction dust and other air quality impacts, erosion, stormwater runoff and potential impacts to habitat, cultural resources and traffic. The Wellfield Alternatives consider reducing the footprint of the expanded wellfield and relocating the wellfield, to reduce or avoid construction impacts.

Ability to Meet Project Objectives

The Wellfield Alternatives would potentially meet most of the basic objectives of the Imported Water Storage Component including the creation of additional storage capacity but potentially to a lesser extent than the proposed Project.

Comparison of Environmental Impacts

Similar to the Groundwater Conservation and Recovery Component, the Wellfield Alternatives seek to reduce the overall development footprint of the proposed Project and to avoid or lessen potentially significant impacts. While most of the objectives of the proposed Project could be achieved, the overall capacity for recharge and withdrawal may be reduced. The Wellfield Alternatives include consideration of the Northern Wellfield Location alternative previously analyzed (see 7.6.2) as well as a reduction in the number of new wells. The Northern Wellfield Location alternative could reduce effects of salinity, but would have greater impacts on habitat

for the desert tortoise and would reduce the amount of recharge that could be conserved. Other impacts would be similar to the proposed Project. By reducing the number of additional wells or replacing existing wells with high capacity wells, under a reduced wells alternative impacts resulting from construction activities would be reduced including potential impacts to habitat.

7.8.4 Project Operations Alternative

As currently conceptualized, the Imported Water Storage Component would store up to 1 MAF and withdrawals and recharge would be limited to a maximum of 75,000 to 105,000 AFY of water. Potential impacts of the withdrawal and recharge could include subsidence and migration of saline water into freshwater zones. Similar to the Groundwater Conservation and Recovery Component, the Project Operations Alternative considers a Phased Implementation Alternative. New wells would be added to the wellfield gradually to confirm the results of future predictive modeling for the recharge operations.

Ability to Meet Project Objectives

This alternative would meet most of the basic objectives of the proposed Project. However, under the Phased Implementation Alternative, achieving the objectives would be delayed.

Comparison of Environmental Impacts

The Project Operations (Phased Implementation) Alternative would result in the same level of impacts of the proposed Project but spread out over a longer period of time.

7.8.5 Conservation/Alternate Storage Alternatives

Under the Conservation/Alternate Storage Alternatives, conservation strategies and alternate storage projects that might substantially reduce or avoid any potentially significant effects of the Imported Water Storage Component are considered. The feasibility of these potential alternatives vary according to the Project Participants conservation efforts and alternate water storage projects.

Ability to Meet Project Objectives

This alternative would not meet any of the objectives of the proposed Project because it depends on identifying other programs to satisfy storage needs.

Comparison of Environmental Impacts

Potential effects of the Conservation/Alternate Storage Alternatives include construction of alternative storage facilities and water conveyance facilities by individual Project Participants to increase the reliability of their water supplies to meet existing planned growth in their respective service areas. Because each participant would participate in other programs or facilities, the combined impacts may be greater than the effects of the Imported Water Storage Component. Because the other programs would be implemented in different geographic areas and involve

different facilities and equipment, there would be the potential for greater impacts to aesthetics, agricultural resources, air quality, biological resources, cultural resources, geology, hazardous materials, hydrology, land use, mineral resources, noise, recreation and traffic.

7.9 Comparison of Alternatives and Identification of the Environmentally Superior Alternative: Imported Water Storage Component

7.9.1 Comparison of Alternatives

Conceptually, the alternatives identified for the Imported Water Storage Component are evaluated to determine whether they will satisfy the Project Objectives. The No Project Alternative would avoid all construction and operational impacts associated with the proposed Project, but the No Project Alternative would not meet any of the Project objectives.

In comparison, Relocating the Spreading Basins to South of BNSF Railroad Alternative would be the environmentally superior alternative since it would move spreading basins out of critical habitat for desert tortoise. The Wellfield Alternative would result in the fewest new wells and result in fewer impacts to biological resources and resources affected by construction activities such as air, noise and traffic, but the critical habitat area would not be avoided.

7.9.2 Environmentally Superior Alternative

CEQA requires that an EIR identify the environmentally superior alternative of a project other than the No Project Alternative (*State CEQA Guidelines* Section 15126.6(e)(2)). The Relocate Spreading Basins to South of BNSF Railroad Alternative would be the environmentally superior alternative since it would move spreading basins out of critical habitat for desert tortoise. However, it would potentially meet the Project Objectives to a lesser extent than the Proposed Project because relocation and reduction of the spreading basin infrastructure could reduce the recharge capacity for the Project. Also by relocating the wellfields, some impacts may increase with respect to limited placement options for the wells to remain outside tortoise habitat.

CHAPTER 8
Irreversible and Irretrievable Commitment of Resources

8.1 Introduction and Approach

The purpose of this Section is to identify elements of the proposed Project that could result in an irreversible or irretrievable commitment of resources. The discussion includes a description of the Project's long-term benefits and how these benefits offset the irretrievable commitment of resources.

8.1.1 CEQA Statutory Guidance

Section15126.2(c) of the *CEQA Guidelines* requires a discussion of any significant irreversible environmental changes that would be caused by a proposed Project, including the use of nonrenewable resources. The analysis also examines whether primary or secondary impacts commit future generations to similar types of uses.

8.1.2 Approach

Significance Threshold

For purposes of this section, per Section 15126.2(c) of the *CEQA Guidelines*, a project would result in an irreversible and irretrievable commitment of resources if it:

- Involved a large commitment of nonrenewable resources;
- Created primary and secondary impacts that would generally commit future generations to similar uses;
- Involved uses in which irreversible damage would result from any potential environmental accidents associated with the project; or
- Proposed consumption of resources that were not justified (e.g., the project involves the wasteful use of energy).

Methodology

The significant irreversible impact analysis consists of an evaluation of construction and operation activities and the identification of any nonrenewable resources consumed during these activities. For this evaluation, it has been assumed that the proposed pipeline conveyance system would be operated for 50 years. Groundwater pumped from the aquifer is considered a renewable resource that is naturally recharged on an ongoing basis. Without the Project pumping, this resource would eventually migrate to the brine zone of the Bristol and Cadiz Dry Lakes and be lost to evaporation. Accordingly, implementation of the proposed Project would not result in an irreversible or irretrievable commitment of groundwater resources.

8.2 Analysis of Commitment of Resources

8.2.1 Groundwater Conservation and Recovery Component

Biological Resources

Construction and operational activities would result in direct and indirect loss of habitat. The removal of vegetation and wildlife habitat in the Project area for construction of the wellfields and conveyance system, and the periodic maintenance on the Project components, are all considered an irreversible and irretrievable commitment of these resources. Implementation of mitigation measures would ensure resources are not significantly impacted. Over time the area of temporary effect would recover. Permanent loss of open space would be less than 250 acres. Much of this would be within 50 feet of an existing active railroad. This amount of acreage would not constitute a commitment of significant amount of land in the area.

Cultural Resources

Construction of the Groundwater Conservation and Recovery Component could potentially disturb cultural resources within the Project area. Despite application of mitigation measures to reduce potential impacts to less than significant levels, activities involving data recovery of cultural resources discovered during construction would result in some irreversible losses. Data recovery requires removal of artifacts from their original context. Therefore if data recovery is required due to Project implementation, an irreversible and irretrievable commitment of resources would occur. The Project's effects to cultural resources analyzed in this Draft EIR are less than significant as discussed in Section 4.5.

Geology and Soils

Soil erosion and topsoil loss during and following construction activities of the proposed facilities associated with the Groundwater Conservation and Recovery Component would be mitigated per the implementation of mitigation measures to ensure impacts are less than significant. Nonetheless, some exposed soils would be removed due use of heavy machinery for grading, trenching, well drilling, facilities installation, and other proposed activities. Furthermore,

increases in erosion could result in changes to nearby topography, drainage patterns, and vegetation patterns. Therefore, construction activities would result in irreversible and irretrievable commitment of losses to geology and soil resources. The Project's effects to top soil are less than significant as discussed in Section 4.6.

Land Use and Planning

Installation of the pipeline in the ARZC ROW would permanently commit that portion of the ROW to use as a water utility corridor. Since this easement currently supports a transportation corridor, the addition of a water utility would not inappropriately commit land to a permanent use. Furthermore, the use of property for wells and access roads would permanently remove the land for other uses. However, the low intensity of development in the wellfield would not substantially affect future uses of the properties as a whole. Irreversible affects to land use would be less than significant.

Mineral Resources

Construction of water facilities proposed under the Groundwater Conservation and Recovery Component would involve grading activities that would result in the consumption and loss of sand, gravel, rock and other minerals to fabricate construction materials such as steel and concrete. The extraction of mineral resources for various end uses and purposes, most of them construction and development-related, are considered to be non-renewable resources that will be precluded from future uses. Therefore, construction activities will result an irreversible and irretrievable commitment of losses to mineral resources. However, the use of these materials does not constitute a wasteful use of resources. The use of construction materials is not considered a significant impact.

Public Services and Utilities

Construction and operation of the Groundwater Conservation and Recovery Component would consume fossil fuels, a non-renewable resource to generate energy for vehicles during construction, and to operate pumps for the life of the Project. The use of energy to enhance reliability of water supply is not a wasteful use of irretrievable resources. Developing local water supplies reduces energy required to import water from greater distances. Therefore, the Project is not wasteful and the use of energy is justified.

8.2.2 Imported Water Storage Component

Biological Resources

Construction and operational activities associated with the Imported Water Storage Component will result in direct and indirect loss of habitat. The removal of vegetation and wildlife habitat in the larger Project footprint anticipated for construction of the additional wellfields and conveyance system, and the periodic maintenance on the Project components, are all considered

an irreversible and irretrievable commitment of these resources. Implementation of mitigation measures would ensure resources are not significantly impacted. Given the small acreages affected by the low intensity development, the Project would not be wasteful.

Cultural Resources

Construction of the Imported Water Storage Component could potentially disturb significant cultural resources within the Project area. Despite application of mitigation measures to reduce potential impacts to less than significant levels, activities involving data recovery of cultural resources discovered during construction will result in some irreversible losses. Data recovery will involve some loss because it requires removal of artifacts from their original context. Construction activities will result an irreversible and irretrievable commitment of losses to cultural resources. However, the effects would be justified given the utility of the Project and the limited effects to cultural resources.

Geology and Soils

The expanded wellfield, pump station and spreading basins proposed under the Imported Water Storage Component would increase the potential for soil erosion during construction. Soil erosion and topsoil loss during and following construction activities of proposed facilities associated would be mitigated per the implementation of mitigation measures to ensure impacts are less than significant. Nonetheless, some exposed soils will be removed due use of heavy machinery for grading, trenching, well drilling, facilities installation, and other proposed activities. Therefore, construction activities will result an irreversible and irretrievable commitment of losses to geology and soil resources. However, the effect would not be wasteful and would be justified by the utility of the Project.

Public Services and Utilities

Operation of the proposed facilities associated with the Imported Water Storage Component would consume fossil fuels, a non-renewable resource to generate energy for vehicles during construction, and to operate pumps for the life of the Project. The use of energy to enhance reliability of water supply is not a wasteful use of irretrievable resources. Developing local water supplies may be substituted for water being imported from greater distances and thereby reduces the relative energy required to satisfy the designated beneficial uses. Moreover the Project would provide water in any climatic condition and therefore, Project Participants would not have to diversify their water supply portfolio to the same extent as if they pursued less reliable water. Therefore, the Project is not wasteful and the use of energy is justified.

CHAPTER 9
Report Preparers

9.1 Project Sponsor / Lead Agency

Santa Margarita Water District

26111 Antonio Parkway
Rancho Santa Margarita, CA 92688

John Schatz, General Manager
Daniel Ferons, Chief Engineer

9.2 EIR Authors and Consultants

Environmental Science Associates (ESA)

626 Wilshire Boulevard, Suite 1100
Los Angeles, California 90017

Leslie Moulton, Project Director
Tom Barnes, Project Manager

ESA Technical Staff

Donnie Ambroziak	Candace Ehringer	Monica Strauss
Madeleine Bray	Gus JaFolla	Kerri Tuttle
Poonam Boparai	Jason Nielsen	Jon West
Justin Conley	Sarah Spano	Victoria Zalameda
Allyson Dong	Nicolle Steiner	

RBF Consulting

40810 County Center Drive, Suite 100
Temecula, CA 92591

Kevin Thomas, CEP, Environmental Services Manager

CH2M Hill

325 East Hillcrest Drive, Suite 125
Thousand Oaks, CA 91360

Terry Foreman, Vice President

Paleo Solutions Inc.

2035 Placentia Ave, Suite D
Costa Mesa, CA 92627

Geraldine Aron

Circle Mountain Biological Consultants, Inc.

P.O. Box 3197
Wrightwood, CA 92397

Ed La Rue

GEOSCIENCE Support Services, Inc.

P.O. Box 220
Claremont, CA 91711

Dennis Williams
Brian Villalobos
Johnson Yeh

CHAPTER 10
Acronyms

AB	Assembly Bill
AB 32	California Global Warming Solutions Act of 2006
ACEC	Areas of Critical Environmental Concern
ADT	Average Daily Trips
AF	Acre-feet
AFY	Acre-feet Per Year
AG	Agriculture designation
amsl	Above mean sea level
APCD	Air Pollution Control District
APS	Alternative Planning Strategy
AQMD	Air Quality Management District
ARZC	Arizona and California Railroad
ASCE	American Society of Civil Engineers
ATSF	Atchison, Topeka, & Sante Fe
AVAQMD	Antelope Valley Air Quality Management District
Basin Plans	Water quality control plans
Bay-Delta	Sacramento-San Joaquin Bay-Delta
BEP	Business Emergency Plan
bgs	Below ground surface
BLM	U.S. Bureau of Land Management
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
BR	Biotic Resources
C	Celsius
Cadiz Program	Cadiz Groundwater Storage and Dry-Year Supply Program
Cadiz	Cadiz Inc.
CAL FIRE	California Department of Forestry and Fire Protection

Cal OSHA	California Occupational Safety and Health Administration
Cal Water	California Water Service Company
CalEPA	California Environmental Protection Agency
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CAT	Climate Action Team
CBC	California Building Code
CCAA	California Clean Air Act
CCR	California Code of Regulations
CDA	Chino Basin Desalter Authority
CDCA	California Desert Conservation Area
CDFG	California Department of Fish and Game
CDMG	California Division of Mines and Geology
CDPA	California Desert Protection Act
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CGS	California Geological Survey
CH_4	Methane
CHL	California Historical Landmarks
CHP	California Highway Patrol
CHRIS	California Historical Resources Information System
CII	Commercial/Industrial/Institutional
CIWMB	California Integrated Waste Management Board
CMA	Congestion Management Agency
CMP	Congestion Management Plan
CMWD	Calleguas Municipal Water District
CNEL	Community Noise Equivalent Level
CO	Carbon monoxide
CO_2e	Carbon dioxide equivalents
COG	Council of Government

Contractors	State Water Contractors
CPSD	Consumer Protection and Safety Division
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
CREZ	Competitive Renewable Energy Zones
CRHR	California Register of Historical Resources
CRMC	Colorado River Medical Center
CSLC	California State Lands Commission
CSP	Concentrating Solar Power
CUP	Conditional Use Permit
CUPA	Certified Unified Program Agencies
CUWCC	California Urban Water Conservation Council's
CVP	Central Valley Project
CVWD	Coachella Valley Water District
CVWD	Cucamonga Valley Water District
CWA	Clean Water Act
dB	Decibels
dBA	A-weighted decibels
DEH	Department of Environmental Health
DMM	Demand Management Measures
DOD	U.S. Department of Defense
DOE	Department of Energy
DOF	Department of Finance
DOGGR	Division of Oil, Gas and Geothermal Resources
DOI	Department of Interior
DPH	Department of Public Health
DPR	Department of Parks and Recreation
DRECP	Desert Renewable Energy Conservation Plan
Dry Lakes	Cadiz and Bristol Dry Lakes
DTC-CAMA	Desert Training Center California-Arizona Maneuver Area
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
EDD	Employment Development Department
EIR	Environmental Impact Report

EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Environmental Science Associates
F	Fahrenheit
FCAA	Federal Clean Air Act
FEMA	Federal Emergency Management Agency
FESA	Federal Endangered Species Act
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FLPMA	Federal Land Policy and Management Act of 1976
FMMP	Farmland Mapping and Monitoring Program
Forum	Colorado River Basin Salinity Control Forum
FPP	Farmland Protection Program
FPPA	Farmland Protection Policy Act
FRA	Federal Railroad Administration
ft/yr	Feet per year
FTA	Federal Transit Administration
FVMWC	Fenner Valley Mutual Water Company
FY	Fiscal Year
GBV	Ground borne vibration
GCM	Global Climate Model
GHG	Greenhouse gas
GMMMP	Groundwater Management, Monitoring and Mitigation Plan
Golden State	Golden State Water Company
GPCD	Gallons per capita per day
gpm	Gallons per minute
GWMP	Groundwater Monitoring Plan
GWP	Global Warming Potential
HCP	Habitat Conservation Plan
HET	High Efficiency Toilets
HFCs	Hydrofluorocarbons
HMBP	Hazardous Materials Business Plan
hp	Horsepower
HRI	Historical Resources Inventory

HWMP	Hazardous Waste Management Plan
Hz	Hertz
I-40	Interstate 40
IEUA	Inland Empire Utilities Agency
IFI	Important Farmlands Inventory
IID	Imperial Irrigation District
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Water Resources Plan
IRWD	Irvine Ranch Water District
ITA	Indian Trust Assets
JCSD	Jurupa Community Services District
JPA	Joint Powers Authority
KCAPCD	Kern County Air Pollution Control District
kWh	Kilowatt hours
LACM	Natural History Museum of Los Angeles County
LESA	Land Evaluation and Site Assessment
LOI	Letter of Interest
LOS	Level of Service
M&I	Municipal and Industrial
M/C	Minor Use Permit
MAF	Million Acre-feet
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MDAB	Mojave Desert Air Basin
MDAQMD	Mojave Desert Air Quality Management District
Metropolitan	Metropolitan Water District of Southern California
MG	Million gallon
mg/L	milligrams per liter
MMI	Modified Mercalli Scale
MMP	Mitigation Monitoring Program
MMRP	Mitigation Monitoring and Reporting Plan
MOU	Memorandum of Understanding
mpg	Miles per gallon
MPO	Metropolitan Planning Organization

MPOs	Metropolitan Planning Organizations
MRZs	Mineral resource zones
MSDS	Material safety data sheets
$MTCO_2e$	Metric tons of CO_2e
MTR	Military Training Route
MUN	Municipal supply
MWD	Municipal Water District
MWDOC	Municipal Water District of Orange County
MY	Model years
N_2O	Nitrous Oxide
NAHC	Native American Heritage Commission
NCCP	Natural Community Conservation Plan
NCCPA	Natural Communities Conservation Planning Act
NECO	Northern and Eastern Colorado Desert
NEHRP	National Earthquake Hazards Reduction Program
NEHRPA	National Earthquake Hazards Reduction Program Act
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGVD	National Geodetic Vertical Datum
NHI	Natural Heritage Institute
NHPA	National Historic Preservation Act
NO_2	Nitrogen dioxide
NOC	Notice of Completion
NOD	Notice of Determination
NOP	Notice of Preparation
NOx	Nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPPWR	National Primary Drinking Water Regulations
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NUSD	Needles Unified School District
OHP	California Office of Historic Preservation
OPR	Governor's Office of Planning and Research
OSHA	Occupational Safety and Health Administration

PDF	Project Design Feature
PET	Potential evapotranspiration
PFCs	Perfluorocarbons
PFYC	Potential Fossil Yield Classification System
PGAs	Peak ground
PHI	Points of Historical Interest
Piute Property	Piute Wash
PM10	Particulate matter (10 microns or less)
PM2.5	Particulate matter (2.5 microns or less)
PMMP	Paleontological Mitigation and Monitoring Plan
PPV	Peak Particle Velocity
PRC	Public Resources Code
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
Project	Cadiz Valley Water Conservation, Recovery, and Storage Project
PSD	Prevention of Significant Deterioration
QSA	Quantification Settlement Agreement
RailAmerica	RailAmerica Inc.
RC	Resource Conservation
RCRA	Resource Conservation and Recovery Act
REAT	Renewable Energy Action Team
REPG	Renewable Energy Policy Group
REPT	Renewable Energy Permit Team
RESP	Rice Solar Energy Project
RETI	Renewable Energy Transmission Initiative
REZ	Renewable Energy Development Zones
RMS	Root Mean Square
RMV	Rancho Mission Viejo
RMV	Rancho Mission Viejo
ROG	Reactive organic gases
ROI	radius of influence
ROW	Right-of-way
RPS	Renewable Portfolio Standards
RTP	Regional Transportation Plan
RUWMP	Regional Urban Water Management Plan

RWQCB	Regional Water Quality Control Board
SANBAG	San Bernardino Associated Governments
SANDAG	San Diego Association of Governments
SARA	Superfund Amendments and Reauthorization Act
SB	Senate Bill
SBAIC	San Bernardino Archaeological Information Center
SBCFD	San Bernardino County Fire Department
SBCM	San Bernardino County Museum
SBCPL	San Bernardino County Public Library
SBCSD	San Bernardino County Sheriff-Coroner's Department
SBx7-7	Senate Bill 7 of the Seventh Extraordinary Session
SCAG	Southern California Association of Governments
SCE	Southern California Edison
SCS	Soil Conservation Service
SDC	Seismic Design Category
SDCWA	San Diego County Water Authority
SDWA	Safe Drinking Water Act
SEZ	Solar Energy Zone
SF_6	Sulfur Hexafluoride
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SJBA	San Juan Basin Authority
SMARA	Surface Mining and Reclamation Act of 1975
SMBG	State Mining and Geology Board
SMWD	Santa Margarita Water District
SO_2	Sulfur dioxide
SR	State Route
SRA	State Recreation Area
SRRE	Source Reduction and Recycling Element
Suburban	Suburban Water Systems
SUP	Special Use Permit
SVP	Society for Vertebrate Paleontology
SWP	State Water Project
SWPPP	Storm Water Pollution Prevention Plan

SWRCB	State Water Resources Control Board
TAC	Toxic Air Contaminants
TDS	Total dissolved solids
Three Valleys	Three Valleys Municipal Water District
TW	Test Well
UAW	Unaccounted for Water
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
US	U.S. Route
USACE	U.S. Army Corps of Engineers
USBR	U.S. Department of the Interior, Bureau of Reclamation
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USTs	Underground storage tanks
UWMP	Urban Water Management Plan
UXO	Unexploded Ordnance
V/C	Volume to Capacity
VOC	Volatile organic chemicals
Watermaster	Chino Basin Watermaster
Watersheds	Fenner, Orange Blossom Wash, Cadiz, and Bristol Watersheds
WMO	World Meteorological Organization
WQOs	Water Quality Objectives
WRP	Water Reclamation Plant
WSAs	Wilderness Study Areas
WSDM	Water Surplus and Drought Management
WTP	Water Treatment Plant
WWII	World War II

CHAPTER 11
References

101st Congress, *Tax Relief and Health Care Act of 2006 – Public Law 101-628,* November 1990, Section 101(d).

Advanced Geologic Exploration, *Map of Recorded Earthquake Epicenters in Proximity to Bristol Dry Lake, San Bernardino County, CA*, Report to Cadiz, 1997.

Agricultural Issues Center, University of California Davis, *The Measure of California Agriculture*, August 2009.

Anonymous, Combined Environmental and Historic Report, *Arizona and California Railroad Company – Abandonment – in San Bernardino and Riverside Counties, CA (Between Rice and Ripley)*, Docket No. AB-1022 (Sub-No. 1X), on file at the San Bernardino Archaeological Information Center, October 2008.

Applied Development Economics, Inc., *2010 California Regional Progress Report, 2007-2010*, http://www.scag.ca.gov/publications/pdf/2010/CARegionalProgress2010.pdf, accessed October 2010.

Applied Earthworks, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources,* 1999.

Aquifonia, *The Colorado River*, http://aquafornia.com/where-does-californias-water-come-from/the-colorado-river, accessed October 2011.

Argonne National Laboratory, *Proposed Section 368 Energy Corridors*, November 2008.

Argonne National Laboratory, *Visual Resources Analysis Map Series*, 2008.

Baldwin, John L., *Climates of the United States*, 1973.

Bassett, A.M., and D.H. Kupfer, *A Geologic Reconnaissance in the Southeastern Mojave Desert, California*, California Division of Mines and Geology Special Report 83, 1964.

Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*, U.S. Geological Survey Bulletin, 1045-D, 1959.

Bean, Lowell John, and Sylvia Brakke Vane, *The Native American Ethnography and Ethnohistory of Joshua Tree National Park: An Overview*, August 2002.

Bedford, D.R., Miller, D.M., and Phelps, G.A., *Surficial geologic map data and physical properties for the Amboy 30 x 60 minute Quadrangle, California*, 2010.

Bedinger, M.S., Langer, W.H., and Moyle, W.R., *Maps Showing Ground Water Units and Withdrawal, Basin and Range Province, Southern California*, U.S. Geological Survey Water-Resources Investigations Report 83-4116-A, 1984.

Belnap, Jayne, *Cryptobiotic Soils: Holding the Place in Place*, http://geochange.er.usgs.gov/sw/impacts/biology/crypto/, accessed September 2011.

Bing Maps Aerial, http://www.arcgis.com/home/item.html?id=677cd0c509d842a98360c46186a2768e, accessed May 2010.

Bischoff, Matthew C., *The Desert Training Center/California-Arizona Maneuver Area, 1942-1944: Historical and Archaeological Contexts*, 2000.

Bishop, C.C., *Geologic Map of California: Needles Sheet*, 1963.

Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001.

Bureau of Land Management, *Energy Policy Act of 2005, Section 211*, August 2005.

Bureau of Land Management, *Final Environmental Impact Statement for the Proposed Northern & Eastern Colorado Desert Coordinated Management Plan, an amendment to the California Desert Conservation Area Plan 1980 and Sikes Act Plan with the CDFG*, 2002.

Bureau of Land Management, *GeoSpatial Data Downloads*, http://www.blm.gov/ca/gis/, accessed October 2010.

Bureau of Land Management, *Proposed Northern & Eastern Colorado Desert Coordinated Management Plant and Final Environmental Impact Report*, July 2002.

Bureau of Land Management, *Wilderness Act of 1974*, http://www.blm.gov/nv/st/en/fo/ely_field_office/blm_programs/wilderness/wilderness_act_of.html, accessed January 2011.

Cadiz Inc., *10th Annual Groundwater Monitoring Report, January 2007-December 2007 & Five-Year Summary Report, Cadiz Valley Agricultural Development*, April 2008.

Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009.

Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009.

Cadiz Inc., *12th Annual Groundwater Monitoring Report, January-December 2009, Cadiz Valley Agricultural Development*, June 2010.

Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011.

Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011.

Cadiz Inc., *6th Annual Groundwater Monitoring Report, January 2003-December 2003, Cadiz Valley Agricultural Development*, January 2009.

Cadiz Inc., *Cadiz Valley Agricultural Development Project Mitigation Monitoring and Compliance Program*, December 2000.

Cadiz Inc., *Communication entitled "Cadiz RE pipeline project"* to RailAmerica Inc., September 17, 2008.

Cadiz Inc., *Communication with ESA*, December 9, 2010, August 4, 2011, October 19, 2011, October 21, 2011.

Cadiz Inc., *Memorandum of Lease Agreement between Cadiz Real Estate, LLC and Arizona & California Railroad Company*, September 2008.

Cadiz Inc., *Memorandum of Understanding for Land Stewardship Between the Natural Heritage Institute and Cadiz*, May 2009.

Cadiz Land Co., Inc. v. Rail Cycle, L.P. (2000) 83 Cal.App.4th 74, 81-82, 113-15.

Cal-Adapt, *Snow Pack: Decadal Averages Map*, http://cal-adapt.org/snowpack/decadal/, accessed August 2011.

California Air Pollution Control Officers Association, *CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act*, January 2008.

California Air Resources Board, *Air Quality and Land Use Handbook: A Community Health Perspective*, April 2005.

California Air Resources Board, *Ambient Air Quality Standards*, September 2010.

California Air Resources Board, *ARB Fact Sheet: Air Pollution Sources, Effects and Control*, http://www.arb.ca.gov/research/health/fs/fs2/fs2.htm, accessed January 2011.

California Air Resources Board, *Area Designation Maps*, http://www.arb.ca.gov/desig/adm/adm.htm, accessed January 2011.

California Air Resources Board, *Climate of the Southeast Desert Air Basin*, July 1975.

California Air Resources Board, *Final Supplement to the AB 32 Scoping Plan Functional Equivalent Document*, August 2011.

California Air Resources Board, *Mandatory Reporting of California Greenhouse Gas Emissions*, Presentation at Cal/EPA Headquarters, August 2007.

California Air Resources Board, *Senate Bill No. 104*, October 2009.

California Air Resources Board, *Summaries of Air Quality Data, 2008 through 2010*, http://www.arb.ca.gov/adam/cgi-bin/db2www/polltrendsb.d2w/start, accessed January 2011.

California Business and Professional Code §65867.5.

California Climate Change Center, *Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment*, August 2009.

California Code of Regulations, Title 14, Chapter 3, §§15126.2(d), 15131, 15358(a)(2); Title 22, Chapter 15; Title 23, Division 3, Article 659 *et seq.*

California Department of Conservation, *Farmland Mapping & Monitoring Program*, http://conservation.ca.gov/dlrp/fmmp/Pages/Index.aspx, accessed October 2010.

California Department of Conservation, *Williamson Act 2006*, http://www.consrv.ca.gov/dlrp/lca/Pages/Index.aspx, accessed October 2010.

California Department of Employment Development Department, *Labor Market Info for San Bernardino County, California*, September 2011.

California Department of Finance, *E-5 Population and Housing Estimates for Cities, Counties and the State, 2010-11, with 2010 Census Benchmark*, May 2011.

California Department of Fish and Game, Biogeographic Data Branch, California Natural Diversity Database, Rarefind Computer Program (Version 3.1.0), July 2009 and September 5, 2010.

California Department of Fish and Game, *California Natural Diversity Data Base*, http://www.dfg.ca.gov/biogeodata/cnddb/, accessed 2010.

California Department of Fish and Game, Natural Diversity Database, *Special Vascular Plants, Bryophytes, and Lichens List*, January 2010.

California Department of Fish and Game, *Staff Report on Burrowing Owl Mitigation*, Memorandum from C.F. Raysbrook, October 1995.

California Department of Forestry and Fire Protection, *Very High Fire Hazard Severity Zone Map*, Southeast San Bernardino County, October 2008.

California Department of Resources Recycling and Recovery, *Active Landfills Profile for USMC - 29 Palms Disposal Facility (36-AA-0067)*, http://www.calrecycle.ca.gov/profiles/Facility/Landfill/LFProfile1.asp?COID=36&FACID=36-AA-0067, accessed October 2010.

California Department of Resources Recycling and Recovery, *Statewide Anaerobic Digester Facilities for the Treatment of Municipal Organic Solid Waste Draft Program Environmental Impact Report*, February 2011.

California Department of Transportation, *California State Scenic Highways, San Bernardino County*, http://www.dot.ca.gov/hq/LandArch/scenic_highways/index.htm, accessed October 2010.

California Department of Transportation, *Technical Noise Supplement*, October 1998.

California Department of Water Resources, *California Water Plan Update 2009, Integrated Water Management*, December 2009.

California Department of Water Resources, *Climate Change*, http://www.water.ca.gov/climatechange/, accessed August 2011.

California Department of Water Resources, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*, October 2008.

California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources*, March 2008.

California Department of Water Resources, *Rainfall Records*, ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%202.xls and, ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%201.xls, accessed October 2010.

California Department of Water Resources, *The State Water Project Reliability Report 2009*, August 2010.

California Department of Water Resources, *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity*, Bulletin No. 91-14, 1967.

California Desert.gov, *Places to Go Rockhounding in the Californa Desert*, http://www.californiadesert.gov/actinfo.php?act=rh, accessed October 2011.

California Employment Development Department, Labor Market Information Division, *California's Agricultural Employment Report 2008*, www.edd.ca.gov, accessed June 2010.

California Energy Commission, *California Distributed Energy Resource Guide*, http://www.energy.ca.gov/distgen/equipment/reciprocating_engines/reciprocating_engines.html, accessed November 2011.

California Energy Commission, *California's Water – Energy Relationship*, November 2005.

California Energy Commission, *Current Renewable Energy Transmission Initiative Projects*, August 2011.

California Energy Commission, *Desert Renewable Energy Conservation Plan Notice of Preparation*, July 2011.

California Energy Commission, *Energy Action Plan II, Implementation Roadmap for Energy Policies*, September 2005.

California Energy Commission, *Implementing the Renwable Energy Executive Order*, http://www.energy.ca.gov/33by2020/, accessed August 2011.

California Energy Commission, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004*, December 2006.

California Energy Commission, *Renewable Energy Action Team Generation Tracking Projects, California Desert Protection Act of 2011 and Draft Proposed Competitive Renewable Energy Zones*, October 2011.

California Energy Commission, *Renewable Energy Transmission Initiative Phase 2B Final Report and Maps*, May 2010.

California Energy Commission, *Rice Solar Energy Project*, http://www.energy.ca.gov/sitingcases/ricesolar/index.html, accessed May 2011.

California Farm Bureau Federation, *San Bernardino County Farm Bureau*, http://www.cfbf.com/counties/?id=36, accessed October 2010.

California Geographical Survey, *Guidelines for Evaluating and Mitigating Seismic Hazards in Californi*a, Special Publication 117A, 2008.

California Geological Survey, *Alquist-Priolo Earthquake Fault Zones*,http://www.consrv.ca.gov/cgs/rghm/ap/Pages/index.aspx, accessed May 2010.

California Geological Survey, *Background Information on the Shake Maps*, http://quake.usgs.gov/research/strongmotion/effects/shake/about.html, accessed April 2010.

California Geological Survey, *California Geomorphic Provinces*, Note 36, 2002.

California Geological Survey, *Landslides*,http://www.consrv.ca.gov/cgs/geologic_hazards/landslides/Pages/Index.aspx, accessed May 2010.

California Geological Survey, *Probabilistic Seismic Hazard Assessment for the State of California*, from CDMG Open File-Report 96-08, http://www.consrv.ca.gov/CGS/rghm/psha/ofr9608/, accessed April 2010.

California Geological Survey, *Probabilistic Seismic Hazards Mapping Ground Motion,* http://redirect.conservation.ca.gov/cgs/rghm/ pshamap/pshamain.html, accessed April 2010.

California Geological Survey, *Regional Geologic Mapping Program, Epicenters of and Areas Damaged by M>5California Earthquakes, 1800-1999, Map Sheet 49, 2000.*

California Government Code §§65080, 65400, 65583, 65584.01, 65584.02, 65584.04, 65587, 65588, 65041, 65041.1, 65300, 14522.1, 14522.2, 65080.01, 66455.3, 66473.7.

California Health and Safety Code §38500.

California Native Plant Society, *Inventory of Rare and Endangered Plants*, http://www.rareplants.cnps.org/, accessed February 2010, November 2010, June 2011.

California Natural Resources Agency, *2009 California Climate Adaption Strategy Discussion Draft*, 2009.

California Public Resources Code §§75076, 75077, 75100, 775120, 21061.3, 21159.28, 21155.

California Pulbic Utilities Commission, *California Renewables Portfolio Standard,* http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm, accessed August 2011.

California State Lands Commission, *El Paso Line 1903 Pipeline Conversion Project,* http://www.slc.ca.gov/Division_Pages/DEPM/DEPM_Programs_and_Reports/El_Paso/ElPaso_PipelineConversion_DEIR.html, accessed September 2011.

California State Lands Commission, *Environmental Justice Policy*, http://www.slc.ca.gov/Policy_Statements/Environmental_Justice_Home_Page.html, accessed October 2011.

California Water Code §§10631, 10656, 10910, 10911, 10912,10915, 10610.16, 10610.2.

California Water Services Company, *Dominguez District 2010 Urban Water Management Plan,* June 2011.

California Water Service Company, *East Los Angeles District 2010 Urban Water Management Plan,* June 2011.

California Water Service Company, *Westlake District 2010 Urban Water Management Plan,* June 2011.

Campaign for the California Desert, http://www.californiadesert.org/, accessed September 2011.

Campaign for the California Desert, Mojave Trails National Monument, http://www.californiadesert.org/places/mojave_trails_national_monument, accessed September 2011.

Cayan, Daniel R., et al., *Future Dryness in the Southwest U.S. and the Hydrology of the Early 21st Century*, Proceedings of the National Academies of Science Vol. 107, No. 50, December 2010.

Center for Demographic Research, California State University, Fullerton, 2010.

Central and West Basin Water Replenishment Dist. v. Southern Cal. Water Co., 135 Cal.Rptr.2d 486, 491-492 (2003).

CH2M Hill, *Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs, August 2011*.

CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010.

CH2M Hill, *Cadiz Groundwater Conservation Project – Conceptual Engineering and Opinions of Probable Cost Technical Memorandum,* December 2010.

CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan,* November 2011.

Chino Basin Municipal Water District v. City of Chino et al., San Bernardino County Superior Court Case No. RCV 51010, Order Concerning Motion for Approval of Peace II Documents, December 21, 2007.

Circle Mountain Biological Consultants, *Cadiz Groundwater Storage and Dry-Year Supply Program: Biological Resources Technical Report: Focused Desert Tortoise Survey and Special-Status Reptile Inventory*, June 1999 and updated October 1999.

Circle Mountain Biological Consultants, *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California*, Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, Los Angeles, CA, November 2010.

Circle Mountain Biological Consultants, *Streambed Delineation for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California*, Unpublished report prepared by Ed LaRue for ESA Southern California Water Group, December 2010.

City of Anaheim, *City of Anaheim Final General Plan and Zoning Code Update Environmental Impact Report No. 330*, May 2004.

City of Barstow, *General Plan – Part E: Environmental Impact Report Reference Document*, prepared May 1997.

City of Indio, *Pop-Facts: Demographic Quick Facts 2011 Report*, May 2011.

City of Irvine, *City of Irvine Comprehensive General Plan Update (Phase 2) Master EIR*, April 1995.

City of Irvine, City *of Irvine Comprehensive General Plan Update (Phase 3) Master EIR*, February 1997.

City of Los Angeles v. City of San Fernando, 14 Cal.3d 199, 280 (1975).

City of Los Angeles, *City of Los Angeles Citywide General Plan Framework Draft Environmental Impact Report*, January 1995.

City of Los Angeles, *Los Angeles Citywide General Plan Framework Final Environmental Impact Report*, June 1996.

City of Ontario, *The Ontario Plan Draft Environmental Report Volume I*, April 2009

City of Ontario, *The Ontario Plan Final Environmental Impact Report*, July 2009.

City of Palmdale, *City of Palmdale Draft General Plan Draft Environmental Impact Report*, August 1992.

City of Riverside, *City of Riverside General Plan and Supporting Documents Final Program Environmental Impact Report*, November 2007.

City of San Diego, *Final Program Environmental Impact Report*, March 2008.

Climate Action Team, *Climate Action Team Report to Governor Schwarzenegger and the Legislature*, March 2006.

Code of Federal Regulations: Title 14, Part 77, Subpart B; Title 21, Chapter 165, Part 110(a)(2)(vi); Title 40, Chapter 1, Part 143.3.

Colorado River Basin Salinity Control Program, *Monthly Salinity Data at 20 Key Stations in Colorado River Basin*, http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf, accessed August 2011.

Contra Costa Water District (CCWD), *Los Vaqueros Reservoir Expansion Project Draft Environmental Impact Statement and Environmental Impact Report*, February 2009.

Council on Environmental Quality, *Environmental Justice Guidance Under the National Environmental Policy Act*, December 1997.

County of San Bernardino Planning Department, *Accepted Application APN 0592-251-01-0000*, October 2010.

County of San Bernardino Planning Department, *Accepted Application APN 0626-131-07-0000*, January 2011.

County of San Bernardino Planning Department, *Accepted Application APN 0626-231-13-0000*, January 2011.

County of San Bernardino Planning Department, *Accepted Application APN 0629-181-01-0000*, March 2011.

County of San Bernardino Planning Department, *Accepted Application, APN 0649-201-02-0000*, 2007.

County of San Bernardino Planning Department, *Accepted Application, APN 0647-061-08-0000*, July 2006.

County of San Bernardino, *County of San Bernardino 2007 Development Code, As Amended*, September 2010.

County of San Bernardino, *County of San Bernardino* 2007 *General Plan*, April 2007.

County of San Bernardino, *Draft Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development*, October 1993.

County of San Bernardino, *Final Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development*, October 1993.

County of San Bernardino, *Land Use Services Projects*, http://www.sbcounty.gov/landuseservices/Public%20Notices/Projects/Projects.htm, accessed July 2011, September 2011.

County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006.

County of San Bernardino, *San Bernardino* County 2007 *General Plan Program Final Program Environmental Impact Report*, February 2007.

County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report and Appendices*, March 2007.

County of San Bernardino, San Bernardino County Code, Title 3, Division 3, Chapter 6, Article 5, § 33.06552.

County of San Diego, San *Diego County General Plan Update Draft Program Environmental Impact Report*, July 2009

County of San Diego, *San Diego County General Plan Update Final Program Environmental Impact Report*, August 2011.

Crowley, S., *Site Record for CA-SBR-3233H and CA-SBR-3235H*, on file at SBAIC, San Bernardino County Museum, Redlands, 1978.

Cunniff, P.F., *Environmental Noise Pollution*, 1977.

Czarnecki, J.B., *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California*: USGS Water Supply Paper 2377, 1997.

Davisson, M.L., and T.P. Rose, *Estimating Annual Precipitation in the Fenner Basin of the Eastern Mojave Desert, California,* U.S. Dept. of Energy, May 2000.

Davisson, M.L., and T.P. Rose, *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California,* Lawrence Livermore National Laboratory, May 2000.

de Kehoe, Joe, *The Silence and the Sun,* Trails End Publishing Company, Bakersfield, CA, 2007.

DeLorme World Basemap, http://www.arcgis.com/home/item.html?id=b165c3df453e4be6b5ac4fdb241effbe, accessed October 2010.

Department of the Interior, *Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (As Amended and Annotated): Professional Qualification Standards*, http://www.nps.gov/history/local-law/arch_stnds_9.htm, accessed November 2010.

Department of Toxic Substances Control, *EnviroStor Database Results for Napa,* http://www.envirostor.dtsc.ca.gov/public/map.asp?global_id=&x=-119.1357421875&y=37.82280243352756&zl=5&ms=640,480&mt=m&findaddress=True&city=NAPA&zip=&county=&federal_superfund=true&state_response=true&voluntary_cleanup=true&school_cleanup=true&corrective_action=true&permit_site=true&permit_and_ca_site=true, accessed April 2011.

Department of Water Resources, *Water Use Efficiency / Leak Detection,* http://www.water.ca.gov/wateruseefficiency/leak/, accessed October 2011.

Desert Renewable Energy Conservation Plan, *Boundary Area Map*, February 2011.

Desert Renewable Energy Conservation Plan, http://www.drecp.org/, accessed September 2011.

Dokka, R.K, and C.J. Travis, *Late Cenozoic Strike Slip Faulting in the Mojave Desert, California*, Tectonics, Vol. 9, 1990.

Durbin Timothy, *Comments on Draft EIR/EIS Cadiz groundwater storage project Cadiz and Fenner Valleys, San Bernardino County, California*: Prepared for County of San Bernardino, February 21, 2000, In Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001.

Economics & Politics, Inc., *Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project Final Report,* April 2011.

Eloy Ruvalcaba, San Bernardino Department of Public Works, *Phone conversation with ESA,* October 20, 2010.

Environmental Protection Agency, *Nitrous Oxide, Sources and Emissions,* http://www.epa.gov/nitrousoxide/sources.html, accessed September 2011.

Environmental Science Associates, *Phase 1 Cultural Resources Assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County (CA)*, January 2011.

ESRI Corporation, *Data & Maps*: *StreetMap,* http://www.esri.com/data/data-maps/data-and-maps-server.html, accessed October 2010, October 2011.

Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways,* November 2003.

Federal Interagency Committee On Noise, *Federal Agency Review of Selected Airport Noise Analysis Issue,* August 1992.

Federal Railroad Administration, *DesertXpress – Las Vegas to Victorville,* http://www.fra.dot.gov/rpd/freight/1703.shtml, accessed July 2011.

Federal Register, *Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* Vol. 59, No. 32, February 1994.

Federal Transit Administration, *Transit Noise and Vibration Impact Assessment,* May 2006.

Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California,* USGS Water Resources Investigation Report 83-4082, July 1984.

Gale, H.S., *Geology of the Saline Deposits, Bristol Dry Lake, San Bernardino County, California,* California Division of Mines and Geology Special Report 13, 1951.

Gary Faulkner, San Bernardino County Fire Department, *Phone conversation with ESA,* October 20, 2010.

Geographic Information Systems, *County of San Bernardino,* http://gis.sbcounty.gov/default.aspx, accessed October 2010.

GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project Phase 1 – Conservation Scenarios,* August 2011.

GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1 and 2, Report No. 1163,* November 1999.

GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis,* September 2011.

GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area,* April 2010.

GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins, Prepared for Cadiz Land Company, Inc. and Mojave Water District,* September 1995.

GEOSCIENCE Support Services, Inc., *Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis,* November 2011.

GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery and Storage Project,* September 2011.

GeoSpatial Data Downloads, http://www.blm.gov/ca/gis/, accessed November 2010.

Geothermal Surveys, Inc., *Ground Water Resources Investigation near Cadiz, San Bernardino County, California*, August 1984, prepared for Cadiz Agricultural Project I, In GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins,* September 1995.

Golden State Water Company, *2010 Urban Water Management Draft Plan, Multiple Water Systems*, 2010.

Golden State Water Company, *2010 Urban Water Management Plan Barstow Final Report,* July 2011.

Golden State Water Company, *2010 Urban Water Management Plan Placentia Draft Report*¸ August 2011.

Golden State Water Company, *2010 Urban Water Management Plan San Dimas Draft Report*¸ August 2011.

Google Earth, accessed June 2011.

Gudde, Erwin Gustav, *California Place Names*, 1969.

Hazlett, R.W., "Some Thoughts on the Development of Amboy Crater" In *Old Routes to the Colorado, San Bernardino County Museum Association Special Publication 92-2*.

Holland, R., *Preliminary Descriptions of the Terrestrial Natural Communities of California*, 1986.

Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, *Nevada's Weather and Climate*, Nevada Bureau of Mines and Geology, Special Publication No. 2, 1975.

Howard, K. A. and D.M. Miller, "Late Cenozoic Faulting at Boundary between Mojave and Sonoran Blocks: Bristol Lake, CA", In S.M. Richard, ed., Deformation Associated with the Neocene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, CA., San Bernardino Museum Special Publications 92-1, 1992.

Howard, K.A., *Geologic Map of the Sheep Hole Mountains 30'x 60' quadrangle, San Bernardino and Riverside Counties, California,* 2002.

HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California*, August 2011.

Hydrobio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California,* September 2011.

Intergovernmental Panel on Climate Change, *Intergovernmental Panel on Climate Change Fourth Assessment Report*, 2007.

Intergovernmental Panel on Climate Change, *Summary for Policymakers, Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* , http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf , accessed, October 2011.

Irvine Ranch Water District, Baker Water Treatment Plant, http://www.irwd.com/your-water/construction-projects/baker.html, accessed October 2011.

Jachens, R.C., and Howard, K.A, "Bristol Lake Basin – A Deep Sedimentary Basin Along the Bristol-Danby Trough, Mojave Desert" In *Old Routes to the Colorado*, San Bernardino County Museums Special Publication 92-2, Redlands, CA, 2002.

Jurupa Community Services District, *2010 Urban Water Management Plan*, May 2011.

Kameran L. Olney, Acting Assistant Secretary for Water and Science, U.S. Department of the Interior, *Correspondence with Senator Dianne Feinstein*, January 18, 2009.

KCDZ FM, http://www.kcdzfm.com/news/fullstory032411.html, accessed July 2011.

Kelly, I. T., and C.S. Fowler, "Southern Paiute," in *Handbook of North American Indians, Volume 11: Great Basin*, 1986.

Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011.

King, C., and D. G. Casebier, *Background to Historic and Prehistoric Resources of the East Mojave Desert Region*, 1976.

Koehler, J.H., *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California:* USGS Water Resources Investigations Report 83-4053, 1983.

Kremmerer, J., *Map of San Bernardino County, California Showing Roads, Railroads, Springs, and Mining Districts of the Desert Portion*, 1925.

Kristen Mouton, Branch Manager of Needles Library, *Phone conversation with ESA*, October 20, 2010.

Kroeber, A. L., *Handbook of the Indians of California*, 1925.

Lease, Richard Oliver, Nadine McQuarrie, Michael Oskin, and Andrew Leier, *Quantifying Dextral Shear on the Bristol-Granite Mountains Fault Zone: Successful Geologic Prediction from Kinematic Compatibility of the Eastern California Shear Zone*, Journal of Geology, Vol. 117, 2009.

Levy, Steve, *California's Changing Demography: Implications for Housing, Center for the Continuing Study of the California Economy*, http://www.scag.ca.gov/events/pdfs/demo23/p4Levy.pdf, accessed September 2011.

Lieutenant Rich Boswell, San Bernardino County Sheriff's Department, *Phone conversation with ESA*, October 20, 2010.

Longitudinal Lease Agreement between ARZC and Cadiz, September 17, 2008.

M.L. Davisson, *Discussion Regarding Sources and Ages of Groundwater in Southeastern California*, Lawrence Livermore National Laboratory, March 2000.

Maas, J., *Depth to Basement Calculated from Gravity Data*, Proprietary Report to Cadiz Land Company, Inc., 1994, In CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010.

Memorandum of Lease Agreement between Cadiz Real Estate, LLC and Arizona & California Railroad Company, dated September 17, 2008.

Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement, Volumes I and 2*, September 2001.

Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report, Biological Resources*, 1999.

Metropolitan Water District of Southern California, *2006 Revised Power Integrated Resource Plan for Metropolitans's Colorado River Aqueduct Power Operations*, October 2006.

Metropolitan Water District of Southern California, *2010 Integrated Water Resources Plan*, 2010.

Metropolitan Water District of Southern California, *Integrated Water Resources Plan 2010 Update: Executive Summary*, 2010, http://www.mwdh2o.com/mwdh2o/pages/yourwater/irp/IRP2010ExecutiveSummary.pdf, accessed October 2011.

Metropolitan Water District of Southern California, *Member Agencies: Three Valleys Municipal Water District*, www.mwdh2o.com/mwdh2o/pages/memberag/agencies/threevalleys.htm, accessed February 2011.

Metropolitan Water District of Southern California, *Regional Urban Water Management Plan 2010*, November 2010.

Midwest Research Institute, *Improvement of Specific Emission Factors (BACM Project No. 1) Final Report Prepared for the South Coast AQMD*, November 1995.

Mike Anton, "Destiny in the Desert", Los Angeles Times, January 2007.

Miles, S.R. and C.B. Goudey, *Ecological Subregions of California*, USDA Forest Service Technical Report R5-EM-TP-005, 1997.

Mojave Desert Air Quality Management District, *2004 Ozone Attainment Plan (State and Federal), April 2004.*

Mojave Desert Air Quality Management District, *CEQA and Federal Conformity Guidelines*, February 2009.

Mojave Desert Air Quality Management District, *Rule Book: Regulation IV –Prohibitions; Regulation XI – Source Specific Standards*, http://www.mdaqmd.ca.gov/index.aspx?page=138, accessed November 2011.

Memorandum of Understanding between the State of California and the Department of the Interior on Renewable Energy, October 12, 2009.

Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California,* California Department of Water Resources Bulletin 91-14, 1967.

Myrick, David, F., *Railroads of Nevada and Eastern California: Volume Two-The Southern Roads*, 1963.

National Conservation Resource Service, *Fourwing Saltbush (Atriplex canescens (Pursh.) Nutt*, Factsheet, January 2002.

National Park Service, *Mojave National Preserve, General Management Plan*, 2002.

National Public Radio, *California Desert Becomes Home for Renewable Energy,* http://www.npr.org/templates/story/story.php?storyId=102679730, accessed August 2011.

Neves, J., and J. Goodman, *Site Record for CA-SBR-10521*, on file at SBAIC, San Bernardino County Museum, Redlands, 2000.

NORCAL Geophysical Consultants, Inc., *Seismic Reflection Survey Cadiz Valley, Cadiz, California*, Proprietary Report to Cadiz, 1997.

Norris, Robert M. and Robert W. Webb, *Geology of California*, Second Edition, 1990.

Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005.

Pacific Municipal Consultants, *General Plan Amendment and Greenhouse Gas Reduction Plan, Draft Supplemental Program Environmental Impact Report*, March 2011.

Paleo Solutions, *Paleontology Survey and Assessment for the Cadiz Groundwater Project, San Bernardino County, CA*, November 2010.

Parker, R.B., *Recent Volcanism at Amboy Crater San Bernardino County*, California Division of Mines and Geology Special Report 76, *1963.*

PCR Services Corporation, *Technical Memorandum: Assessment for CEQA Compliance – Cadiz Valley Aquifer Storage Project*, October 2006.

Peabody v. Vallejo, 2 Cal.2d 351 (1935).

Petersen, Mark D., William A. Bryant, Chris H. Cramer, Tianqing Cao, and Michael Reichle, *Probabilistic Seismic Hazard Assessment for the State of California,* California Department of Conservation, Division of Mines and Geology, Open-File Report 96-08, and U.S. U.S. Geological Survey Open-File Report 96-706, 1996.

PR Newswire, *29 Palms PV Project Press Release*, http://www.prnewswire.com/news-releases/independent-energy-solutions-powers-up-new-us-marine-corps-solar-project-in-29-palms-126215078.html, accessed September 2011.

Price, Evelyn J. and Roland Bürgmann, *Interactions between the Landers and Hector Mine, California, Earthquakes from Space Geodesy, Boundary Element Modeling, and Time-*

Dependent Friction, Bulletin of the Seismological Society of America, V. 92, No. 4, May 2002.

PRISM Climate Group, *Latest PRISM Data*, www.prism.oregonstate.edu, accessed October 2010.

RBF Consulting, *Power Requirements Analysis Technical Memorandum, Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California, Phase* 1, November 2010.

Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006.

Rice Solar Energy Project, http://ricesolarenergy.com, accessed June 2011.

Robert J. Mellors, Lydie Sichoix, and David T. Sandwell, *Lack of Precursory Slip to the Hector Mine Earthquake as Constrained by INSAR*, Bulletin Seismological Society of America, Vol.92(4), 2002.

Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, 1989.

Rustycans.com, *Can of the Month: Eastside Beer*, http://www.rustycans.com/COM/month0305.html, accessed December 2010.

San Bernardino Archaeological Information Center, California Historical Resources Information System, records search for the Cadiz Groundwater Project, September 28, 2010.

San Bernardino County Fire Department website, http://www.sbcfire.org/fire rescue/southd1.asp, accessed October 2010.

San Bernardino County Public Library website, http://www.sbcounty.gov/library/home/, accessed October 2010.

San Bernardino County, *Notice of Preparation of a Draft Supplement to the County of San Bernardino General Plan Program Environmental Impact Report for the Proposed Countywide Greenhouse Gas Emissions General Plan Amendment, GHG Reduction Plan and Development Code Amendments*, http://www.sbcounty.gov/ehlus/Depts/Planning/documents/GHGSEIRFinalGHGNOP.pdf, accessed September 2011.

San Bernardino County, *San Bernardino County 2011 Community Indicators Report*, May 2011.

San Diego Association of Governments, *Board Report: 2050 Regional Growth Forecast, Board of Directors Agenda Item No. 10-02*-16, February 2010.

San Diego Association of Governments, *Info: 2030 Regional Growth Forecast Update No. 2*, July 2008.

San Diego County Water Authority, *News Release: QSA remains most reliable path for California's Colorado River Supplies*, http://www.sdcwa.org/qsa-remains-most-reliable-path-californias-colorado-river-supplies, accessed October 2011.

Santa Margarita Water District, *2010 Urban Water Management Plan*, July 2011.

Santa Margarita Water District, *About Us: Operations*, www.smwd.com/operations.htm, accessed December 2010.

Santa Margarita Water District, *Water Supply Assessment for "The Ranch Plan" General Plan Amendment/Zone Change (PA 01-113) Rancho Mission Viejo*, June 2003.

Sawyer, J. and T. Keeler-WoIf, *A Manual of California Vegetation, 1995 Online Manual*, http://davisherb.ucdavis.edu/cnpsActiveServer/index.html, accessed November 2010.

Semitropic Water Storage District, *Delta Wetlands Project Place of Use Draft EIR*, April 2010.

Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964.

Sheppard, J. M., *Le Conte's Thrasher (Toxostoma lecontei)*, January 1996.

Shuford, W.D., and Gardali, T., *California Bird Species of Special Concern*, February 2008.

Simpson, R.W., R.C. Bracken and D.J. Stierman, *Aeromagnetic, Bouguer Gravity, and Interpretation Maps, Sheep Hole-Cadiz Wildness Study Area, California*: USGS MF 1615-B, 4 sheets, scale 1:62,500 (ID163), 1984.

Skinner, M.W., Pavlik, B.M., *Inventory of Rare and Endangered Vascular Plants of California: Electronic Inventory Update of 1994, 5th Edition*, 1997.

Solar PEIR website, http://solareis.anl.gov/maps, accessed September 2011.

South Coast Air Quality Management District, Board Meeting, Agenda No. 31 – *Interim CEQA GHG Significance Threshold for Stationary Sources, Rules and Plans*, December 2008.

Southern California Association of Governments, *Draft Statistics for Existing Housing Need: The 5th Cycle of Regional Housing Needs Assessment (RHNA) for SCAG Region, Attachment 2 Household Distribution by RHNA Income Category Based on County Median Income (MHI) from American Community Survey 2005-09 5-year average – unincorporated San Bernardino County*, July 2011.

Southern California Association of Governments, *Integrated Growth Forecast, Adopted 2008 RTP Growth Forecast, by City*, http://www.scag.ca.gov/forecast/downloads/excel/RTP07_CityLevel.xls, accessed October 2011.

Southern California Association of Governments, *Local Profiles Report 2011 for Unincorporated Areas of San Bernardino County*, May 2011.

Southern California Assoication of Governments, *Integrated Growth Forecast*, http://www.scag.ca.gov/forecast/index.htmk, accessed October 2010.

Southern California Assoication of Governments, *Profile of the Unincorporated area of San Bernardino County*, May 2011.

SouthWest Water Company, *Suburban Water Systems*, www.swwc.com/suburban/about-our-water/, accessed February 2011.

Star Javier, District Coordinator, San Bernardino County Fire Department, *Phone conversation with ESA*, October 20, 2010.

State Mining and Geology Board, *A Report of Mineral Land Classification and Designation Under the Surface Mining and Reclamation Act of 1975*, State Mining and Geology Board Information Report 2008-05, July 2008.

State of California Department of Transportation, *Statement of Ongoing Contracts as of 06/20/11*, June 2011.

State of California, Governor's Office of Planning and Research, *General Plan Guidelines*, October 2003.

State of California, Health and Safety Code, Chapter 6.95, Section 25501(o).

State Water Resources Control Board Cases, 39 Cal.Rptr.3d 189, 267-72 (Cal. App. 3 Dist. 2006).

State Water Resources Control Board, *Adoption Of Policy Entitled Sources Of Drinking Water*, Resolution No. 88-63, as Revised by Resolution No. 2006-0008, 2006.

State Water Resources Control Board, *GeoTracker Database*, http://www.geotracker.swrcb.ca.gov/map/, accessed April 2011.

Suburban Water Systems, *2010 Urban Water Management Plan*, June 2011.

Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "*Advances in Understanding Mojave Desert Prehistory*," in *California Prehistory: Colonization, Culture, and Complexity*, 2007.

Tetra Technologies, *Draft Preliminary Study: ARZC Railroad Alignment*, 2008.

Tetra Technologies, *Location of Various Exploration Boreholes, Coreholes, Wells, and Production Pits, Bristol Dry Lake, California*, Plate 1, November 1999.

The Public Policy Institute of California, *Adapting California's Water Management to Climate Change*, November 2008.

The Renewable Energy Action Team Mitigation Account Memorandum of Agreement between the Renewable Energy Action Team Agencies and the National Fish and Wildlife Foundation, May 2010.

Thompson, D.G., *The Mojave Desert Region, California: A Geographic, Geologic, and Hydrologic Reconnaissance*, U.S. Geological Survey Water Supply Paper 578, 1929.

Thompson, David G., *Relief Map of Part of Mohave Desert Region Showing Desert Watering Places*, 1917-1918.

Three Valleys Municipal Water District, *2010 Urban Water Management Plan*, June 2011.

Tierra Environmental Services, *Cultural Resources Survey Report for the All American Pipeline Replacement Project, Daggett to Blythe, San Bernardino and Riverside Counties, California*, 2001.

Tierra Madre Consultants, Inc., *Draft Cadiz Valley Rare Plant Surveys*, June 1999.

Todd, David K., *Groundwater Resource Investigations near Cadiz, San Bernardino County, California*, October 1984.

Todd, David K., *Supplemental Information on Groundwater Resources near Cadiz, California*, November 1984.

Town of Yucca Valley, *General Plan*, March 2011.

Transportation Research Board, *Highway Capacity Manual*, 2000.

Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist., 45 P.2d 972, 1007 (Cal. 1935).

U.S. Army Corps of Engineers, Department of Defense, *Federal Register*, Vol.72, No. 47, March 2007.

U.S. Army Corps of Engineers, *Final Site Inspection Report, Former Cadiz Lake Sonic Target No. 5 and No. 9, San Bernardino County, California*, September 2009.

U.S. Army Corps of Engineers, *Revised Guidance on Clean Water Act Jurisdiction Following the Supreme Court Decision in Rapanos v. U.S. and Carabell v. U.S.*, December 2008.

U.S. Army Corps of Engineers, War Department Corps of Engineers, *Milligan 15' Topographic Map*, 1943.

U.S. Army Corps of Engineers, War Department Corps of Engineers, *Rice 15' Topographic Map*, 1944.

U.S. Bureau of Reclamation, *Indian Trust Asset Policy and NEPA Implementing Procedures*, August 1994.

U.S. Bureau of Reclamation, *Quality of Water, Colorado River Basin, Progress Report No. 22*, 2005.

U.S. Census Bureau, *2010 Census Demographic Profiles, Census Tract 104.09*, http://2010.census.gov/2010census/popmap/, accessed December 2010.

U.S. Department of Agriculture, Forest Service, San Bernardino National Forest, *About the Forest*, www.fs.fed.us/r5/sanbernardino/, accessed October 2010.

U.S. Department of Agriculture, Natural Resources Conservation Service, *Farmland Protection Policy Act*, http://www.nrcs.usda.gov/programs/fppa/, accessed October 2010.

U.S. Department of Energy and U.S. Department of the Interior, *Draft Solar Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States*, December 2010.

U.S. Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011*, April 2011.

U.S. Department of the Interior, National Park Service, *Historic Resource Study: A History of Land Use In Joshua Tree National Monument*, September 1983.

U.S. Department of the Interior, National Park Service, *National Register Bulletin: How to Apply the National Register Criteria for Evaluation*, 1995.

U.S. Department of the Interior, Office of the Solicitor, *Memorandum of Opinion M-37025 Partial Withdrawal of M-36964*, November 2011.

U.S. Department of the Navy, Bureau of Land Management, Federal Aviation Administration, and U.S. Marine Corps, *Draft Environmental Impact Statement Land Acquisition and Airspace Establishment to Support Large-Scale Marine Air Ground Task Force Live Fire and Maneuver Training, Marine Corps Air Ground Combat Center, Twentynine Palms, CA*, February 2011.

U.S. Department of Transportation Federal Railroad Administration, *Record of Decision, DesertXpress High-Speed Passenger Train*, July 2011.

U.S. Ecology, Inc., *California Low-Level Radioactive Waste Disposal Facility License Application*, 1989.

U.S. Environmental Protection Agency, *Draft Guidance on Identifying Waters Protected by the CWA*, May 2011.

U.S. Environmental Protection Agency, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, December 1971.

U.S. Environmental Protection Agency, *PSD and Title V Permitting Guidance for Greenhouse Gases*, 2010.

U.S. Fish & Wildlife Service, *Revised Recovery Plan for the Mojave Population of the Desert Tortoise (Gopherus agassizii)*, May 2011.

U.S. Fish and Wildlife Service, *2010 List of Federal Endangered or Threatened Species for San Bernardino County*, 2010.

U.S. Fish and Wildlife Service, *Desert Tortoise (Mojave Population) Recovery Plan*, 1994.

U.S. Fish and Wildlife Service, Division of Migratory Bird Management, *Birds of Conservation Concern*, December 2002.

U.S. Fish and Wildlife Service, *Endangered and Threatened Wildlife and Plants: Determination of Critical Habitat for the Mojave Population of the Desert Tortoise, Federal Register 55(26):5820-5866*, Washington, D.C., 1994.

U.S. Fish and Wildlife Service, *Field Survey Protocol For Any Non-Federal Action That May Occur Within The Range of The Desert Tortoise*, January 1992.

U.S. Fish and Wildlife Service, *Preparing for Any Action That May Occur Within the Range of the Mojave Desert Tortoise (Gopherus agassizii)*, 2010

U.S. Geological Survey, *Mineral Resources Online Spatial Data*, http://mrdata.usgs.gov/mineral-resources/active-mines.html, accessed April 2011.

U.S. Geological Survey, *Cadiz 15' Topographic Map*, 1956.

U.S. Geological Survey, *Iron Mountains 15' Topographic Map*, 1956.

U.S. Geological Survey, *Milligan 15' Topographic Map*, 1956.

U.S. Geological Survey, *Rice 15' Topographic Map*, 1954.

U.S. Geological Survey, *Active Mines and Mineral Plants in the U.S. 2003,* http://mrdata.usgs.gov/mineral-resources/active-mines.html, accessed April 2011.

U.S. Geological Survey, *Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region, California: A Digital Database,* USGS Open File Report 00-444, 2000.

U.S. Geological Survey, *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report*, Groundwater Resources, Volumes 1 and 2, 2000*:* Memorandum from J.F. Devine to M.S. Brady, February 2000.

U.S. Geological Survey, *Special Report: The Hector Mine Earthquake, 10/16/1999,* http://pasadena.wr.usgs.gov/hector/report.html, accessed April 2010.

U.S. Marine Corps, Twentynine Palms Marine Corps, *Land Acquisition and Air Space Establishment Study Updates*, http://www.marines.mil/unit/29palms/LAS/pages/updates.aspx, accessed July 2011.

URBEMIS 2007 Version 9.2.4, February 2008; Appendix F1.

Vallecitos Water District, *2010 Urban Water Management Plan,* http://www.vwd.org/uploads/I_Section_5_Water_Quality_Final.pdf, accessed August 2011.

Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert*, 1981.

Vredenburgh, Larry M., *An Overview of Mining in the California Desert*, http://vredenburgh.org/mining_history/pages/mining_overview2005.htm, accessed December 2010.

Warren, C. N., "The Desert Region", In *California Archaeology*, 1984.

Warren, Elizabeth Von Till, Robert H. Crabtree, Claude N. Warren, Martha Knack, and Richard McCarty, *A Cultural Resources Overview of the Colorado Desert Planning Units,* 1981.

Water Replenishment District of Southern California, *Will Climate Change Affect Groundwater in the Central and West Coast Basins?*, Technical Bulletin Volume 10, 2007.

Weigand, J. and S. Fitton, *Le Conte's Thrasher (*Toxostoma lecontei*),* In *The Draft Desert Bird Conservation Plan: a strategy for reversing the decline of desert-associated birds in California*, http://www.prbo.org/calpif/htmldocs/desert.html, accessed November 2010.

Williams, D. F. *Mammalian Species of Special Concern in California*, June 1986.

Wood, Warren. W., *Use and Misuse of the Chloride Balance Method in Estimating Ground Water Recharge*, in Groundwater, Vol. 37, No.1, January 1999.

Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., *California's Wildlife, Vol. 2, Birds*, California Department of Fish and Game, 1990.

CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Scoping Report

Introduction

The Santa Margarita Water District is the Lead Agency for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project) that would be constructed in the Cadiz and Fenner Valleys in the eastern Mojave Desert portion of San Bernardino County, California. SMWD, along with other participating water agencies acting as Responsible Agencies, is proposing to implement the Project in partnership with Cadiz Inc. (Cadiz), a Delaware Corporation that owns approximately 34,000 contiguous acres of land in the Cadiz and Fenner Valleys (Cadiz Property), and the Fenner Mutual Water Company (FMWC), a non-profit California mutual water company formed to deliver water at cost to its shareholders that are comprised of public water systems that purchase water from the Project. Cadiz would make available its land, easements, and appurtenant rights for the operation of the Project.

Substantial quantities of percolating groundwater underlie the Cadiz property. The groundwater naturally flows to the Bristol and Cadiz Dry Lakes and is lost to evaporation. The total volume of groundwater in storage in the Watersheds has been estimated to be more than 20 million acre-feet (MAF).

In the Project area, the depth to water is consistently more than 180 feet below ground surface (bgs), reaching over 400 feet bgs in some areas. In parts of the Watersheds the groundwater extends to depths of nearly 2,000 feet bgs. The proposed Project would be executed in two phases, each of which is described in more detail below. The entire Project would be operated under two guiding principles: to optimize the reasonable and beneficial use of water and to do so without causing harm to the environment.

Notice of Preparation

On March 1, 2011, a Notice of Preparation (NOP) for the proposed Project was submitted to the California Office of Planning and Research (State Clearinghouse and Planning Unit) and distributed to Responsible and Trustee Agencies, County Clerks, and other interested parties for a 30-day review period that ended March 30, 2011 (see Attachment 1). A Notice of Completion (NOC) was also prepared by SMWD and sent to the State Clearinghouse (see Attachment 2). The NOP was mailed to approximately 120 interested parties, including local, state, and federal agencies and groups or individuals who had expressed interest in the Project. The NOP was distributed via certified mail or FedEx delivery (see Attachment 3). Copies of the NOP were made available for public review on the SMWD website (http://www.SMWD.com), at the SMWD offices located at 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- San Bernardino County Library, 104 W. 4th Street, San Bernardino, CA 92415
- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twentynine Palms, CA 92277
- City of Barstow Library, 304 E. Buena Vista St., Barstow, CA 92311
- City of Needles Library, 1111 Bailey, Needles, CA 92363
- Joshua Tree Library, 6465 Park Blvd., Joshua Tree, CA 92252

Scoping Meetings

The 30-day project scoping period, which began with the distribution of the NOP on March 1, 2011, remained open through March 30, 2011. SMWD held two public scoping meetings during the 30-day public scoping period. On March 16, 2011, SMWD held a meeting at their District Boardroom on 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688. On March 24, 2011, SMWD held a meeting at the Joshua Tree Community Center at 6171 Sunburst Street, Joshua Tree, CA 92252. The District placed public notices advertising the scoping meetings and announcing the availability of the NOP in the following newspapers on the following dates (see Attachment 4):

- The Press-Enterprise: Sunday March 13 and Sunday March 20.
- The Orange County Register: Sunday March 13 and Sunday March 20.
- Desert Trail: Thursday March 17.
- Hi Desert Star: Saturday March 12 and Saturday March 19.

The next formal opportunity for the public to comment on the proposed Project will occur when the Draft Environmental Impact Report is distributed for a 45-day review period, which is currently anticipated to occur sometime in early fall 2011.

NOP Comments

During the scoping period, SMWD received **25** comment letters via mail, e-mail or facsimile (see Attachment 5) and received verbal and written comments at the public scoping meetings (see Attachment 6). Table A-1 lists the comments that were received via mail and email. Table A-2 shows dates of oral comments received during the public scoping meetings.

TABLE A-1
NOP COMMENTS RECEIVED VIA MAIL AND EMAIL

	Agency/Affiliation	Name of Individual	Date of Comment Received
Federal Agencies			
1	US Department of Interior – National Park Service	Christine Lehnertz	March 29, 2011 (via mail)
2	United States Marine Corps	B.R. Norquist	March 29, 2011 (via mail)
State Agencies			
3	Office of Planning and Research (State Clearinghouse)	Scott Morgan	March 1, 2011 (via mail)
4	Department of Toxic Substances Control	Leonard Robinson	March 21 2011 (via mail)
5	Native American Heritage Commission	Dave Singleton	March 21, 2011 (via mail)
6	California Department of Fish and Game	Michael Flores	March 30, 2011 (via mail)
Organizations			
7	Mojave Desert Air Quality Management District	Alan De Salvio	March 2, 2011 (via mail)
8	East Mojave Land Owners Association	Richard MacPherson	March 21, 2011 (via mail)

	Agency/Affiliation	Name of Individual	Date of Comment Received
9	San Bernardino County Public Works Department	Annesley Ignatius	March 23, 2011 (via mail)
10	Center for Biological Diversity	Ileene Anderson	March 28, 2011 (via mail)
11	Mojave Preserve Land Owners Association	Richard MacPherson (2)	March 28, 2011 (via email)
12	Defenders of Wildlife	Jeff Aardahl	March 29, 2011 (via mail)
13	National Parks Conservation Association	Seth Shteir	March 29, 2011 (via mail)
14	Metropolitan Water District	John Shamma	March 30, 2011 (via mail)
15	Mojave Desert Heritage and Cultural Association	Chris Ervin	March 30, 2011 (via mail)
16	San Bernardino County Land Use Services Department	Christine Kelly	March 30, 2011 (via mail)
Individuals			
17	Public commenter	Joe Ross	March 12, 2011 (via email)
18	Public commenter	Russel and Marilyn Woodruff	March 23, 2011 (via mail)
19	Public commenter	Brenden Hughes	March 25, 2011 (via email)
20	Public commenter	Valerie Finstad	March 25, 2011 (via mail)
21	Public commenter	Chris Brown	March 28, 2011 (via email)
22	Public commenter	Elden Hughes	March 28, 2011 (via email)
23	Public commenter	Helena Bongartz	March 28, 2011 (via email)
24	Public commenter	Helena Bongartz (2)	March 29, 2011 (via email)
25	Public commenter	Chris Ervin	March 30, 2011 (via mail)

TABLE A-2
NOP COMMENTS RECEIVED AT SCOPING MEETINGS

Agency/Affiliation	Meeting Date, Location
Oral public comments	March 16, 2011, District Boardroom, Rancho Santa Margarita
Oral public comments	March 24, 2011, Joshua Tree Community Center

Contents of this Report

This Scoping Report contains documents pertinent to the scoping process. The following items are included:

Attachment 1: Notice of Preparation
Attachment 2: Notice of Completion
Attachment 3: NOP Distribution List
Attachment 4: Proof of Publication of Public Notices
Attachment 5: Comment Letters Received by SMWD
Attachment 6: Scoping Meeting Comments
Attachment 7: Matrix of Comments
Attachment 8: Matrix of Alternative Suggestions

Attachment 1
Notice of Preparation

BOARD OF DIRECTORS
BETTY H. OLSON, PH.D CHARLEY WILSON
SAUNDRA F. JACOBS BILL LAWSON
ROGER FAUBEL JOHN J. SCHATZ
GENERAL MANAGER

Santa Margarita Water District

NOTICE OF PREPARATION OF A DRAFT EIR AND PUBLIC SCOPING MEETING NOTICE

Cadiz Valley Water Conservation, Recovery, and Storage Project

To: California Office of Planning and Research; Responsible and Trustee Agencies; County Clerks; and Other Interested Parties

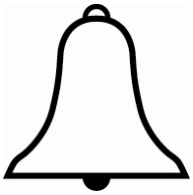
Subject: Notice of Preparation of an Environmental Impact Report and Public Scoping Meeting Notice

Project: Cadiz Valley Water Conservation, Recovery, and Storage Project

Lead Agency: Santa Margarita Water District

This Notice of Preparation (NOP) has been prepared to notify agencies and interested parties that the Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). SMWD, along with other participating water agencies acting as Responsible Agencies, is proposing to implement the Project in partnership with Cadiz Inc. (Cadiz), which owns approximately 34,000 acres of land located in the Cadiz and Fenner Valleys of San Bernardino County, and the Fenner Mutual Water Company (FMWC), a non-profit California mutual water company formed to deliver water at cost to its shareholders that are public water systems that purchase water from the Project.

Substantial quantities of percolating groundwater underlie the Cadiz property. The groundwater naturally flows to the Bristol and Cadiz Dry Lakes (Dry Lakes) and is lost to evaporation. The proposed Project would be executed in two phases: the first phase of the Project is the Conservation and Recovery Component, and the second phase is the Imported Water Storage Component. In the first phase, the Conservation and Recovery Component would be constructed to capture and conserve the average annual natural recharge in the Fenner and northern Bristol Valleys that would otherwise discharge to the Bristol and Cadiz Dry Lakes. The Project would construct extraction wells (wellfield) on the Cadiz property and a 42-mile underground water conveyance pipeline within an active railroad right-of-way that intersects the Colorado River Aqueduct (CRA). The



Project would extract the amount of water that would otherwise flow to the Dry Lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years.

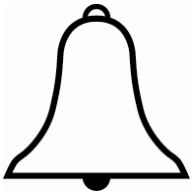
A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects (Cal. Water Code § 79170 et seq.). Under the Imported Water Storage Component, Colorado River water would be conveyed to recharge basins in the Fenner Valley to percolate into the ground for storage and future withdrawal as a dry-year supply. Because the Imported Water Storage Component would be implemented at a later date, it will be evaluated in the EIR on a programmatic basis. Prior to implementing the Imported Water Storage Component, it will undergo appropriate further environmental review consistent with CEQA.

SMWD is acting as Lead Agency as the first public agency with a discretionary decision regarding the Project and because the Project will be owned in part and operated by SMWD. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD and other Responsible Agencies when considering approval of the Project. Other confirmed participating water providers include Three Valleys Municipal Water District, Suburban Water Systems, and Golden State Water Company.

In accordance with the time limits mandated by CEQA, comments on the NOP must be received by SMWD no later than 30 days after publication of this Notice. We request that comments on this NOP be received no later than March 30, 2011. Please send your comments, including a return address and contact name, via mail to this address:

c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
Telephone: 213-599-4300
FAX: 213-599-4301

Or by email to: cadizproject@esassoc.com



Public meetings will be held to receive public comments and suggestions on the Project. One scoping meeting will be held in San Bernardino County and a second scoping meeting will be held within SMWD's service area. The scoping meetings will be open to the public on the following dates and in the following locations:

Wednesday, March 16, 2011, 4 p.m.
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

Thursday, March 24, 2011, 6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

PROJECT LOCATION AND SETTING

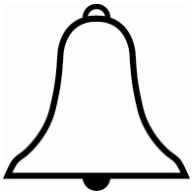
The Project proposes active management of the groundwater basin underlying Cadiz Inc. property in the Cadiz and Fenner Valleys located in the eastern Mojave Desert, San Bernardino County, California (**Figure 1**). The purpose of the Project is to develop a new, reliable water supply and storage facility for SMWD and other participating water providers. The Project would be operated by FMWC, which is comprised of shareholders that are public water systems.

The Project area is located at the confluence of the Fenner Valley and Orange Blossom Watersheds (Watersheds), which span nearly 1,300 square miles and contain an estimated total volume of groundwater in storage of more than 20 MAF. The Project area is underlain by an aquifer system composed of saturated alluvial materials, limestone-carbonates, and granitic rocks with a depth to groundwater of consistently more than 180 feet below ground surface (bgs) and reaching over 400 feet bgs in many areas.

PROJECT DESCRIPTION

The Project would be implemented in two phases:

> The first phase, referred to as the **Conservation and Recovery Component**, would employ a strategy to lower water levels beneath Cadiz property in the vicinity of the proposed Project wellfield to establish hydraulic control and intercept groundwater presently migrating to the Bristol and Cadiz Dry Lakes and being lost to evaporation. Facilities that would be constructed under the first



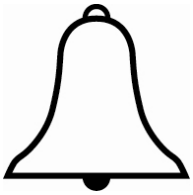
phase include a Project wellfield, water conveyance facilities, tie-in to the Colorado River Aqueduct (CRA), access roads, and power supply and distribution facilities.

- The second phase, referred to as the **Imported Water Storage Component**, would use the established hydraulic control for the importation, storage and recovery of imported developed water made available from the CRA. Facilities that would be constructed under the second phase include a Project wellfield expansion, extension of the water conveyance facilities, CRA diversion structure and pump station, access roads, expansion of the power supply and distribution facilities, and spreading basins.

A. Conservation and Recovery Component

As part of the Conservation and Recovery Component, native groundwater currently being lost annually to evaporation at the Bristol and Cadiz Dry Lakes from the aquifer system underlying the Project area would be captured and conserved through the active management of the groundwater basin. Wells would be constructed within the Fenner Gap portion of the Watersheds to withdraw the amount of groundwater necessary to achieve an optimal level to create a natural hydraulic barrier. The hydraulic barrier would allow for the recovery of groundwater that otherwise would be lost to evaporation. The proposed wells would be constructed on Cadiz property, and a 42-mile underground pipeline would be installed within the privately-owned railroad right-of-way (ROW) that connects the Project wellfield to the CRA. The recovered groundwater would be conveyed to SMWD and other participating water providers through the CRA delivery system owned and operated by the Metropolitan Water District of Southern California (Metropolitan). The Draft EIR will include a detailed project description showing facility locations and access points. **Figure 2** shows the proposed Project, including the following components:

- wellfield area
  - groundwater wells
  - interconnecting pipelines
  - natural gas distribution system
- 42-mile water conveyance pipeline
- CRA tie-in
- equalization storage reservoir and pump station near CRA (if necessary)

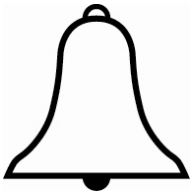


Only the quantity of water that is equal to (a) the amount required to attain an optimal groundwater level, plus (b) the amount of long-term average recoverable recharge, would be extracted from the groundwater basin under the Conservation and Recovery Component. The specific quantity and schedule for groundwater recovery that is required to achieve this objective will be determined by an operations plan. However, the Project would operate under a self-imposed limit so that the total quantity of native groundwater that would be recovered and conveyed to the CRA would not exceed an annual average of 50,000 AFY over the life of the Project, which is considered to be 50 years. During that period, the Project would conserve and recover the sustainable yield that would otherwise have evaporated from the Dry Lakes. The sustainable yield from the Watersheds has been estimated to be approximately 32,500 AFY. As described above, to maintain access to this sustainable yield, the groundwater within the wellfield area would be dewatered to an optimal level. The drawdown would create a groundwater trough that would modify groundwater flow by creating a hydraulic control mechanism. To maintain hydraulic control, an annualized surplus of approximately 17,500 AFY averaged over the life of the Project would be extracted and conveyed to the CRA. This water would be available for delivery to participating water providers, bringing the annual average delivery capacity of the Project to 50,000 AFY.

In certain wet years, participants may opt to decrease or forego their contracted annual groundwater deliveries and instead store that water in the aquifer system at the Project site. This stored water, or "carry-over water," could then be conveyed to Project participants in a future dry year as a supplement to their contracted annual supply. The capacity of the pipeline would be sized to accommodate 75,000 AFY so that carry-over storage water in addition to the contracted annual supply could be accommodated. This would not alter the long-term average annual withdrawal of 50,000 AFY over the 50-year term of the Project.

B. Imported Water Storage Component

The second phase of the Project, the Imported Water Storage Component, would allow for storage of imported surface water from the CRA into the aquifer system. When water is available by direct delivery or exchange, such as surplus water in wet years, a Project participant could convey surplus from the CRA to the Project site via the pipeline. The Project participants for the second phase may include Colorado River rights holders, located in southern California. This water would be recharged into the aquifer system via spreading basins proposed to be constructed on Cadiz property. When needed, participants could extract previously stored surface water from the aquifer system, and it would be conveyed to the CRA and delivered through the CRA delivery system to Project participants. The storage capacity of the aquifer system is estimated to be more than 1 MAF. The second phase would benefit from established hydraulic control. The creation of hydraulic control will allow project participants to store water from year-to-



year without losing the water to evaporation because lowering the water table in the wellfield will also change the gradient and intercept groundwater flowing beneath the surface into the wellfield. Accordingly, the groundwater pumping will act as a barrier to outflow from the groundwater basin into the Dry Lakes where it presently evaporates.

In the event that imported water from the Colorado River is subsequently stored in the Project, the existence of hydraulic control will also allow the imported water to be held in storage for longer periods of time without suffering losses.

The potential quantity and schedule for spreading, storage, and extraction will be explored at the programmatic level in this EIR, pursuant to CEQA Guidelines Section 15168 (14 Cal. Code Regs. § 15168.). Further appropriate environmental review would be conducted as required under CEQA and when specific Project participants are identified and express an interest in accessing the storage space. For example, additional information regarding the specific location and design of the proposed wellfield expansion could be necessary to fully evaluate groundwater quality impacts associated with the Imported Water Storage Component.

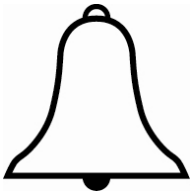
PROJECT APPROVALS

Implementation of the proposed Project will require the following approvals:

- US Fish and Wildlife Service, Endangered Species Act Section 7
- US Army Corps of Engineers, Clean Water Act Section 404
- California Department of Fish and Game, California Fish and Game Code Section 2081 and California Fish and Game Code Section 1602
- Regional Water Quality Control Board, Clean Water Act Section 401; Storm Water Pollution Prevention Plan; Waste Discharge Requirements for spreading basins; and Anti-Degradation Analysis
- Metropolitan Water District of Southern California, Approval to modify CRA and Wheeling Agreement
- Mojave Desert Air Quality Management District, Natural gas engine emissions permits

PROJECT HISTORY

In the early 1990s, Cadiz recognized the potential for developing a groundwater storage and transfer project on its properties and partnered with Metropolitan. Metropolitan, as the lead agency, evaluated the feasibility of operating the project, referred to as the "Cadiz Groundwater Storage and Dry-Year Supply Program" (Program). An EIR/EIS (Environmental Impact Statement) was prepared for the Program, which would have involved transporting surplus Colorado River water to the Program site, recharging it



through a series of recharge basins, storing the water, and then extracting the stored water during times of drought. A pipeline was proposed to be constructed on federal Bureau of Land Management (BLM) land to convey water from the CRA to the Program site. In August 2002, the United States Department of Interior issued a right-of-way grant for the pipeline.[1] However, although the feasibility studies completed under the partnership demonstrated a significant potential for water supply development, Metropolitan decided not to pursue the Program in October 2002.[2]

Since 2002, Cadiz has continued to pursue partnerships to develop a revised water supply project different than the Program previously contemplated with Metropolitan. Because water supply to Southern California from the State Water Project and Colorado River is often either unreliable or unpredictable, and future costs of supply are uncertain, SMWD and other Southern California water purveyors have partnered with Cadiz to augment their current water supply with the new Project, as proposed.

The new proposed Project is distinct from the prior Program because:

a) A conservation component has been added to recover native groundwater currently being lost to evaporation, which was not part of the prior Program;

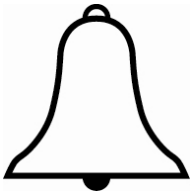
b) The proposed water conveyance pipeline would be constructed within a privately-owned railroad right-of-way, under a 99-year lease agreement, and not on public lands, as was previously proposed;

c) End users have been identified as project participants, as opposed to the prior Program, which only identified one public agency. In addition to SMWD, other confirmed Project participants include Three Valleys Municipal Water District, Suburban Water Systems, and Golden State Water Company.

d) The imported water storage component is not part of the initial project approval. Accordingly, the groundwater extraction facilities have been sized to accommodate the annual variations in the delivery of conserved, recovered and stored indigenous water.

1 U.S. Dept. of the Interior, Bureau of Land Management, Record of Decision for California Desert Conservation Area Plan Amendment and Right-of-Way Grant/Temporary Use Permit, August 29, 2002.

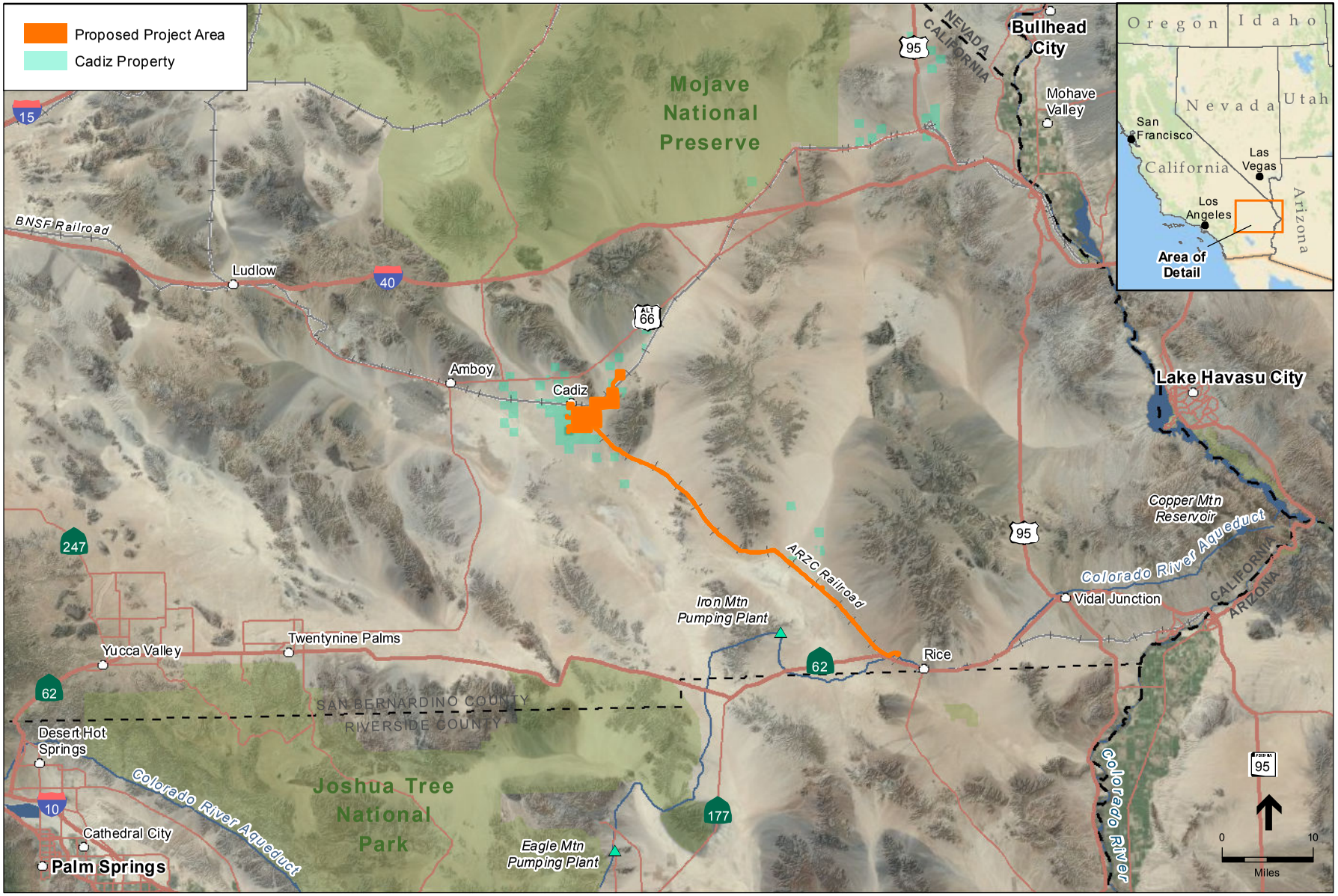
2 Final Environmental Impact Report/Environmental Impact Statement, Cadiz Groundwater Storage and Dry-Year Supply Program, SCH. No. 99021039, Sept. 2001.



DISCUSSION OF POTENTIAL ENVIRONMENTAL IMPACTS

The EIR will address all topics listed in Appendix G of the CEQA Guidelines, regardless of whether the potential impact may be significant, so that information regarding this project is available in a single document to facilitate public review. The content of the EIR will also be subject to input received during the NOP comment period. Where necessary, the EIR will identify mitigation measures to minimize potentially significant impacts of the proposed Project. The EIR will evaluate the following environmental resource issues in addition to CEQA-mandated topics such as cumulative impacts, growth inducement, and Project alternatives:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality and Greenhouse Gas Emissions
- Biological Resources
- Cultural Resources
- Geology, Soils, Faulting and Seismicity
- Hazards and Hazardous Materials
- Hydrology, Water Quality, and Groundwater
- Land Use and Planning
- Population and Housing
- Mineral Resources
- Noise
- Public Services
- Recreation
- Traffic and Circulation
- Utilities & Service Systems / Water Supply

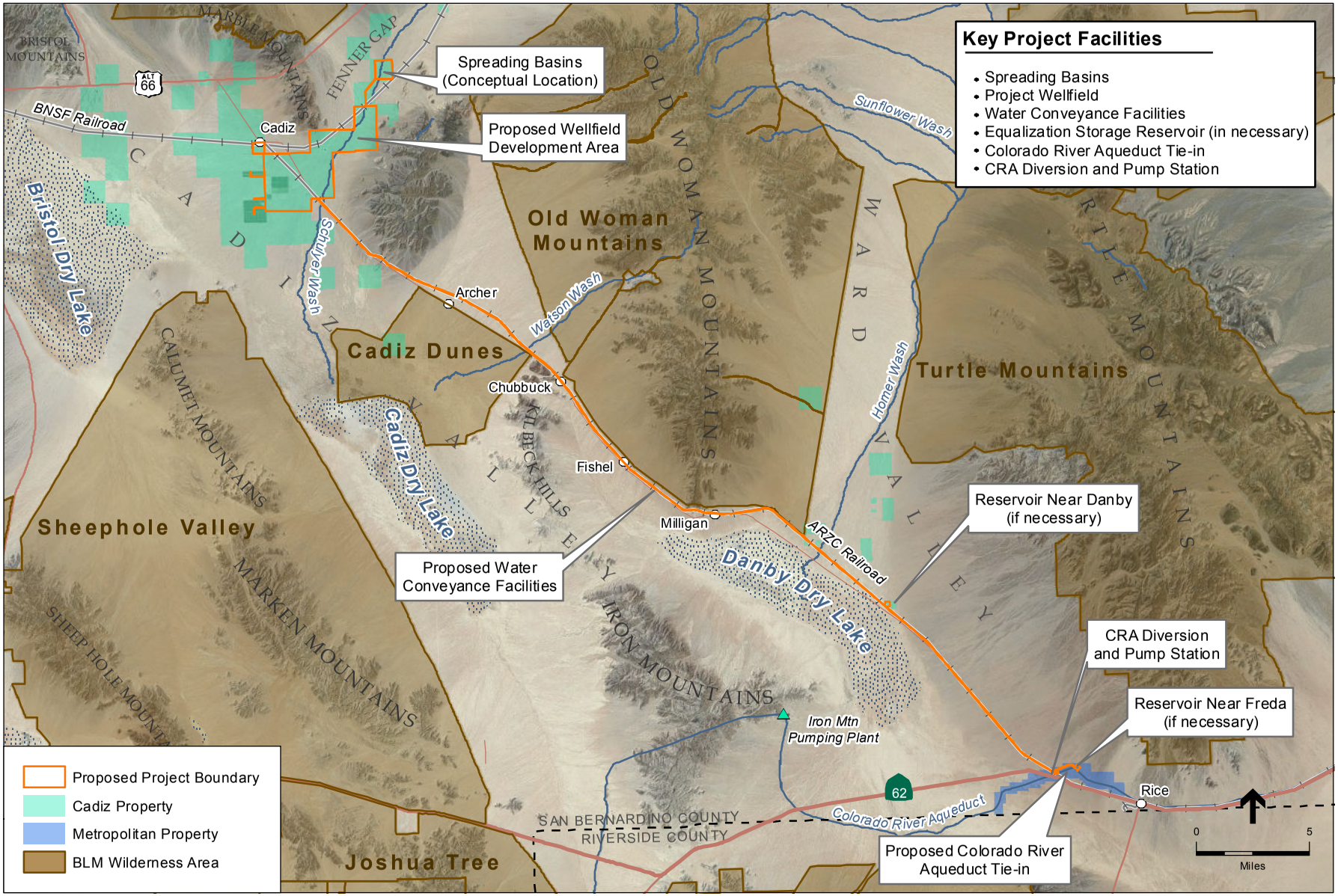


SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 1

Regional Location



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 2

Key Project Facilities

Attachment 2
Notice of Completion

Notice of Completion & Environmental Document Transmittal

Mail to: State Clearinghouse, P.O. Box 3044, Sacramento, CA 95812-3044 (916) 445-0613
For Hand Delivery/Street Address: 1400 Tenth Street, Sacramento, CA 95814

SCH #

Project Title: Cadiz Valley Water Conservation, Recovery, and Storage Project

Lead Agency: Santa Margarita Water District | Contact Person: Tom Barnes

Mailing Address: 626 Wilshire Blvd., Suite 1100 | Phone: 213 599 4300

City: Los Angeles | Zip: 90017 | County: Los Angeles

Project Location: County: San Bernardino | City/Nearest Community: Cadiz

Cross Streets: Cadiz Road & National Trails Hwy | Zip Code: 92304

Longitude/Latitude (degrees, minutes and seconds): 34 ° 18 ′ 38 ″ N / -115 ° 14 ′ 21 ″ W | Total Acres:

Assessor's Parcel No.: | Section: 36 | Twp.: 5N | Range: 14E | Base: SBB&M

Within 2 Miles: State Hwy #: Highway 62 | Waterways: Colorado River Aqueduct (CRA)

Airports: | Railways: ARZC; BNSF | Schools:

Document Type:

CEQA: ☑ NOP ☐ Draft EIR | NEPA: ☐ NOI | Other: ☐ Joint Document
☐ Early Cons ☐ Supplement/Subsequent EIR | ☐ EA | ☐ Final Document
☐ Neg Dec (Prior SCH No.) | ☐ Draft EIS | ☐ Other:
☐ Mit Neg Dec ☐ Other: | ☐ FONSI

Local Action Type:

☐ General Plan Update	☐ Specific Plan	☐ Rezone	☐ Annexation
☐ General Plan Amendment	☐ Master Plan	☐ Prezone	☐ Redevelopment
☐ General Plan Element	☐ Planned Unit Development	☐ Use Permit	☐ Coastal Permit
☐ Community Plan	☐ Site Plan	☐ Land Division (Subdivision, etc.)	☑ Other: Water Supply

Development Type:

☐ Residential: Units	Acres		
☐ Office: Sq.ft.	Acres	Employees	☐ Transportation: Type
☐ Commercial: Sq.ft.	Acres	Employees	☐ Mining: Mineral
☐ Industrial: Sq.ft.	Acres	Employees	☐ Power: Type MW
☐ Educational:			☐ Waste Treatment: Type MGD
☐ Recreational:			☐ Hazardous Waste: Type
☑ Water Facilities: Type Conserve/Store	MGD 75-150		☐ Other:

Project Issues Discussed in Document:

☑ Aesthetic/Visual	☐ Fiscal	☑ Recreation/Parks	☑ Vegetation
☑ Agricultural Land	☑ Flood Plain/Flooding	☑ Schools/Universities	☑ Water Quality
☑ Air Quality	☑ Forest Land/Fire Hazard	☐ Septic Systems	☑ Water Supply/Groundwater
☑ Archeological/Historical	☑ Geologic/Seismic	☐ Sewer Capacity	☑ Wetland/Riparian
☑ Biological Resources	☑ Minerals	☑ Soil Erosion/Compaction/Grading	☑ Growth Inducement
☐ Coastal Zone	☑ Noise	☑ Solid Waste	☑ Land Use
☑ Drainage/Absorption	☑ Population/Housing Balance	☑ Toxic/Hazardous	☑ Cumulative Effects
☐ Economic/Jobs	☑ Public Services/Facilities	☑ Traffic/Circulation	☑ Other: GHG/climate chng.

Present Land Use/Zoning/General Plan Designation:

Agriculture, Resource Conservation

Project Description: *(please use a separate page if necessary)*

The proposed project would be executed in two phases: the first phase, the Conservation and Recovery Component (project level evaluation), would capture and conserve the annual natural recharge in the Fenner and northern Bristol Valleys that would otherwise discharge to the Bristol and Cadiz Dry Lakes. The second phase is the Imported Water Storage Component (program level evaluation), and would make up to one million acre-feet of groundwater storage space available, to store water for future withdrawal.

Note: The State Clearinghouse will assign identification numbers for all new projects. If a SCH number already exists for a project (e.g. Notice of Preparation or previous draft document) please fill in.

Reviewing Agencies Checklist

Lead Agencies may recommend State Clearinghouse distribution by marking agencies below with and "**X**".
If you have already sent your document to the agency please denote that with an "**S**".

x	Air Resources Board	x	Office of Emergency Services
	Boating & Waterways, Department of	x	Office of Historic Preservation
x	California Highway Patrol		Office of Public School Construction
x	Caltrans District # 8	x	Parks & Recreation, Department of
	Caltrans Division of Aeronautics		Pesticide Regulation, Department of
x	Caltrans Planning	x	Public Utilities Commission
	Central Valley Flood Protection Board	x	Regional WQCB # 7
	Coachella Valley Mtns. Conservancy	x	Resources Agency
	Coastal Commission		S.F. Bay Conservation & Development Comm.
x	Colorado River Board		San Gabriel & Lower L.A. Rivers & Mtns. Conservancy
x	Conservation, Department of		San Joaquin River Conservancy
	Corrections, Department of		Santa Monica Mtns. Conservancy
	Delta Protection Commission		State Lands Commission
	Education, Department of		SWRCB: Clean Water Grants
x	Energy Commission	x	SWRCB: Water Quality
x	Fish & Game Region # 6	x	SWRCB: Water Rights
x	Food & Agriculture, Department of		Tahoe Regional Planning Agency
x	Forestry and Fire Protection, Department of	x	Toxic Substances Control, Department of
	General Services, Department of	x	Water Resources, Department of
x	Health Services, Department of		
x	Housing & Community Development		Other:
x	Integrated Waste Management Board		Other:
x	Native American Heritage Commission		

Local Public Review Period (to be filled in by lead agency)

Starting Date March 1, 2011 Ending Date March 31, 2011

Lead Agency (Complete if applicable):

Consulting Firm: Environmental Science Associates
Address: 626 Wilshire Blvd. Suite 1100
City/State/Zip: Los Angeles, CA 90017
Contact: Tom Barnes
Phone: 213 599 4300

Applicant: Santa Margarita Water District
Address: 26111 Antonio Parkway
City/State/Zip: Rancho Santa Margarita, CA 92688
Phone: 949 459 6400

Signature of Lead Agency Representative: _____ **Date:** March 1, 2011

Authority cited: Section 21083, Public Resources Code. Reference: Section 21161, Public Resources Code.

Attachment 3
NOP Distribution List

Reason	Fedex	Certified	First Name	Last Name	Title	Organization	Division	Address	City	State	ZIP	NOP Copies
NEWSPAPERS												
LIBRARIES												
Agency Outreach	X		Linda	Muller	Librarian	City of Twentynine Palms Library		6078 Adobe Rd	Twentynine Palms	CA	92277-2354	1
Agency Outreach	X		Debbie	Medina	Branch manager Librarian	City of Barstow Library	Barstow Library	304 E. Buena Vista St.	Barstow	CA	92311	1
Agency Outreach	X					City of Needles Library	Needles Branch Library	1111 Bailey	Needles	CA	92363	1
Agency Outreach	X				Branch manager Librarian	Rancho Santa Margarita Water District		30902 La Promesa	Rancho Santa Margarita	CA	92688	1
Agency Outreach	X		Leonard	Hernandez	County Librarian	San Bernardino County Library	Library Administration	104 W. 4th Street	San Bernardino	CA	92415	1
Agency Outreach	X		Pat	Gowland	President	Town of Joshua Tree Library	Joshua Tree Branch	6465 Park Blvd	Joshua Tree	CA	92252	1
FEDERAL AGENCIES												
Agency Outreach	X		Robert A.	Johnson		29 Palms Marine Base		G-5, USMC	Twentynine Palms	CA	92277	1
Agency Outreach	X		Jared	Blumenfeld	Regional Administrator	Environmental Protection Agency	Region 9	75 Hawthorne Street	San Francisco	CA	94105	1
Agency Outreach	X		Christine	Lehnertz	Regional Director	National Park Service		1111 Jackson Street, Suite 700	Oakland	CA	94607	1
Agency Outreach	X		Dianne	Feinstein	Senator	Senate		331 Hart Senate Office Building	Washington	DC	20510	1
Agency Outreach	X		Barbara	Boxer	Senator	Senate		112 Hart Senate Office Building	Washington	DC	20510	1
Agency Outreach	X				Regional Manager	Southern California Agency - Bureau of Indian Affairs	Southern California	2038 Iowa Avenue, Suite 101	Riverside	CA	92507	1
Statutory		X	Brian	Moore	Deputy District Engineer	US Army Corps of Engineers	Los Angeles District	PO Box 532711	Los Angeles	CA	90053	1
Agency Outreach	X					US Bureau of Indian Affairs	Office of Public Affairs	1849 C Street NW	Washington	DC	20240-0001	1
Statutory	X		Jeff	Krauss	Division Chief	US Bureau of Land Management	National Public Affairs	1620 L Street NW, Rm. 401	Washington	DC	20036	1
Agency Outreach	X		JoAnn	Schiffer-Burdett		US Bureau of Land Management	California Desert District - Riverside	6221 Box Springs Blvd	Riverside	CA	92507	1
Agency Outreach	X		Rusty	Lee	Field Manager	US Bureau of Land Management	Needles Field Office	1303 S. Hwy 95	Needles	CA	92363	1
Agency Outreach	X		John	Kalish	Field Manager	US Bureau of Land Management	Palm Springs - South Coast Field Office	1201 Bird Center Drive	Palm Springs	CA	92262	1
Agency Outreach		X	Lorri	Gray-Lee	Regional Director	US Bureau of Reclamation	Lower Colorado Region	PO Box 61470	Boulder City	NV	89006	1
Agency Outreach	X					US Department of Agriculture	Natural Resources Conservation Service	14393 Park Ave Sute 200	Victorville	CA	92392	1
Agency Outreach	X		Ken	Salazar	Secretary	US Department of the Interior	Secretary Office	1849 C Street, N.W.	Washington	DC	20240	1
Statutory	X		Robyn	Thorson	Regional Director	US Fish and Wildlife Service	Pacific Region	911 NE 11th Ave	Portland	Oregon	97232	1
Agency Outreach	X		Kara	Capelli	Water	USGS Water Resources Division - Federal Building	California Water Science Center	6000 J Street	Sacramento	CA	95819	1
STATE AGENCIES (SENT BY STATE CLEARING HOUSE AS INDICATED ON NOC)												
Agency Outreach	N/A	N/A	Richard	Corey	Division Chief	California Air Resources Board	Stationary Source Division	PO Box 2815	Sacramento	CA	95812	x
Agency Outreach	N/A	N/A				California Highway Patrol		PO Box 942898	Sacramento	CA	94298	x
Statutory	N/A	N/A	John	Chrisholm	District Coordinator	California Department of Transportation - District 8	District 8	464 W. 4th Street	San Bernardino	CA	92401	x
Agency Outreach	N/A	N/A	Chris	Ratekin	Interim Chief	Caltrans Planning		PO Box 942874	Sacramento	CA	95274	x
Agency Outreach	N/A	N/A	Christopher	Harris	Acting Executive Director	Colorado River Board of California		770 Fairmont Ave Suite 100	Glendale	CA	91203	x
Agency Outreach	N/A	N/A	Tom	Gibbs	Deputy Director	California Department of Conservation		801 K Street, MS 24-01	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A	Erick	Solorio	Project Manager	California Energy Commission	Siting, Transmission, and Environmental Protection	1516 Ninth Street, MS-15	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A			Regional Manager	California Department of Fish and Game	Inland Deserts Region - 6	3602 Inland Empire Boulevard	Ontario	CA	91764	x
Agency Outreach	N/A	N/A	Karen	Ross	Secretary	California Department of Food and Agriculture		1220 N Street	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A	Patti	Cox	Staff Service Analyst	California Department of Forestry		PO Box 944246	Sacramento	CA	94244	x

Agency Outreach	N/A	N/A	Jean	Lacino	Special Assistant to the Director	California Department of Public Health		1615 Capitol Avenue	Sacramento	CA	95815	x
Agency Outreach	N/A	N/A				California Department of Housing and Community Development		1800 Third Street	Sacramento	CA	95811	x
Agency Outreach	N/A	N/A	Alicia	McGee	Assistant Director	California Integrated Waste Management Board	Office of Public Affairs	801 K Street, MS 19-01	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A	Larry	Myers	Executive Secretary	Native American Heritage Commission		915 Capitol Mall, Room 364	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A				California Emergency Management Agency		3650 Schriever Ave	Mather	CA	95655	x
Agency Outreach	N/A	N/A	Milford	Donaldson	State Historic Preservation Officer	Office of Historic Preservation	Sacramento Office	1725 23rd Street, Suite 100	Sacramento	CA	95816	x
Agency Outreach	N/A	N/A	Ruth	Coleman	Director	California Department of Parks and Recreation		PO Box 942896	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A				California Public Utilities Commission		505 Van Ness Avenue	San Francisco	CA	94102	x
Agency Outreach	N/A	N/A	Robert	Perdue	Executive Officer	Colorado River Regional Water Quality Control Board		73-720 Fred Waring Drive, Suite 100	Palm Desert	CA	92260	x
Agency Outreach	N/A	N/A	John	Laird	Secretary	California Resources Agency		1416 Ninth Street, Suite 1311	Sacramento	CA	95814	x
Agency Outreach	N/A	N/A				State Water Resources Control Board	Division of Water Rights	P.O. Box 100	Sacramento	CA	95812	x
Agency Outreach	N/A	N/A				State Water Resources Control Board	Division of Water Quality	P.O. Box 100	Sacramento	CA	95812	x
Agency Outreach	N/A	N/A	L.	Robinson	Director	Calif. Dept. of Toxic Substances Control	Headquarters	PO Box 806	Sacramento	CA	95812	x
Agency Outreach	N/A	N/A			Director	California Dept of Water Resources	Southern District	770 Fairmont Ave Suite 102	Glendale	CA	91203	x
STATE AGENCIES												
Statutory	X		Ryan	Broodrick	Director	California Department of Fish and Game	Headquarter Office	1416 9th Street. 12th Floor	Sacramento	CA	95814	1
Agency Outreach		X	David	Schaub		California Department of Parks and Recreation	Natural Heritage Section	PO Box 942896	Sacramento	CA	94296-0001	1
Agency Outreach		X	Veda	Lewis		California Department of Transportation	Environmental Analysis	PO Box 942874	Sacramento	CA	94274	1
Agency Outreach	X		Linda	Adams	Environmental Protection	California Environmental Protection Agency	Executive Management	1001 I Street P.O. Box 2815	Sacramento	CA	95812	1
Agency Outreach		X				State Clearing House	Office of Planning and Research	1400 Tenth Street	Sacramento	CA	95814	1
Agency Outreach	X		Cy	Oggins	Division Chief Environmental Planning	State Lands Commission	Sacramento Office	100 Howe Ave Suite 100 South	Sacramento	CA	95825-8202	1
LOCAL / REGIONAL AGENCIES												
Agency Outreach	X		Marina	West	General Manager	Bighorn-Desert View Water Agency		622 South Jemez Trail	Yucca Valley	CA	92284	1
Agency Outreach	X		Curt	Mitchell	City Manager	City of Barstow		220 E Mountain View St #A	Barstow	CA	92311	1
Agency Outreach	X		David G.	Brownlee	Acting City Manager	City of Needles		817 Third Street	Needles	CA	92363	1
Agency Outreach	X		John	Tooker	Interim City Manager	City of Twentynine Palms		6136 Adobe Road	Twentynine Palms	CA	92277	1
Agency Outreach	X				Regional Director	Golden State Water Company		630 E. Foothill Blvd	San Dimas	CA	91773	1
Agency Outreach	X		Martha	Ostrander	Associate Engineer	Hi-Desert Water District	Engineering Department	55439 29 Palms Highway	Yucca Valley	CA	92284	1
Agency Outreach	X		William	Brunet	Director of Public Works	Imperial County	Public Works	155 South 11th Street	El Centro	CA	92243	1
Agency Outreach		X			Board of Directors	Imperial Irrigation District		PO Box 937	Imperial	CA	92251	1
Agency Outreach		X			Office Manger	Inland Empire Utilities Agency		P.O. Box 9020	Chino Hills	CA	91709	1
Agency Outreach	X		Richard	Bruckner	Director of Planning	Los Angeles County	Regional Planning	320 West Temple Street, 13th Floor	Los Angeles	CA	90012	1
Agency Outreach	X		Stephen	Jenkins	Lead Air Quality Specialist	Mojave Desert Air Quality Management District	Compliance Department	14306 Park Ave	Victorville	CA	92392	1
Agency Outreach	X		Steve	Mongrain	President	Mojave Desert Heritage and Cultural Association		37198 Lanfair Road G-15	Essex	CA	92332	1
Agency Outreach	X		JoAnn	Finnegan	President	Municipal Water District of Orange County	Board of Directors	18700 Ward Street	Fountain Valley	CA	92708	1
Agency Outreach		X			Office Manager	Orange County	Community Developemt	PO Box 4048	Santa Ana	CA	92702	1
Agency Outreach		X	Mark	Esslinger		Orange County Public Works	Community Developemt	PO Box 4048	Santa Ana	CA	92702	1
Agency Outreach	X				General Manager	Palo Verde Irrigation District	Water Department	180 W. 14th Ave	Blythe	CA	92225	1

Agency Outreach	X				Director	Riverside County	Planning Department - Desert Office	38686 El Cerrito Road	Palm Desert	CA	92211	1
Agency Outreach	X		Warren	Williams	Chief Engineer	Riverside County Flood Control and Water Conservation District		1995 Market Street	Riverside	CA	92501	1
Agency Outreach	X		Ed	Layaye	Agricultural Commissioner	San Bernardino Agricultural Commission		777 E. Rialto Ave	San Bernardino	CA	92415	1
Agency Outreach	X		Ty	Schuiling	Director of Planning	San Bernardino Associated Governments		1170 W. 3rd Street, 2nd Floor	San Bernardino	CA	92410-1715	1
Agency Outreach	X		Laura	Welch	Clerk of the Board	San Bernardino County	Board of Supervisors	385 N. Arrowhead Ave, 2nd Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Christine	Kelly	Director	San Bernardino County	Land Use Services Department	385 N. Arrowhard Avenue - 1st Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Brad	Mitzelfelt	First District Supervisor	San Bernardino County	Board of Supervisors	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Janice	Rutherford	Second District Supervisor	San Bernardino County	Board of Supervisors	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Neil	Derry	Third District Supervisor	San Bernardino County	Board of Supervisors	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Gary	Ovitt	Fourth District Supervisor	San Bernardino County	Board of Supervisors	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Josie	Gonzales	Fifth District Supervisor	San Bernardino County	Board of Supervisors	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Randy	Coleman	Supervisor	San Bernardino County	1st District - Planning Commission	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Raymond	Allard	Supervisor	San Bernardino County	2nd District - Planning Commission	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Bill	Collazo	Supervisor	San Bernardino County	3rd District - Planning Commission	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Elizabeth	Rider	Supervisor	San Bernardino County	4th District - Planning Commission	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Audrey	Mathews	Supervisor	San Bernardino County	5th District - Planning Commission	385 N. Arrowhard Avenue - 5th Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Granville	Bowman	Flood Control Engineer	San Bernardino County	Flood Control District	825 E 3rd Street	San Bernardino	CA	92415	1
Agency Outreach	X		Wes	Reeder	San Bernardino County Geologist	San Bernardino County	Building and Safety Division	385 North Arrowhead Avenue	San Bernardino	CA	92415	1
Agency Outreach	X				Office Manager	San Bernardino County	Building and Safety Division	385 North Arrowhead Avenue	San Bernardino	CA	92415	1
Agency Outreach	X		Greg	Devereaux	CAO	San Bernardino County	County Administrative Office	385 N. Arrowhead Ave	San Bernardino	CA	92415	1
Agency Outreach	X				Office Manager	San Bernardino County Environmental Health	Land Use Services Department	385 North Arrowhead Avenue #2	San Bernardino	CA	92415	1
Agency Outreach	X		Dan	Wurl	Fire Chief	San Bernardino County Fire Department		157 W. 5th Street, 2nd Floor	San Bernardino	CA	92415	1
Agency Outreach	X		Kathleen	Springer	Senior Curator, Geological Science	San Bernardino County Museum		2024 Orange Tree Lane	Redlands	CA	92374	1
Agency Outreach	X		Robert	McKernan	Director	San Bernardino County Museum		2024 Orange Tree Lane	Redlands	CA	92517	1
Agency Outreach	X				Office Manager	San Bernardino County Regional Parks Department		777 E. Rialto Ave	San Bernardino	CA	92415	1
Agency Outreach	X		Josie	Gonzales	Supervisor	San Bernardino International Airport		294 S Leland Norton Way	San Bernardino	CA	92408	1
Agency Outreach	X					San Bernardino Valley Municipal Water District		380 East Vanderbilt Way	San Bernardino	CA	92408	1
Agency Outreach	X				Office Manager	San Diego County	Planning and Land Use	5201 Ruffin Road, Suite B	San Diego	CA	92123	1
Agency Outreach			John	Schatz	General Manager	Santa Margarita Water District		26111 Antonio Parkway	Rancho Santa Margarita	CA	92688	1
Agency Outreach			Joanne	Drabek	Office Manager	Sierra Club		85 Second Street, 2nd Floor	San Francisco	CA	94105	1
Agency Outreach	X		Elden	Hughes		Sierra Club	San Gorgonio Chapter	4079 Mission Inn Avenue	Riverside	CA	92501	1
Agency Outreach	X		Floyd	Wicks	Chief Executive Officer	Suburban Water Systems		1211 E Center Court Drive	Covina	CA	91724	1
Agency Outreach	X					The Nature Conservancy	International Headquarters	4245 North Fairfax Drive, Suite 100	Arlington	VA	22203-1606	1
Agency Outreach	X		Bob	Kuhn	President	Three Valleys Municipal Water District		1021 E Miramar Ave	Claremont	CA	91711	1
Agency Outreach	X		Mark	Nuaimi	Town Manager	Town of Yucca Valley	Town Hall	57090 Twentynine Palms Highway	Yucca Valley	CA	92284	1
Agency Outreach	X				Office Manager	Ventura County	Planning Division	800 South Victoria Ave L-1740	Ventura	CA	93009	1

Organizations

Requested by NAHC		X	Linda	Otero	Direct	AhaMaKav Cultural Society, Mojave Indian		PO Box 5990	Mohave valley	AZ	92346	1
Requested by NAHC		X	Preston	Arrow-weed		Ah-Mut-Pipa Foundation		PO Box 160	Bard	CA	92236	1
Requested by NAHC	X		Tanya	Cecil	General Manager	Arizona and California Railroad		1301 California Ave	Parker	AZ	92363	1
Requested by NAHC	X		Mathew	Rose	Chairman and Chief Executive Officer	Burlington Northern Santa Fe Corporation	Headquarter Office	2650 Lou Menk Drive	Fort Worth	TX	86440	1
Agency Outreach	X		Mike	Winn	Preident	California Building Industry Association		1215 K Street, Suite 1200	Sacramento	CA	95814	1
Agency Outreach	X		Tara	Hansen	Executive Director	California Native Plant Society		2707 K Street, Suite 1	Sacramento	CA	92346	1
by written request		X	Joe	Benitez	Tribal Elder	Chemehueve Indian Tribe		PO Box 1829	Indio	CA	92363	1
Requested by NAHC		X	Charles	Wood	Chairman	Chemehuevi Reservation		PO Box 1976	Chemehuevi Valley	CA	92363	1
Agency Outreach	X		Justin	Nakano	Environmental Specialist	Chino Basin Watermaster		9641 San Bernardino Road	Rancho Cucamonga	CA	91730	1
Agency Outreach		X	Steve	Robbins	General Manager	Coachella Valley Water District		PO Box 1058	Coachella	CA	92222	1
Agency Outreach	X		Christopher	Harris	Acting Executive Director	Colorado River Board		770 Fairmont Avenue, Suite 100	Glendale	CA	92220	1
Requested by NAHC	X		Ginger	Scott	Acting Cultural Contact	Colorado River Reservation		26600 Mojave Road	Parker	AZ	89025	1
Agency Outreach		X	Crystal	Thompson	Contact	Colorado River Water Users Association		PO Box 1058	Coachella	CA	92236	1
Agency Outreach	X		David	Luker	General Manager	Desert Water Agency		1200 Gene Autry Trail	Palm Springs	CA	93263	1
Agency Outreach		X			Office Manager	El Paso Natural Gas Company		PO Box 1087	Colorado Springs	CO	80944	1
Requested by NAHC	X		Tim	Williams	Chairman	Fort Mojave Indian Tribe		500 Merriman Ave	Needles	CA	93555	1
Requested by NAHC	X		Nora	McDowell	Cultural Resources Coordinator	Fort Mojave Indian Tribe		500 Merriman Ave	Needles	CA	92363	1
Requested by NAHC	X		Esadora	Evanston	Environmental Coordinator	Fort Mojave Indian Tribe		500 Merriman Ave	Needles	CA	90048	1
Requested by NAHC	X					Las Vegas Paiut Tribe - Cultural Resources Dept.		1 Paiute Drive	Las Vegas	NV	94105	1
Agency Outreach		X	John	Shamma	Senior Engineer	Metropolitan Water District		PO Box 54153	Los Angeles	CA	90054	1
Agency Outreach		X	Jeff	Kightlinger	General Manager	Metropolitan Water District		PO Box 54153	Los Angeles	CA	90054	1
Requested by NAHC		X				MOAPA Paiute Band of the Moapa Reservation - Cultural Resources Dept.		PO Box 340	Moapa	NV	94612	1
Agency Outreach	X				President	Mojave Desert Heritage and Cultural Association		37198 Landfair Road G-15	Essex	CA	92332	1
Agency Outreach	X		Jackie	Lindgren	District Coordinator	Mojave Desert Resource Conservation District		14393 Park Ave, #200	Victorville	CA	94105	1
Agency Outreach	X				President	Mojave Pipeline Operating Company, Inc		5401 E. Brundage Lane	Bakersfield	CA	90401	1
Agency Outreach	X		Kirby	Brill	General Manager	Mojave Water Agency		22450 Headquarters Drive	Apple Valley	CA	92521	1
Requested by NAHC	X		Michael	Contreras	Cultural Heritage Program	Morongo Band of Mission Indians		12700 Pumarra Road	Banning	CA	92220	1
Requested by NAHC	X		Ernest	Siva		Morongo Band of Mission Indians		9570 Mias Canyon Road	Banning	CA	93307	1
Agency Outreach		X	Laraine	Turk	President	Morongo Basin Desert Conservation Association		PO Box 24	Joshua Tree	CA	92392	1
Agency Outreach	X				Manager	National Chloride Company of America		Amboy Road	Amboy	CA	92277	1
Agency Outreach	X		Tom	Kiernan	President	National Parks Conservation Association		777 6th Street NW Suite 700	Washington	DC	20001	1
Requested by NAHC	X				Regional Manager	Pacific Gas & Electric Company		530 S China Lake Blvd	Ridgecrest	CA	92264	1
Agency Outreach	X		Dr. Peter	Gleick	President	Pacific Institute for Development, Environmental & Security Preservation Park	California Office	654 13th Street, Preservation Park	Oakland	CA	92236	1
Requested by NAHC		X	Joseph	Hamilton	Chairman	Ramona Band of Cahuilla Mission Indians		PO Box 391670	Anza	CA	94612	1
Requested by NAHC	X		James	Ramon	Chairman	San Manuel Band of Mission Indians		26569 Community Center Drive	Highland	CA	91030	1
Requested by NAHC	X		Ann	Brierty	Cultural Resources Department	San Manuel Band of Mission Indians		28669 Community Center Drive	Highland	CA	94945	1
Requested by NAHC		X	Goldie	Walker		Serrano Nation of Indians		PO Box 343	Patton	CA	90401	1

Attachment 4

Proof of Publication of Public Notices

Advertising Receipt

Hi-Desert Publishing
P.O. Box 880
Yucca Valley, CA 92286
Phone: (760)365-3315
Fax: (760)365-8686

Star Legals
PUBLIC NOTICE

YUCCA VALLEY, CA 92284

Cust#: 02101386 000
Ad#: 01548155
Phone: (760)365-3725
Date: 03/14/11

Ad taker: BE **Salesperson:** **Classification:** 999

Description	Start	Stop	Ins.	Cost/Day	Surcharges	Total
03 The Desert Trail	03/17/11	03/17/11	1	173.85		173.85

Payment Reference:

Total:	173.85
Tax:	0.00
Net:	173.85
Prepaid:	173.85
Total Due	0.00

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the

PROOF OF PUBLICATION
(2015.5 C.C.P.)

STATE OF CALIFORNIA
County of San Bernardino

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years, and not a party to or interested in the above-entitled matter. I am the principal clerk of the printer of the:

DESERT TRAIL

a newspaper of general circulation, printed and published WEEKLY in the City of TWENTYNINE PALMS County of San Bernardino, and which newspaper has been adjudged a newspaper of general circulation by the Superior Court of the County of San Bernardino, State of California,

under the date of 11/17 19 38

Case Number 43099; that the notice, of which the annexed is a printed copy (set in type not smaller than nonpareil), has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to-wit:

3/17

all in the year 2011.

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Dated at : TWENTYNINE PALMS

California, this **17th.** day of **March,2011**

Bekie Edelbrock

Signature
Bekie Edelbrock

This space is for the County Clerk's Filing Stamp

Proof of Publication

NOTICE OF PREPARATION OF A DRAFT ENVIRONMENTAL IMPACT REPORT

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the Colorado River Aqueduct (CRA). The Project would extract the amount of water that would otherwise flow to the dry lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years. A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects. This second phase would deliver surplus Colorado River water via the CRA and the 44-mile conveyance pipeline. Various appurtenant facilities and structures would be involved.

A public scoping meeting will be held to receive public comments and suggestions on the project. The following scoping meeting will be open to the public:

Thursday, March 24, 2011
6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

The Notice of Preparation (NOP) will be circulated for a 30-day period, beginning March 1, 2011 and ending March 30, 2011. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD when considering approval of the Cadiz Valley Water Conservation, Recovery, and Storage Project.

In accordance with the time limits mandated by CEQA, comments to the NOP must be received by SMWD no later than 30 days after publication of this notice. We request that comments to this NOP be **received no later than March 30, 2011**. The public and interested parties are invited to comment on the proposed project and submit written comments to:

The public and interested parties are invited to comment on the proposed project and submit written comments to:

Santa Margarita Water District
c/o Tom Barnes, Environmental Science Associates
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017
cadizproject@esassoc.com

The NOP is available on the SMWD website: http://www.SMWD.com and will also be made available at Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twentynine Palms, CA 92277

Please submit your comments by March 30, 2011.
(PUB: T. 3/17/2011)

FREEDOM

The Orange County Register • Excélsior • SqueezeOC.com
Orange County Home • Coast • Preferred Destinations • OC Kids

PAYMENT RECEIPT

Friday, March 11, 2011

Transaction Type: **Payment**
Ad Number: **0009346436**
Apply to Current Order: **Yes**
Payment Method: **Credit Card**
Bad Debt: -
Credit Card Number: **XXXXXXXXXXXX7128 - Mastercard**
Credit Card Expire Date: **February 2012**
Payment Amount: **$796.00**
Amount Due: **$0.00**
Reference Number:
Charge to Company: **OCRC**
Category: **Classified**
redit to Transaction Numbe
Invoice Text:
Invoice Notes:

attn: Pecalle

Customer Type: **Small Business**
Customer Category:
Customer Status: **Active**
Customer Group:
Customer Trade:
Account Number: **1001034169**
Phone Number: **8187038600**
Company / Individual: **Company**
Customer Name: **ESA/WATER**

Customer Address: **21650 OXNARD STREET**

WOODLAND HILLS, CA 91367 USA

Check Number:
Routing Number:

MAR-11-2011 10:47 ORANGE COUNTY REGISTER 714 796 3622 P.01

FREEDOM

The Orange County Register • Excélsior • SqueezeOC.com
Orange County Home • Coast • Preferred Destinations • OC Kids

PAYMENT RECEIPT

Friday, March 11, 2011

Transaction Type:	**Payment**
Ad Number:	**0009346432**
Apply to Current Order:	**Yes**
Payment Method:	**Credit Card**
Bad Debt:	-
Credit Card Number:	**XXXXXXXXXXXX7128 - Mastercard**
Credit Card Expire Date:	**February 2012**
Payment Amount:	**$868.00**
Amount Due:	**$0.00**
Reference Number:	
Charge to Company:	**OCRC**
Category:	**Classified**
redit to Transaction Numbe	
Invoice Text:	
Invoice Notes:	

attn: Nicole

Customer Type:	**Small Business**
Customer Category:	
Customer Status:	**Active**
Customer Group:	
Customer Trade:	
Account Number:	**1001034169**
Phone Number:	**8187038600**
Company / Individual:	**Company**
Customer Name:	**ESA/WATER**
Customer Address:	**21650 OXNARD STREET**
	WOODLAND HILLS, CA 91367 USA
Check Number:	
Routing Number:	

MAR-11-2011 10:48 ORANGE COUNTY REGISTER 714 796 3622 P.02

TOTAL P.02

attn: Priscilla
$196.00

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the Colorado River Aqueduct (CRA). The Project would extract the amount of water that would otherwise flow to the dry lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years. A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects. This second phase would deliver surplus Colorado River water via the CRA and the 44-mile conveyance pipeline. Various appurtenant facilities and structures would be involved.

A public scoping meeting will be held to receive public comments and suggestions on the project. The following scoping meeting will be open to the public:

Thursday, March 24, 2011
6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

The Notice of Preparation (NOP) will be circulated for a 30-day period, beginning March 1, 2011 and ending March 30, 2011. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD when considering approval of the Cadiz Valley Water Conservation, Recovery, and Storage Project.

In accordance with the time limits mandated by CEQA, comments to the NOP must be received by SMWD no later than 30 days after publication of this notice. We request that comments to this NOP be **received no later than March 30, 2011.** The public and interested parties are invited to comment on the proposed project and submit written comments to:

The public and interested parties are invited to comment on the proposed project and submit written comments to:

Santa Margarita Water District
c/o Tom Barnes,
Environmental Science Associates
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017
cadizproject@esassoc.com

The NOP is available on the SMWD website: http://www.SMWD.com and will also be made available at Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twentynine Palms, CA 92277

Please submit your comments by March 30, 2011.

Publish: Orange County Register March 20, 2011 R-386

attn: Nicolee

$868.00

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the Colorado River Aqueduct (CRA). The Project would extract the amount of water that would otherwise flow to the dry lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years. A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects. This second phase would deliver surplus Colorado River water via the CRA and the 44-mile conveyance pipeline. Various appurtenant facilities and structures would be involved.

Two public scoping meetings will be held to receive public comments and suggestions on the project. The scoping meetings will be open to the public at the following dates, times, and locations:

Wednesday, March 16, 2011
4 p.m.
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

and

Thursday, March 24, 2011
6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

The Notice of Preparation (NOP) will be circulated for a 30-day period, beginning March 1, 2011 and ending March 30, 2011. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD when considering approval of the Cadiz Valley Water Conservation, Recovery, and Storage Project.

In accordance with the time limits mandated by CEQA, comments to the NOP must be received by SMWD no later than 30 days after publication of this notice. We request that comments to this NOP be **received no later than March 30, 2011.** The public and interested parties are invited to comment on the proposed project and submit written comments to:

The public and interested parties are invited to comment on the proposed project and submit written comments to:

Santa Margarita Water District
c/o Tom Barnes,
Environmental Science Associates
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017
cadizproject@esassoc.com

The NOP is available on the SMWD website: http://www.SMWD.com and will also be made available at Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twentynine Palms, CA 92277

Please submit your comments by March 30, 2011.

Publish: Orange County Register March 13, 2011 R-385

THE PRESS-ENTERPRISE

CLASSIFIED ADVERTISING RECEIPT

Printed by: **Gribbin, Kristin** Ad #: **10581908**
at: **2:46 pm**
on: **Thursday, Mar 10, 2011**

3450 Fourteenth St.
Riverside, CA 92501-3878
1-800-880-0345
951-684-1200
951-368-9018 Fax

Payment Information

Date	Payment #	Type	Card Holder	Exp.	Approval	Amount
03-10-11	2752113	MasterCard	NICOLLE IANELLI-STEINER	2/12	33049Z	405.00
					Total payments:	$ 405.00

Note: Advertising may be subject to credit approval.

Account Information

Phone #: (818) 703-8600
Name: ESA WATER
Address: 21650 OXNARD STREET
SUITE 1680
WOODLAND HILLS CA 91367

Acct #:
Client:
Placed by: Nicolle Ianelli Steiner
Fax #: (951)

Ad Information

Classification: Legals
Publications: Press-Enterprise

Start date: **03-13-11**
Stop date: **03-13-11**
Insertions: 1

Rate code: LE-Open
Ad type: Ad Liner
Taken by: Gribbin, Kristin

Size: 2x112.260
Bill size: 225.00x 5.14 agate lines

Gross price:	$ 405.00
Net price:	$ 405.00
Total payments:	$ 405.00
Amount Due:	**$ 0.00**

Ad Copy:

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the Colorado River Aqueduct (CRA). The Project would extract the amount of water that would otherwise flow to the dry lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years. A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects. This second phase would deliver surplus Colorado River water via the CRA and the 44-mile conveyance pipeline. Various appurtenant facilities and structures would be involved.

Two public scoping meetings will be held to receive public comments and suggestions on the project. The scoping meetings will be open to the public at the following dates, times, and locations:

Wednesday, March 16, 2011
4 p.m.
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

and

Thursday, March 24, 2011
6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

The Notice of Preparation (NOP) will be circulated for a 30-day period, beginning March 1, 2011 and ending March 30, 2011. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD when considering approval of the Cadiz Valley Water Conservation, Recovery, and Storage Project.

In accordance with the time limits mandated by CEQA, comments to the NOP must be received by SMWD no later than 30 days after publication of this notice. We request that comments to this NOP be **received no later than March 30, 2011.** The public and interested parties are invited to comment on the proposed project and submit written comments to:

THE PRESS-ENTERPRISE

CLASSIFIED ADVERTISING RECEIPT

Printed by: **Gribbin, Kristin** Ad #: **10581908**
at: **2:46 pm**
on: **Thursday, Mar 10, 2011**

3450 Fourteenth St.
Riverside, CA 92501-3878
1-800-880-0345
951-684-1200
951-368-9018 Fax

The public and interested parties are invited to comment on the proposed project and submit written comments to:
Santa Margarita Water District
c/o Tom Barnes, Environmental Science Associates
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017
cadizproject@esassoc.com
The NOP is available on the SMWD website: http://www.SMWD.com and will also be made available at Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twenty-nine Palms, CA 92277

Please submit your comments by March 30, 2011. 3/13

Advertising Receipt

Hi-Desert Publishing
P.O. Box 880
Yucca Valley, CA 92286
Phone: (760)365-3315
Fax: (760)365-8686

Star Legals
PUBLIC NOTICE

YUCCA VALLEY, CA 92284

Cust#: 02101386 000
Ad#: 01548142
Phone: (760)365-3725
Date: 03/11/11

Ad taker: BE **Salesperson:** **Classification:** 999

Description	Start	Stop	Ins.	Cost/Day	Surcharges	Total
01 Hi-Desert Star	03/19/11	03/19/11	1	173.85		173.85

Payment Reference:

Total:	173.85
Tax:	0.00
Net:	173.85
Prepaid:	0.00
Total Due	173.85

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the

PROOF OF PUBLICATION
(2015.5 C.C.P.)

STATE OF CALIFORNIA
County of San Bernardino

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years, and not a party to or interested in the above-entitled matter. I am the principal clerk of the printer of the:

HI-DESERT STAR

a newspaper of general circulation, printed and

published BI-WEEKLY

in the City of YUCCA VALLEY County of San Bernardino, and which news- paper has been adjudged a newspaper of general circulation by the Superior Court of the County of San Bernardino, State of California,

under the date of 11/27 19 61

Case Number 107762 : that the notice, of which the annexed is a printed copy (set in type not smaller than nonpareil), has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to-wit:

3/19

all in the years 2011

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Dated at: YUCCA VALLEY, California,
this **19th.** day **March 2011**

Bekie Edelbrock

Signature
Bekie Edelbrock

This space is for the County Clerk's Filing Stamp

Proof of Publication

NOTICE OF PREPARATION OF A DRAFT ENVIRONMENTAL IMAPCT REPORT

Notice of Preparation of a Draft Environmental Impact Report and Public Scoping Meeting for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz, California)

Santa Margarita Water District (SMWD) as the Lead Agency is beginning preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project). The Project would be designed and implemented in partnership with other Southern California water providers ("Project Participants") to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California. These Project Participants include Golden State Water Company, Three Valleys Water Company and Suburban Water Company.

The purpose of the Project is to capture water that would otherwise evaporate from the local dry lakes, and convey it to SMWD and other Project Participants as a new reliable water supply. The Project would construct extraction wells (wellfield) on the Cadiz property and a 44-mile underground water conveyance pipeline within an active ARZC railway right-of-way that intersects with the Colorado River Aqueduct (CRA). The Project would extract the amount of water that would otherwise flow to the dry lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The pipeline would be sized to convey an annual average of 50,000 acre-feet per year (AFY) of water from the Fenner Valley groundwater basin to SMWD and other participating water agencies, for a period of 50 years. A second phase of the Project, the Imported Water Storage Component, would make available up to one million acre-feet (MAF) of groundwater storage space to be used as part of a conjunctive use project, which is consistent with State policy favoring and supporting conjunctive use projects. This second phase would deliver surplus Colorado River water via the CRA and the 44-mile conveyance pipeline. Various appurtenant facilities and structures would be involved.

A public scoping meeting will be held to receive public comments and suggestions on the project. The following scoping meeting will be open to the public:

Thursday, March 24, 2011
6 p.m.
Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

The Notice of Preparation (NOP) will be circulated for a 30-day period, beginning March 1, 2011 and ending March 30, 2011. SMWD is soliciting the views of interested persons and agencies as to the scope and content of the environmental information to be studied in the EIR. In accordance with CEQA, agencies are requested to review the Project description provided in this NOP and provide comments on environmental issues related to the statutory responsibilities of the agency. The EIR will be used by SMWD when considering approval of the Cadiz Valley Water Conservation, Recovery, and Storage Project.

In accordance with the time limits mandated by CEQA, comments to the NOP must be received by SMWD no later than 30 days after publication of this notice. We request that comments to this NOP be **received no later than March 30, 2011**. The public and interested parties are invited to comment on the proposed project and submit written comments to:

The public and interested parties are invited to comment on the proposed project and submit written comments to:

Santa Margarita Water District
c/o Tom Barnes, Environmental Science Associates
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017
cadizproject@esassoc.com

The NOP is available on the SMWD website: http://www.SMWD.com and will also be made available at Santa Margarita Water District, 26111 Antonio Parkway, Rancho Santa Margarita, CA 92688, and at the following libraries.

- Rancho Santa Margarita Public Library, 30902 La Promesa Drive, Rancho Santa Margarita, CA 92688
- Twentynine Palms Library, 6078 Adobe Rd. Twentynine Palms, CA 92277

Please submit your comments by March 30, 2011.
(PUB: S. 3/19/2011)

Attachment 5

Comment Letters Received by SMWD

United States Department of the Interior

NATIONAL PARK SERVICE
Pacific West Region
1111 Jackson Street, Suite 700
Oakland, California 94607-4807

IN REPLY REFER TO:

L7619 (PWR-P)

29 MAR 2011

Tom Barnes, ESA
626 Wilshire Blvd., Ste. 1100
Los Angeles, CA 90017

Re: *Scoping Comments Responding to Notice of Preparation of Draft Environmental Impact Report for the Cadiz Valley Water Conservation, Recovery and Storage Project*

Dear Mr. Barnes:

By Notice of Preparation (NPO) dated March 1, 2011, the Santa Margarita Water District (SMWD), as the Lead Agency, informed interested parties of its intent to begin preparation of an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) for the *Cadiz Valley Water Conservation, Recovery, and Storage Project* (Project), and invited scoping comments on the EIR to be submitted by March 30, 2011. SMWD, along with other participating water agencies acting as Responsible Agencies, is proposing to implement the Project in partnership with Cadiz Inc. (Cadiz), which owns approximately 34,000 acres of land located in the Cadiz and Fenner Valleys of San Bernardino County, and the Fenner Mutual Water Company (FMWC), a non-profit California mutual water company formed to deliver water at cost to its shareholders that are public water systems that purchase water from the Project. The following letter and attachments constitute the complete set of comments of the National Park Service (NPS) and the Mojave National Preserve (Preserve).

Mojave National Preserve and the Water Resources Division of the National Park Service were involved in the preparation of the preceding draft and final EIR/EIS for the *Cadiz Groundwater Storage and Dry-Year Supply Program* as a cooperating agency and, as a result, have some familiarity with this proposed project, now headed by the Santa Margarita Water District renamed the Cadiz Valley Water Conservation, Recovery and Storage Project. From the project description posted on the Santa Margarita Water District website it appears that the proposed hydrology is very similar to the previous project, with a planned annual extraction of native groundwater at a rate of 50,000 acre-feet per year but with the major difference being the planned route of the water conveyance infrastructure.

Our comments regarding this NOP revolve around two primary issues: the sustainability of the proposed pumping rate and the use of the Arizona & California Railroad Company right-of-way from Cadiz to the Colorado River Aqueduct.

TAKE PRIDE® IN AMERICA

The NOP describes the Arizona & California Railroad Company right-of-way as a privately owned railroad right-of-way, not on public lands, and identifies the US Fish and Wildlife Service and the US Army Corps of Engineers as the only two federal agencies involved. The Project proponents need to demonstrate that the proposed path of the water conveyance infrastructure is entirely on privately owned land and not on a right-of-way that includes portions of public land. If the property in the path of the water conveyance infrastructure is entirely on private land then the NOP misidentifies the role of the US Fish and Wildlife Service. This would not be consultation under §7 of the Endangered Species Act but instead would be §10. If the route of the proposed water conveyance infrastructure crosses any land held by the federal government, this would trigger the National Environmental Policy Act, involve federal land management agencies, and involve the US Fish and Wildlife Service for consultation under §7 of the Endangered Species Act, as the NOP notes.

In addition, the Project proponent should provide confirmation that a right is held, or will be transferred, to use the Arizona & California Railroad Company right-of-way for the express purpose as will be stated in the draft EIR. The NPS is aware of cases in which rights-of-way granted to a railroad or utility foreclose third party or non-railroad/utility use, at risk of reversion to the original grantor, typically the United States or the original railroad. It is noted that an Arizona & California Railroad Company request to abandon portions of the rail line within California has been filed (Surface Transportation Board Decision Document, Docket Number AB_1022_1_X). However, abandoned or not, in the EIR the Project proponent should prove acquisition of needed rights from the legal holder of the right-of-way.

The Project is proposed to be executed in two phases. The first phase is the Conservation and Recovery Component, which would be constructed to capture the average annual natural recharge in the Fenner and northern Bristol Valleys that would otherwise discharge to the Bristol and Cadiz Dry Lakes. In this phase of the Project, extraction wells (well field) would be constructed on the Cadiz property and a 42-mile underground water conveyance pipeline would be constructed within an active, railroad right-of-way that will allow the indigenous groundwater to be conveyed to the Colorado River Aqueduct and southern California for use.

The second phase is the Imported Water Storage Component, which would make available up to one million acre-feet of groundwater storage space to be used as part of a conjunctive use project. In the second phase of the Project, water from the Colorado River would be conveyed to recharge basins in the Fenner Valley to percolate into the ground for temporary storage and future withdrawal and conveyance to southern California as a dry-year water supply. Since the second phase begins at a future date, it is anticipated to be evaluated in the EIR on a programmatic basis. As a result, prior to implementing the second phase of the Project, additional environmental review consistent with CEQA would be necessary.

Water Resource Concerns

The NPS is not averse to the concept of recovering groundwater that naturally discharges to the atmosphere or the concept of using an aquifer to store surplus surface water supplies and extracting these stored supplies during dry years, as long as (1) the Project adopts and adheres

to a hydrologic sustainable yield concept, and (2) the Project does not directly or indirectly affect water resources, water-dependent resources and other natural and cultural resources within NPS park units.

Given proximity of the Project to Mojave National Preserve and considering the fact that most of the natural groundwater recharge to the Fenner Valley originates in the mountains located in the Preserve, the NPS and the Preserve are concerned that groundwater withdrawals associated with the Project have the potential for affecting water resources within the Preserve. Many of the water features in the Preserve are critical to supporting rare and threatened species and vegetation, and therefore, could be adversely impacted if effects from Project pumping significantly alter the groundwater flow regime throughout the Fenner Valley. As a result, the NPS and the Preserve asks that the Lead Agency and the other Responsible Agencies be guided by sound peer-reviewed science in the development and preparation of the EIR for the Project.

The EIR should recognize that most of the groundwater recharge studies conducted in the study area indicate that natural recharge to the Fenner and Bristol Valleys ranges from 2,000 to 11,000 acre-feet per year and that the Project's recharge estimate is 3 to 120 time too high.

The NPS's greatest concern with respect to the Project is related to potential pumping impacts on the water resources within the Fenner Valley and Bristol Valley watersheds. Past groundwater studies in these two valleys and under the former Cadiz Project suggest that most of the water recharging these two valleys originates in the higher mountainous areas located within the Mojave National Preserve, which is managed by the NPS. Given the amount of recoverable groundwater that the Project proponent is seeking to extract from these two watersheds, the NPS is concerned that the proponent is substantially overestimating the amount of natural precipitation recharging the groundwater basins in these two valleys. If this proves to be correct, the Project not only will violate the sustainable yield, but there could also be impacts to the Preserve's water resources under the first phase of the Cadiz Project and possibly under the second phase of the project.

The preponderance of previous study results indicates that annual groundwater recharge to Fenner and Cadiz valleys ranges from 270 to 11,200 acre-feet per year (ac-ft/yr), with average and median values of 4,210 ac-ft/yr and 3,700 ac-ft/yr, respectively. This range of values is based on a summary table of recharge study results for these two valleys presented in earlier revised EIS comments submitted by Dr. John Bredehoeft, Ph.D, (HydroDynamics Group, 2001), one of the preeminent groundwater hydrologists in the country. This table is recreated below for reference. NPS is attaching the August 2001 revised EIS comments (Attachment A) submitted by the Dr. Bredehoeft, and incorporates his comments and concerns by reference as part of our submittal of scoping comments and concerns that should be considered and addressed in the Project EIR.

Methodology/Author	Estimate (ac-ft/yr)
1. Watershed Runoff Model – MWD & BLM (1999)	20,000 – 70,000
GeoScience Groundwater Model	50,000
2. Maxey/Eakin Method	
USGS (2000)	2,550 -11,200
Durbin (2000)	5,000
3. Fenner Gap Groundwater Flow	
Friewald (1984 – USGS)	270
LaMoreaux (1995)	3,700

USGS (2000)	2,600 – 4,300
4. Chloride Method (correctly applied)	
USGS (2000)	1,700 – 9,000
Durbin (2000)	2,000
5. Drawdown Associated with Cadiz Co. pumping	
Boyle Engineering (1996)	4,000

In contrast, the Project proponent previously estimated that groundwater recharge to these two groundwater basins ranged from 20,000 to 70,000 ac-ft/yr (see table above). Under the current version of the Project, the proponent has revised the annual recharge estimate to 32,500 ac-ft/yr. In both cases, the Project proponent is still proposing to pump 50,000 ac-ft/yr, so the magnitude of potential impacts has not changed. The current recharge estimate for the Project is approximately 3 to 120 times greater than all previous estimates of groundwater recharge for this area.

In order to evaluate and resolve this wide disparity in the groundwater recharge estimates reported for the study area, the NPS requests that the EIR address the following issues and questions:

- Provide a thorough discussion of all previous hydrologic investigations related to quantifying the amount of water entering, moving through and discharging from the groundwater system(s) beneath the study area or in other proximal valleys. As the lead agency in preparing the EIR, SMWD is required to utilize all available peer-reviewed science to critically evaluate the possible impacts to water resources in these basins posed by the Project. If there are wide disparities between previous and current estimates of groundwater recharge, underflow and discharge, the major findings of the previous and current studies should be presented in the EIR for fair and equal consideration. If there is disagreement with the results of previous or current studies such that one set of the results are eliminated from further consideration, then a thorough discussion should be presented stating the technical reasons for the disagreement. This will lay the foundation for critically evaluating the Project study results against previous study results.

- The current estimate of annual groundwater recharge for the Project should be supported by several independent lines of analysis. The EIR should thoroughly discuss the different methodologies used to analyze the annual recharge, the data and information supporting each methodology, and the analysis results for each methodology. In cases where the analysis method is similar to a method utilized by a previous investigator in the area and the results vary significantly, the discussion should attempt to ascertain why the results vary (e.g., the analysis method was improperly applied) between the previous and current studies and which set results were ultimately utilized in the EIR.

- If a watershed model is used in the EIR to calculate the recoverable water in the basin, the model should account for bedrock permeability when estimating the amount of recharge to the groundwater system. The model should also incorporate routines to route water through the

surface drainage network and estimate downstream flows and subsequent percolation. The USGS noted these deficiencies as flaws with the watershed model developed for the former Cadiz Project.

- If a chloride mass balance approach is used in the EIR to support groundwater recharge estimates, it should be properly applied to the study area. In the opinion of the USGS, the project proponent misapplied their chloride mass balance approach under the former Cadiz Project in estimating the amount of recharge to the flow system, as they assumed a much higher chloride concentration of precipitation than values used by other previous investigators in the area.

- If isotopic data are used in the EIR to support groundwater recharge estimates, proper data should be collected so that reliable groundwater age determinations can be made or estimated. In their previous attempt to use carbon-14 data to date the groundwater under the former Cadiz Project, the project proponent reported apparent groundwater ages ranging from 11,500 to 14,000 years before present, but suggested that rock-water reactions had occurred and as a result, groundwater ages were younger than the apparent ages indicated. This deficiency can be corrected by (1) collecting aquifer material samples and analyzing for carbon-13/carbon-14 content so that site specific age corrections can be made, or (2) estimating corrected carbon-14 ages for the groundwater using data and rock-water reactions interpreted from other studies. The USGS attempted the latter as part of its previous review and noted that corrected carbon-14 ages ranged from 5,500 to 10,600 years before present, which suggests a very low current-day recharge rate.

- Estimate of annual groundwater discharge from the groundwater flow system should be supported by several independent lines of analysis. Under the former Cadiz Project, USGS in its technical review suggested that discharge estimates by soil evaporation from the Bristol and Cadiz dry lakes were not supported by physical soil evaporation measurements at these sites and groundwater level measurements beneath the dry lakes. Additionally, the project proponent was encouraged by the USGS to utilize existing study results from around the region which have attempted to quantify soil evaporation rates off of similar salt encrusted dry lakes (e.g., USGS study in Death Valley) in order to ascertain the likely amount of groundwater discharge from the flow system. The USGS also recommended that contribution to soil evaporation from the dry lakes due to surface water runoff not be neglected, as it was under the former Cadiz Project. The Project proponent must demonstrate through physical measurements of water loss from the dry lake areas and through measurement of groundwater depths beneath the dry lake areas that groundwater discharge is actively occurring at these dry lake areas. The USGS noted in their previous review that the project proponent's discharge estimate in their groundwater flow model (50,000 ac-ft/yr) was unreasonable on the basis of the depth to water (estimated to be 10 feet or greater) and soil characteristics beneath the dry lake areas. The USGS recommended installation of multiple depth monitoring wells to determine the depth of water

beneath the dry lakes, and the use of energy-budget methods or salt crust accumulation methods to better quantify the water loss off of the dry lakes. Quantification of water loss off of these two dry lakes is extremely important - this is the limiting factor on the amount of recharge entering the flow system and how much recoverable water is available for the project. If it is shown that the amount of soil evaporation occurring at the dry lake areas is small or negligible, then the Project's claim to being sustainable must be re-evaluated.

The lead agency should consider seeking an impartial technical review of the EIR's water resource impact analysis from the US Geological Survey.

Given the sensitivities associated with a regional groundwater exportation project on the scale of the Project and the fact that the Lead Agency, SMWD, is also one of the entities that stands to benefit from this project, the NPS recommends that the SMWD seek an impartial technical review of the Project proponent's water resource impact analysis from the USGS to assess the technical soundness of the hydrologic analysis. Such a commitment may help to alleviate potential concerns by the public related to perceptions of a conflict of interest by SMWD and the other participating water agencies acting as Responsible Agencies, and better inform all interested parties as to whether or not the Project is economically and environmentally feasible, as proposed. An outside technical review by the USGS will help to provide another level of due diligence to the project, which may have value in alleviating concerns that the participating water agencies' water users and investors might have about the Project.

Retaining the USGS to conduct a technical review is consistent with the history of the Cadiz Project. In its previous incarnation as the Cadiz Groundwater Storage and Dry-Year Supply Program (former Cadiz Project), the USGS was asked by the Bureau of Land Management (BLM) to conduct a technical review of the *Draft Environmental Planning Technical Report, Groundwater Resources, Volumes I and II (Draft Report)* to assess the technical soundness of the water resource impact analysis. At that time, it was the opinion of the USGS review team that the Project proponent's regional watershed model, water balance studies, and groundwater flow and transport models were used without adequate data to support the results and conclusions presented in the Draft Report. Their opinion appears to be largely predicated on concerns with an overestimation of natural recharge (and discharge) from the groundwater flow system in the study area by the project proponent. The NPS agreed with most of the USGS's original concerns about characterization of the water resource impacts associated with the former Cadiz Project. Accordingly, the NPS is attaching the February 2000 technical memorandum (Attachment B) submitted by the USGS outlining their concerns with the Draft Report, and incorporates the USGS concerns by reference as part of our submittal of scoping comments and concerns that should be considered and addressed in the Project EIR.

Presumably, in the decade that has passed since this technical review was conducted, the Project proponent has had time to consider and address many of the technical concerns presented by the USGS leading up to the current proposal. Given the USGS's familiarity with the water resource conditions in the Mojave Desert region and with the former Cadiz Project in general, it would be advantageous to all to have the USGS perform another technical review of the revised Project to assess whether or not the USGS's original concerns have been addressed, and if there are new concerns with the analysis that should be addressed. The NPS is concerned that the Project proponent continues to have an overly optimistic view of the amount of recoverable groundwater in the Fenner Valley and Bristol Valley, which would preliminarily indicate that many of the USGS's original concerns have not been

addressed in the interim. If this is the case, the NPS believes that the lead agency should use the USGS's previous technical review as a starting point from which to formulate and evaluate the water resource impact analysis for the current EIR.

The EIR should thoroughly evaluate and discuss the potential impacts associated with the various elements of the Conservation and Recovery Component of the Project.

In general, the NPS is not averse to the concept of recovering groundwater that naturally discharges to the atmosphere, as long as total annual withdrawals do not exceed the annual sustainable yield of the groundwater basin, and given any project pumping does not directly or indirectly affect water resources, water-dependent resources, and other natural and cultural resources within units of the NPS. After reviewing the description of the first phase of the Project (i.e., Conservation and Recovery Component) in the NOP, the NPS has identified the following initial concerns with some of the proposed elements that should be addressed in the EIR:

- The EIR should clearly demonstrate the Project's need for the groundwater stored in the Bristol and Fenner Valleys. Information on current and future water demands within the service areas of the participating water districts should be presented and thoroughly discussed. Information on current and future water demands for existing water users in these two valleys should also be presented and discussed so that potential economic and environmental impacts to the users of the indigenous water supply can be evaluated. What other measures are being taken to conserve the participating water districts' current water supplies and have other sources of supplemental water supplies been assessed?

- How is the first phase of the Project going to conserve or be sustainable when it is proposing to extract an amount equal to the long-term average annual recoverable recharge in the watersheds plus an additional amount required to attain an optimal groundwater level needed to maintain hydraulic control? The description of this phase of the Project in the NOP states that the Project will extract 32,500 ac-ft/yr (the project proponent's estimated sustainable yield of the watersheds) plus an additional 17,500 ac-ft/yr of groundwater to maintain hydraulic control of the groundwater flow system in the Fenner Gap area. These totals account for the Project's self-imposed annual operational limit of 50,000 ac-ft/yr, all of which will be conveyed out of the watershed to the Colorado River Aqueduct. Based on this description, the Project discloses that it will be mining an additional 17,500 ac-ft/yr of groundwater beyond an already optimistic estimate of the sustainable yield. If the proposed Project is truly striving to be environmentally sustainable and part of a larger holistic approach to water supply development as is states on its project web site, then it should strive to maintain its total groundwater pumping within the sustainable yield of the watersheds. What has not been accounted for in the description of the first phase of the Project is the amount of existing pumping that is occurring within these watersheds, which is already utilizing some of the sustainable yield. This presumably includes agricultural pumping by the project proponent (previously estimated to be 4,000 – 5,000 ac-ft/yr) and other agricultural, industrial, municipal and domestic pumping in the watersheds.

Once these existing groundwater withdrawal totals are determined, the Project should only be allowed to develop what sustainable yield remains, if any, in order to remain sustainable.

- In the planning and operational phases, how does the Project propose to confirm that groundwater levels beneath the Bristol and Cadiz Dry Lakes have been lowered sufficiently by Project pumping to cause natural evaporation to cease? If the premise of the Project is to capture or recover groundwater destined for natural evaporation from these dry lake areas, then the Project should be required to demonstrate that soil evaporation is actively occurring from the dry lakes and that their pumping will lower groundwater beneath the dry lake discharge areas to a level that prevents the natural evaporation from occurring during the life of the Project. If this cannot be demonstrated and the Project is allowed to proceed, then the Project will effectively mine upwards of 50,000 ac-ft/yr of groundwater from the groundwater basin, while as much of 32,500 ac-ft/yr of natural evaporative discharge is allowed to continue from the groundwater basin. This could have substantial effects on groundwater levels and spring discharges throughout the groundwater basin over the life of the project.

- The meaning of "hydraulic control" must be addressed in presenting Phase I of the proposed Project. Does hydraulic control only relate to establishing a sufficient area of drawdown in the vicinity of the Fenner Gap to intercept groundwater moving through that area, or does it also apply to lowering the groundwater levels in the area enough to cause natural evaporation to cease from the dry lake areas (see previous comment)? Does hydraulic control also include groundwater injection to help prevent the possible migration of highly saline groundwater beneath the dry lake area toward the project well field? A figure prepared by CH2M Hill (see Attachment C) and posted on the home page of the Cadiz Project web site conceptually illustrates an injection well located downgradient between the conceptual project well field and a dry lake, suggesting that groundwater injection will be utilized to prevent migration of highly saline groundwater toward the Project well field. If groundwater injection is envisioned as part of establishing hydraulic control for the Project, then the EIR should thoroughly discuss and demonstrate the effectiveness of this approach. As part of the discussion, the EIR should identify how much additional groundwater is needed for injection to achieve the desired hydraulic control, where this water will come from, the potential effects on the groundwater flow system resulting from pumping this water from the groundwater basin, and whether sufficient lowering of groundwater levels beneath the dry lake areas can still be achieved to prevent natural evaporation from occurring in these areas (see previous comment).

- The EIR should address in detail whether California statutes allow for the banking of unused groundwater rights (i.e., carry-over groundwater) for use in future years, and if so, how this banking of carry-over groundwater will be managed under Phase I and Phase II of the Project, when surplus Colorado River water supplies also may be stored in the aquifer. Additionally, please describe how this carry-over management will be factored into groundwater modeling scenarios conducted as part of the EIR assessment. Conceptually, please describe whether the

plan is to withdraw unused groundwater in wet years and artificially recharge it back into the aquifer for future use, or to cease pumping in wet years and pump an additional amount of groundwater in a dry year equal to the unused wet year allotment plus the dry year allotment. The EIR should clearly demonstrate through worst-case and best-case scenario modeling of reasonable expectations for dry and wet year occurrences whether or not the Project's claim that management of this carry-over water would not alter the long-term average annual withdrawal and associated impacts over the 50-year term of the Project.

- The EIR should provide a thorough evaluation and discussion of reasonable alternatives to the Proposed Action. The NPS would like to recommend that one of the alternatives include an evaluation of the Project under a lower recharge setting that is in line with previous recharge study results in the area. As noted in an earlier scoping comment, the preponderance of available information on recharge estimates for watersheds in this part of the Mojave Desert indicates a likely annual recharge on the order of 5,000 ac-ft/yr. If the wide disparity between estimates of annual recharge in this area cannot be resolved, then it is also reasonable for a similar project alternative formulated under lower recharge conditions to be considered and evaluated as part of the EIR. Also recommended is that the "environmentally preferred" alternative be identified in the EIR.

- The EIR should utilize groundwater flow modeling to simulate the potential impacts to water resources in the project area watersheds resulting from groundwater extraction during Phase I of the Project, and artificial recharge and groundwater extraction during Phase II of the Project. Modeling simulations should be conducted for the Proposed Action and all of the alternative actions evaluated under the EIR. In its review of the Draft Report submitted under the former Cadiz Project, the USGS noted several deficiencies in the groundwater flow modeling effort conducted at that time and provided recommendations for improving the groundwater flow model's predictive capabilities. The NPS agrees with most of the USGS's assessment and suggests that any groundwater flow model developed under this EIR address the following concerns, many of which were identified from the previous modeling effort:

    - The groundwater flow model should be calibrated to lower estimates of recharge and discharge for the flow system. The USGS noted in its previous review that the former groundwater flow model was incorrectly calibrated as a result of overestimation of natural recharge and discharge in the model. The consequence of an incorrectly calibrated model was inaccurate simulations of steady-state and transient conditions and unreasonable predictions of water levels and fluxes in response to the proposed put/take scenarios.

    - A properly calibrated groundwater flow model should be used to simulate the long-term effects (100 to 1,000 years) of the currently proposed Project on groundwater levels and groundwater discharge to the Bristol and Cadiz Dry Lake areas. To accommodate this

simulation, the USGS recommended expanding the model grid to evaluate the long-term impact of withdrawals on spring discharge and water levels in the Fenner Valley.

- A density-dependent solute transport model is needed to accurately simulate the movement of the highly saline brine beneath the dry lake areas. Under the former Cadiz Project, a nondensity-dependent model, MT3D, was used to simulate the brine movement. The USGS correctly noted that use of a nondensity-dependent model calls into question any results and conclusions regarding the water levels and movement of brine near the dry lakes.

- The conceptualization and development of the groundwater flow model should take into consideration the presence and potential effects that faults might have on the groundwater flow system. The USGS noted in their previous review that several major fault structures were ignored in the conceptualization of the previous model that have the possibility of acting as barriers and/or conduits for flow. Additional hydrogeologic studies may be needed to assess the hydrologic nature of these faults and how they should be addressed in the model.

- The groundwater flow model should utilize realistic estimates of aquifer parameters that can be substantiated either through direct field measurement/testing or published estimates of parameter properties for similar hydrogeologic materials and settings. Under the former Cadiz Project, the USGS noted in their review that the hydraulic conductivity and transmissivity values were too high in the groundwater flow model, which allowed the optimistically high flux rates that were assumed in the previous modeling attempt. Another area of concern noted by the USGS was the use of an excessively deep extinction depth (100 feet) for the bare soil evaporation occurring at the dry lake areas in the model, which allowed much more flux (discharge) to leave the flow system. The USGS review noted that existing studies of bare soil evaporation at that time indicated evaporation extinction depths should be 10 feet or less. The USGS concluded from their review of the former groundwater modeling attempt that the model could not transmit the excessively high inflows (recharge) without increasing the simulated hydraulic gradient beyond the observed hydraulic gradient, even when using unreasonably high transmissivity values, and without having an unreasonable evaporation extinction depth.

- Water level recovery simulations should be conducted as part of the EIR to assess how long it would take for groundwater levels to recover to their original levels under different operating scenarios. This exercise has utility in evaluating whether or not monitoring and mitigation measures such as placement of early warning monitoring systems, a reduction in project pumping, or redistribution of project pumping can be effective measures in avoiding or minimizing possible pumping-related impacts to

water resources in the project watersheds. The NPS's concern is that even after complete cessation of pumping, drawdown affects can continue to propagate throughout the aquifer for a time before water levels start to recover under natural recharge conditions. This was effectively demonstrated in earlier EIS comments submitted by Dr. John Bredehoeft, Ph.D, (see Attachment A) related to the former Cadiz Project. At least two recovery simulations should be conducted for the Proposed Action and for all alternative actions to evaluate water level recovery after the project is shutdown after 50 years of Phase I operations and after 50 years of combined Phase 1 and Phase II operations, so that the range of post-operational water level recovery effects for the proposed project can be evaluated for each action.

The EIR should thoroughly discuss the potential impacts associated with the various programmatic elements of the Imported Water Storage Component of the project.

In general, the NPS is not averse to the concept of using an aquifer to store surplus surface water supplies and extracting these stored supplies during dry years, as long as total annual withdrawals from the aquifer do not exceed the combined annual sustainable yield of the groundwater basin and the amount of surplus water supplies stored in the aquifer, and the project pumping and artificial recharge does not directly or indirectly affect water resources, water-dependent resources and other natural and cultural resources within NPS park units. After reviewing the description of the second phase of the Project (i.e., Imported Water Storage Component) in the NOP, the NPS has identified the following initial concerns with some of the proposed elements that should be addressed in the EIR:

- Please describe in detail the likely availability of surplus Colorado River water supplies that might be stored in the aquifer system during the 50-year life of the Project. Discussion in the NOP notes that water supply to Southern California from the State Water Project and Colorado River is often either unreliable or unpredictable. Given that reality, what effect do the recently negotiated changes to the Colorado River Compact have on future availability of surplus water to participating water agencies? The programmatic evaluation should clearly demonstrate through worst-case and best-case scenario modeling the reasonably expected range of annual surplus water volumes that might be available for storage in the aquifer. This analysis should also factor in potential impacts to Colorado River water supply availability due to potential climate change effects and future water demand projections in the Colorado River Basin.

- The programmatic evaluation of Phase II of the proposed Project should include preliminary modeling of potential impacts to the groundwater flow system resulting from the artificial recharging and subsequent pumping of surplus water supplies that might be stored in the aquifer. Assuming a properly calibrated groundwater flow and transport model is developed to assess the potential pumping impacts related to Phase I of the Project, this same groundwater model should be utilized to estimate both incremental and cumulative effects to the local aquifer resulting from the storage and withdrawal of imported surplus surface water supplies. Modeling simulations should evaluate the potential impacts associated with just Phase II

operations and with combined Phase I and Phase II operations so that incremental and cumulative impacts can be adequately assessed.

- The programmatic evaluation of Phase II of the proposed Project should discuss the potential effects on groundwater levels resulting from storage of surplus surface water supplies in the aquifer. With the stated possibility of storing upward of 1,000,000 ac-ft of surplus water in the aquifer plus additional carry-over groundwater from Phase I of the Project, is there a potential for groundwater levels to rise close enough to land surface, so as to create areas where artificial evaporative (or evapotranspiration) losses could occur? Is there a possibility that the stated hydraulic control could be overwhelmed by the stored surplus water and carry-over groundwater?

- The programmatic evaluation of Phase II of the proposed Project should discuss the expected evaporative losses from the spreading basins that will be used to artificially recharge the aquifer. If evaporative losses are expected, the total volume of stored surplus water to be extracted should be reduced by the estimated volumetric losses due to evaporation from the spreading basins.

If potential adverse impacts to water resources are determined to be significant enough to warrant implementation of mitigation measures, the EIR should first consider the relevancy of the mitigation measures that were developed and proposed under the former Cadiz Project. Given that many of the previous impact concerns are likely to be expressed and evaluated in this EIR, it makes sense to revisit the mitigation measures that were being proposed and developed under the EIS prepared for the former Cadiz Project and determine which measures might have utility to this EIR. Great effort was expended in developing these measures, so they should not be discounted nor neglected if it is determined under this EIR that mitigation measures will be necessary to protect against adverse impacts to the water resources in the Fenner Valley and Bristol Valley. It is possible that some of these measures may need to be adjusted if impact conditions change under the current EIR analysis.

Under no circumstances should monitoring by itself be construed as an acceptable mitigation measure, though it is a necessary activity in determining successful implementation of the Project. Mitigation measures are typically defined as measures that avoid, minimize, reduce and/or eliminate adverse impacts. The EIR should also demonstrate the likely effectiveness of any proposed mitigation measure. Use of a properly calibrated groundwater model can be quite useful in demonstrating the effectiveness of monitoring and mitigation measures such as the placement of an early warning monitoring well system and establishment of trigger levels, a reduction in Project pumping, or a redistribution of Project pumping.

The EIR should provide a thorough discussion on closure plans associated with the Project. Given the 50-year operating period envisioned for the Project, please provide details on closure activities that will be implemented by the Project participants, following shut down of the Project. The discussion should include activities and measures that might be implemented to address remnant impacts to water resources within the project area watersheds.

Thank you for the opportunity to provide scoping comments on this NOP. For any clarification or follow up regarding our comments, please contact Lawrence J. Whalon, Acting Superintendent, Mojave National Preserve at (760)252-6109.

Sincerely,

Patricia L. Neubacher

for

Christine S. Lehnertz
Regional Director

Attachments:3

Cc:
MOJA-S
NPS-WRD

ATTACHMENT A

Revised Comments
Cadiz Groundwater Storage Project
Cadiz and Fenner Valleys
San Bernardino County, California

Prepared by Dr. John Bredehoeft, Ph.D, HydroDynamics Group
for the Western Environmental Law Center
August 2001

THE HYDRODYNAMICS GROUP
Studies in mass & energy transport in the earth

REVISED COMMENTS

CADIZ GROUNDWATER STORAGE PROJECT
CADIZ AND FENNER VALLEYS
SAN BERNARDINO COUNTY, CALIFORNIA

PREPARED FOR: WESTERN ENVIRONMENTAL LAW CENTER
TAOS, NEW MEXICO

JOHN BREDEHOEFT, PH.D.
AUGUST 2001

127 TOYON LANE, SAUSALITO, CA 94965
PO BOX 550, STORY, WY 82842
JDBREDE@AOL.COM
415.332.0666
307.683.3476
530.364.8541 (Fax)

TABLE OF CONTENTS

Overview	2
Introduction	3
The Geographic/Geologic Setting	4
Infeasibility of Monitoring and Control	9
A Five Year Pilot Project	12
A Sustainable Project	13
Conclusion and Recommendation	14
References	15
Figures	

OVERVIEW

I have prepared this supplemental comment in an effort to both clarify and elaborate on points made in made in my earlier report on the proposed Cadiz Water Project. This comment specifically responds 1) to assertions made by the project proponents, 2) to measures that are reportedly being considered by the Agencies responsible for reviewing the project as means of addressing, or avoiding, the concerns raised in my earlier report, and 3) the critiques of other technical reviewers.

[

For example, it has been suggested the inefficacy of the monitoring system that I addressed in my earlier report can be remedied by 1) better placement of the observation wells, 2) by lowering the threshold at which a response would be triggered, and/or 3) or by adjusting the models that are to be used to predict the future response of the groundwater system. While this approach sounds superficially appealing, as I explain below, it does not address the fundamental problem that the recharge is undetermined. It does not address the fact that early warning signals will be subtle, and will be obscured by the operations of recharge and pumping, and by natural fluctuations in water levels. Monitoring for response and control has little chance of being effective.

In addition there is reportedly a proposal to treat the first five years of project life as a pilot project, or trial period, to observe how the groundwater system is responding to project operations. The idea is that magnitude of future extractions of native groundwater would be based upon the aquifer response during the five-year pilot period. As explained below this suggestion, while superficially appealing, is also fraught with problems and as a practical matter probably unworkable.

In this revised comment I conclude:

1. The magnitude of the recharge is an order of magnitude smaller than that suggested by the proponents of the project. The weight of evidence indicates it is approximately 5,000 acre-feet annually (ac-ft/yr) rather than 50,000 ac-ft/yr as the proponents suggest.
2. Monitoring for the purpose of avoiding undesired impacts and controlling the project is unlikely to work because the early warning signals of impending problems are both subtle and small, and will be obscured by the signals associated with the operations along with natural water level fluctuations. The threshold levels of what constitutes an early warning signal of adverse impacts are left unspecified by the project. The remedial measures to stop adverse consequences are also left unspecified.
3. The major uncertainty in assessing the long-term life of the project is the magnitude of the recharge. A pilot project, or trial period, must stress the aquifer sufficiently so as to give an indication of the impact of the long-term pumping of large quantities of native groundwater. The pumping in order to be definitive must be approximately an order of magnitude larger than the current Cadiz Company pumping for agriculture—currently the pumping is approximately 5,000 ac-ft/yr. Pumping 50,000 ac-ft/yr of native groundwater in the first five years of the project is in conflict with the practical consideration that surplus

water from the Colorado River may only be available during the first decade or so of project.

4. A ***sustainable*** Cadiz project is one in which the pumping of native groundwater is restricted to the current rate of pumping by the Cadiz Company for agriculture—approximately 5,000 ac-ft/yr. In a sustainable project the current agriculture pumping would be acquired by the project. ***I recommend a sustainable project in which the pumping of native groundwater is restricted to an average of 5,000 ac-ft/yr.***

INTRODUCTION

Before embarking on the analysis, a brief recap of the principal features of the Cadiz Water Project is in order.

The Cadiz Valley Groundwater Storage Project is proposed to serve three functions: 1) store water from the Colorado River Aqueduct during periods when water is available, 2) pump the water stored, and 3) pump a significant quantity of indigenous native groundwater from the Cadiz and Fenner Valleys when Colorado River water is deficient.

The project facilities consist of a pipeline (approximately 35 miles long) through Cadiz Valley from the Colorado River Aqueduct, at least one pumping station for the pipeline, recharge ponds, and a well field. The recharge ponds are used to infiltrate Colorado River water into the underlying alluvial aquifer where it is stored. The well field is used both to pump out stored water as well as the native groundwater in the area. The facilities are designed to recharge as much 145,000 acre-feet of water per year (ac-ft/yr). Similarly the well field is designed to pump 145,000 ac-ft/yr of groundwater.

The project is proposed both to store water and pump groundwater. The proposal is to extract more groundwater than that which is stored. One scenario of development indicates the project will extract 1,700,000 acre-feet of groundwater in excess of the amount stored during a 50-year period. Under this scenario 1,100,000 acre-feet of Colorado River water will be stored during the 50-year period; however, the total groundwater extracted will be 2,800,000 acre-feet during the period.

The argument put forward in the Draft EIR/EIS is that the 1,700,000 acre-feet of indigenous groundwater pumped is somewhat less than the cumulative recharge to the aquifers in the area during the 50-year period of project operation, and therefore will have no adverse impacts on the groundwater system. The Draft EIR/EIS indicates that the annual recharge is in the range of 40,000 to 50,000 acre-feet per year. It is on this basis that the report suggests little or no adverse impact on the groundwater system. It is the analysis of the impacts of pumping the native groundwater that creates great concern.

In my earlier report (Bredehoeft, 2000) I indicated that:

1. the estimate of annual recharge used in the Draft EIR/EIS is an order of magnitude too high—it is probably only 5,000-6,000 ac-ft/yr;

2. using a more realistic recharge rate there will be adverse impacts to the groundwater system and the environment; and
3. once development has proceeded for a period of several decades simply stopping the pumping of native groundwater, as implied in the Supplemental EIR/EIR, will not halt the adverse environmental impacts—in other words, the groundwater system once perturbed has sufficient persistence that adverse impacts will persist well beyond 100 years, even though the project is stopped after 50 year or earlier.

In this comment I wish to elaborate on some of the points made earlier. In order that the document stands by itself I am restating some of my earlier arguments.

THE GEOGRAPHIC/GEOLOGICAL SETTING

The Cadiz and Fenner Valleys are typical valleys within the Great Basin geographical province. The valleys are situated between mountain ranges. The mountain ranges are composed of older bedrock that ranges in age from PreCambrian through Mesozoic. The mountain ranges were uplifted by the basin and range tectonics of the region. The valleys are underlain by alluvial material that was eroded from the mountain ranges. Often the alluvial valley fill is quite thick, commonly in the more open parts of the valleys several thousand feet thick. The alluvial deposits beneath the valleys are good aquifers.

The valleys and surrounding mountain ranges are often closed topographic basins; the closed topographic basins form closed watersheds. Precipitation that falls in the watershed remains in the watershed. The discharge of water from these closed watersheds occurs either as evaporation or as plant transpiration. This is a desert; the precipitation ranges from a low of the 3 to 4 inches per year in Cadiz Valley to a high of 11 to 12 inches in the higher parts of the Granite Mountains west of Fenner Valley.

Commonly a playa forms in the lowest parts of the valleys in the area. These playas are ephemeral lakes. During periods of unusually high rainfall the runoff from the surrounding area is sufficient that the playas become lakes for a period; however, these events are infrequent. Most times runoff from the surrounding mountains is insufficient to reach the playa. Typically the runoff from winter snowfall and from summer thunderstorms 1) evaporates, 2) is held in the shallow soil where the plants transpire the moisture, or 3) infiltrates to the underlying groundwater table (the ***water table***).

Freshwater is supplied to the playas either as surface runoff in infrequent runoff events, or by underlying groundwater flow. The water evaporates from the playa; as it evaporates it leaves behind dissolved salts. The salts buildup naturally over time in the groundwater associated with the playas. There is highly saline groundwater underlying both Bristol Lake Playa and Cadiz Lake Playa; under Bristol Lake the groundwater is 7 times higher in dissolved salt than seawater. There are commercial salt works associated with both these playas.

The Hydrology of Valleys in the Basin and Range

Under natural conditions the alluvial aquifers that underlie the valleys are full of groundwater. These systems have existed for geologic time. There were periods of higher rainfall in the area during the Pliestocene ice ages. Under natural (virgin) conditions before any development the recharge to the aquifers is balanced by the discharge from the aquifers, or:

Recharge = Discharge (under virgin conditions)

As suggested above, the discharge from the aquifers occurs in many of the closed valleys in the Basin and Range as either evaporation from the playa, or by transpiration from plants in the lower parts of the valleys that draw their water from the water table. (Plants that draw water from the water table are referred to as ***phreatophytes.***) Common plants that draw groundwater from the water table are creosote bush, giant sage, and rabbit brush. Very few of these plants are present in Cadiz Valley; groundwater in this area is thought to discharge, before development, as evaporation from the local playas.

Pumping groundwater in one of these valleys constitutes an additional withdrawal from a system that was in a natural state of balance under virgin conditions. In order for such a groundwater system to reach a new equilibrium (a state of indefinite ***sustainability***) two things must occur: 1) the pumping must increase the recharge, and/or 2) the pumping must decrease the discharge. Usually groundwater pumping has no impact on the recharge; recharge is determined by climatic conditions—precipitation, etc. On the other hand the pumping can decrease the discharge. For example, in Cadiz Valley pumping groundwater can lower the water table beneath Bristol Lake playa and either reduce or eliminate groundwater discharge as evaporation there.

In the parlance of the hydrogeologist, pumping can capture groundwater discharge. *In order for a groundwater system to be indefinitely* ***sustainable*** *the pumping must be balanced by an equal capture of discharge.* If the pumping exceeds the total amount of the natural discharge from the system the system cannot be brought into a new balanced state; in other words one will be mining groundwater—such a system is not indefinitely sustainable.

One rarely hears the discussion of groundwater sustainability put in terms of the capture of virgin discharge. The usual statement is that *pumping must not exceed the recharge (in order for the system to be sustainable).* In the discussion above I made the point that the virgin rate of discharge in these systems equals the virgin rate of recharge. The statement *pumping must not exceed recharge* is a round about way of saying that the pumping must not exceed the virgin discharge—the presumption is that all the virgin discharge can be captured by the pumping.

Nevada Groundwater Law

The Cadiz and Fenner Valleys are comparable to the closed Basin and Range Valleys in Nevada; they are dissimilar to much of the rest of California. For this reason it is worth looking at how Nevada treats groundwater in similar valleys.

Nevada recognized in the early1900s that the water supply for many of the valleys within the state would have to come totally from groundwater. The Nevada decision was to attempt to make that the groundwater supply within these valleys sustainable. The discharge in many of the valleys in Nevada is similar to Cadiz Valley where the groundwater discharge is by evaporation from the playas and from plants that tap the water table—the phreatophytic plants mentioned above. Nevada was willing to let the groundwater pumping capture both the evaporation and the groundwater that went to support the phreatophytic plants. This thinking led to the Nevada doctrine *that groundwater pumping must not exceed the recharge.*

As an aside, it has been difficult for the water managers in Nevada to administer this doctrine in places of heavy urbanization such as Las Vegas, even though Nevada law codified the doctrine.

Nevada has systematically surveyed the entire state in an effort to investigate the recharge in each of its many valleys. Many of the techniques of estimating recharge in the Basin and Range Province have stemmed from efforts in Nevada. One of the widely used methods of estimating recharge is the Maxey/Eakin Method. This is an empirical procedure devised by Burke Maxey and Tom Eakin (1949) working for the U.S. Geological Survey (USGS) in cooperation with the state of Nevada.

Even though the Maxey/Eakin Method is more than 50 years old it is still in widespread use. It applicability has been evaluated in recent years. Avon and Durbin (1994) published an evaluation of the method in which they showed that it gave good estimates of recharge for valleys in the Basin and Range. The Maxey/Eakin Method, along with other methods, indicates a much lower rate of recharge for Cadiz and Fenner Valleys than the method that was used in the Draft EIR/EIS. The method used in the Draft EIR/EIS continues to serve as the basis for overly optimistic projections of the quantity of native groundwater that can be extracted on a sustained basis from the Cadiz-Fenner groundwater system

As discussed above, whether a groundwater system can be brought into a state of indefinite sustainability depends upon whether the system can ultimately capture sufficient natural discharge to balance the pumping. I indicated that under virgin conditions, before development, in these systems the recharge is balanced by an equal amount of discharge. If a proposed development is much larger than the amount of potential discharge that can be captured the system will never be brought into a new equilibrium—one will be continuing to mine groundwater. In other words one will be draining the groundwater system.

Let's state these ideas in another way. Remember the virgin recharge equals the virgin

discharge. If the proposed development is much larger than the recharge (or in other words the virgin discharge since it is equal) one can never capture sufficient natural discharge to bring the system to a new balance. Therefore, one hears the common statement the *development must not exceed the recharge if the development is to be sustainable.*

The estimate of recharge becomes critical in any analysis of how a groundwater system will perform. If the estimate of recharge is in error then predictions of system performance will also be in error. Thus, one cannot make accurate predictions of future performance without a good estimate of the natural recharge. One cannot make a defensible judgment about the impacts of withdrawing native groundwater without a good estimate of recharge. I wish to examine the various estimates of recharge for the Fenner and Cadiz Valleys that were referenced in my earlier report.

Summary of the Recharge Estimates

Table 1 summarizes the various estimates of recharge to the Fenner/Cadiz Valleys.

Table 1. A summary of the recharge estimates.

Methodology/Author	**Estimate (ac-ft/yr)**
1. Watershed Runoff Model—MWD & BLM (1999)	20,000-70,000
GeoScience Groundwater Model	50,000
2. Maxey/Eakin Method	
USGS (2000)	2,550-11,200
Durbin (2000)	5,000
3. Fenner Gap Groundwater Flow	
Friewald (1984—USGS)	270
LaMoreaux (1995)	3,700
USGS (2000)	2,600-4,300
4. Chloride Method (correctly applied)	
USGS (2000)	1,700-9,000
Durbin (2000)	2,000
5. Drawdown Associated with Cadiz Co. pumping	
Boyle Engineering (1996)	4,000

Looking at Table 1, the only investigator that estimated the recharge as high as 50,000 acre-feet per year was GeoScience in their work reported in the Draft EIR/EIS Report. This estimate was commissioned by the Cadiz Company and done in support of the project. The other eight estimates performed using a variety of proven methods indicated that the annual recharge is less than approximately 10,000 ac-ft/yr. While there is a range in the estimates the most probable value for the annual recharge is 5,000 acre-feet per year—an order of magnitude lower than that used in the Draft EIR/EIS.

The Boyle Engineering (1996) report indicated that Cadiz Company was pumping

approximately 4,000 ac-ft/yr for irrigation in 1996. Boyle noted small, continued declines in the groundwater levels of approximately 1 foot per year; they suggested that the recharge was less than the 4,000 ac-ft/yr pumped in 1996. The Cadiz agricultural pumping has, or will capture the natural discharge that is thought to have occurred as evaporation from the dry lakes under virgin conditions. The pumping for irrigation, now approximately 5,000 ac-ft/yr, appears to have had little, or no significant adverse impacts to date. The Cadiz Company has approval from San Bernardino County to continue their pumping for irrigation.

Apart from the GeoScience report there has been one other minority voice among the technical reviewers of the Cadiz Project. Lee Davisson, a scientist at Lawrence Livermore Laboratory, wrote a short letter that endorses the quantity of recharge indicated by GeoScience. The Davisson letter suggested that his support for the GeoScience estimate was based upon isotopic studies of the native groundwater. It is difficult to assess the Davisson suggestion since his letter is brief; it does not contain the usual scientific information—his method of analysis, his assumptions, his data, or his results.

The Supplemental EIR/EIS did not address the issue of how large is the recharge to the local groundwater system. It sidestepped the issue of the recharge by proposing a monitoring and control scheme. The idea is that the project operations would be carefully monitored and modified to control adverse impacts as they were observed. This proposal has two fatal flaws:

1. The future impacts of the project cannot be projected at all accurately without an up-front estimate of the recharge.
2. By the time an adverse impact is detected by the monitoring the groundwater system will be sufficiently perturbed that even completely stopping the pumping of native groundwater will not ameliorate the impacts.

The bottom line is that if a large quantity of native groundwater in mined from the Fenner-Cadiz system it will cause water levels to drop below the dry lakebeds. This in turn will result in an increase in dust from the two associated playas. An increase in dust from a similar dry lakebed in Owens Valley has been a difficult and expensive problem to attempt to ameliorate. In addition, saline water will move out from beneath the playas and invade parts of the aquifer that currently contain freshwater. Springs in the nearby mountains may be caused to dry up.

The connection between the springs in the nearby mountains and the pumping in the valley is undetermined. The proponents of the project argue there is no connection. However, there is insufficient understanding or empirical data to know what will happen to the springs. If the springs do dry up as a result of the local pumping it will have a severe impact on a local herd of Desert Bighorn Sheep.

The Cadiz Company does not seem to be concerned about these impacts. Once a large public investment is made in the project, the pressure will mount to continue the project including the mining of native groundwater.

INFEASIBILITY OF MONITORING & CONTROL

The Cadiz project entails a substantial investment of public funds to build the facilities—pipeline, pumping station, recharge basin, and well field. Monitoring the groundwater system by observing water levels and water quality might reveal that the project operation is creating adverse environmental impacts. However, the early warning signs will be subtle, at best. The signals will be obscured by effects of the project operations, both storage and pumping, and other natural water-level fluctuations

The Supplemental EIR/EIS—Monitoring and Control

A number of individuals, in commenting on the Draft EIR/EIS suggested that the recharge indicated the Draft Report was much too large—approximately an order of magnitude too large. The Supplemental Draft EIR/EIS did not address this issue directly; a different tack was taken. The Supplemental Report proposed extensive monitoring with the idea that adjustments could be made to the project operation that would ameliorate adverse impacts.

The idea put forward in the Supplemental EIR/EIS is that early signs of adverse impacts will trigger modifications in the project operations. Exactly how the operations will be changed is not specified. Nor is it specified what constitutes an early warning sign of an adverse impact—what is the signal that triggers a modification of the project. The trigger signals that indicate adverse impacts are also left unspecified.

The problem with this idea is that once the project has operated for several decades the groundwater system will be sufficiently perturbed that stopping the pumping of native groundwater by the project will not stop the adverse impacts. Entirely stopping the pumping of native groundwater is probably the most drastic corrective action that can be taken. Clear signs of an overdraft of native groundwater will not occur until the project has operated for some time. In the early stages of operation it will be easy to discount early warning signs of adverse impacts as the result of project operations (storing water and pumping stored water) or natural groundwater fluctuations

Once the groundwater system is perturbed, that perturbation will work its way through the system at a rate dictated by the response time of the groundwater system. It is much like a freight train put into motion; once it has started moving it will be difficult, if not impossible, to stop the system from responding.

The traditional method of analyzing the impact of stopping pumping in a groundwater system is:

1. to analyze the aquifer as if the pumping is continued; and
2. to superimpose a recharge well of opposite but equal magnitude at the site of the pumping well.

This has the effect that the impacts of the pumping continue to migrate through the aquifer even though the pumping has ceased. It takes some time for the impact of the

superimposed recharge well to catch up with the impact of the pumping. The rule of thumb is that the impact of the pumping after it is stopped persists for a time approximately equal to the time of pumping. For example if one pumps for a year and then stops, the impact of the pumping will persist for approximately another year—it takes a year for the aquifer to recover. Therein lies the difficulty for monitoring; adverse impacts persist within the system even after pumping ceases.

The problem of recovery of the system is compounded if a large quantity of groundwater is mined. I made the point above that a number of investigators suggested that the recharge to the aquifer in the area is probably 5,000 acre-feet annually (ac-ft/yr). This estimate is an order of magnitude lower than the estimate presented in the Draft EIR/EIS for the Cadiz Project; the project estimate was 50,000 to 60,000 ac-ft/yr. Let's assume for the sake of argument that the project is operated based upon the higher estimate of 50,000 ac-ft/yr. Let's further assume that in 10 years of operation:

pumping indigenous groundwater	10 years @ 50,000 ac-ft/yr	500,000 ac-ft
recharge	10 years @ 5,000 ac-ft/yr	50,000 ac-ft
overdraft (groundwater mined)		450,000 ac-ft

Even if we stopped pumping indigenous groundwater after 10 years of operation we have created an overdraft that will take at least 90 years to refill at a recharge rate of 5,000 ac-ft/yr. This is without any other natural discharge from the system. Of course there will be continued natural discharge or other extractions that the project operators will not be able to control. By extension, if the project extracts groundwater at the proposed rate for two or three decades as seems likely, an overdraft will be created that takes more than a century or two to replenish.

If one is sufficiently alert there will be subtle early warning signs of trouble ahead. However, the early warning will be sufficiently obscure as to not halt the mining of native groundwater. As suggested above, once the project has operated for several decades it will be impossible to halt the adverse impacts even if the pumping of native groundwater is stopped. Let me try to illustrate my point further with results from the earlier modeling.

Water Levels in Selected Observation Wells

Using a groundwater flow model I projected the drawdown at several observation wells to illustrate the point about the difficulty associated with monitoring and control of the Cadiz Project. In order to do the modeling one has to assume some schedule of project operations. My assumed schedule of recharge and pumping is shown in Figure 1. Figure 2 is a map showing selected hypothetical observation well locations. Figure 3 shows the model-projected hydrographs for the three hypothetical well locations.

Consider for example the drawdown in Fenner Valley as observed in the observation well near Danby—see Figures 2 and 3. This well has almost no drawdown in 40 years of project operation. The drawdown is approximately 3 feet in 50 years, but this is only the beginning. The drawdown is 10 feet in 100 years, 50 years after the project was shut

down, and the drawdown at Danby is continuing to decline. At 100 years the drawdown is continuing to migrate up Fenner Valley to the north even though the pumping was totally stopped 50 years earlier.

The monitoring situation is a bit clearer beneath Bristol Lake—see Figure 3. There is no decline in the water table beneath the center of the lake out to 20 years. By 30 years the drawdown is approximately 7 feet and by 50 years it is approximately 12 feet. Again this is only the beginning, the drawdown goes to 20 feet in 80 years and remains at 20 feet to 100 years. Even though the project was stopped after year 50, there is no recovery in water levels beneath the lake in 100 years.

Water Quality in Observation Well SCE 5

I ran a groundwater transport model to simulate the movement of the brine beneath Bristol Lake. Observation well SCE 5 is situated approximately halfway from the proposed project and Bristol Lake playa—see Figure 2. The total dissolved solids, as observed in this observation well, are plotted in Figure 4. Notice that the dissolved solids start to increase slightly in year 30. By year 45 it increases to 1,000 milligrams per liter (mg/l); by year 50 the concentration is 1,300 mg/l. This water is still useable; but again this is only the beginning. The concentration increases to more than 7,500 mg/l by 100 years, and it is still increasing—again the project was halted 50 years earlier.

The point shown especially by the brine movement is that we would have to halt the pumping of native groundwater very early on in order for there not to be a significant degradation in water quality at this location. I selected only one location to make my point, but this is not an isolated location; the degradation in water quality between Bristol Lake and the project will be widespread and continuing out to at least 100 years. The groundwater flow into the cone of depression will still be significant at 100 years. The groundwater flow from the region of Bristol Lake will bring with it brine from beneath the lake. The outward flow of brine will render the groundwater unusable without costly treatment. The modeling suggests an area more than 10 square miles will be impacted.

To make my point that adverse impacts persist I stopped the project after 50 years of operation. To the reader this may suggest a worst-case scenario analysis. However, as suggested above the same point can be made after a much shorter period. As indicated above after a one-year period of pumping at any rate (for example 5,000 ac-ft/yr), pumping impacts will exist in the system for approximately another year; after a decade they will persist for approximately another decade; and so forth. The magnitude of the drawdown created is a direct function of the pumping rate; for example, the drawdown from pumping at 50,000 ac-ft/yr is ten times larger than drawdown from pumping at 5,000 ac-ft/yr. However, the rate at which the impacts migrate outward from the well through the groundwater system are the same for both pumping rates.

Modeling as an Integral Part of Monitoring

Modeling is one of the tools that hydrogeologists use to assess impacts of development—in this case recharge and withdrawal. Models have the ability to project the impacts into

the future. The procedure in using a model is to fit the model output to empirical data. This procedure is referred to as ***calibration***, or in the petroleum industry ***history matching***. Once the model fits the observed data it is referred to as calibrated. The calibrated model is then used to make predictions of the future response of the system.

Models are routinely calibrated based upon limited data sets. A steady-state model can be calibrated using either a high or a low estimate of recharge. Usually the aquifer permeability is adjusted to compensate for the high or low estimate of recharge. It will take a period of sustained high pumping from the aquifer before the impact of the recharge rate will be felt and a better estimate of the recharge provided by the modeling or other analyses. The bottom line is that the long-term behavior of the aquifer cannot be accurately estimated without a good upfront estimate of recharge.

During calibration what constitutes a good fit to the observed data is a matter of judgment on the part of the modeler. Compounding the calibration is the fact that the data is never sufficient to provide a unique model. The modeler adjusts the model parameters until an adequate fit to the observations is achieved. However, the non-uniqueness arises from the fact that another set of different model parameters could provide a similar fit to the observations. In colloquial terms, there are too many knobs to adjust in the model to be sure that the model is unique. Even so, once the model is calibrated it is used to make predictions of aquifer response.

This leads to the fact that analysis of the future response using models, or other analytical tools, has an inherent uncertainty associated with the prediction. The question is: in a situation where one is controlling one's actions based upon model predictions that are uncertain, ***how seriously will the model results be taken?*** This question becomes more important as the investment in the project increases.

Model uncertainty is likely to be used as an excuse for not taking warning signs predicted by the model seriously. This is especially likely in a project like Cadiz where a very substantial initial investment is made in the project before the model begins predicting problems. The likelihood of discounting the early warning signs of a model prediction are even greater where the decision to take remedial action is controlled by parties having a direct financial stake in the production of native groundwater.

A FIVE-YEAR PILOT PROJECT

It has been suggested that concerns associated with the long-term impact of pumping native groundwater can be resolved by using the first five years of the project as a pilot project or trial period. Such a pilot project might give an indication of the potential long-term impacts of pumping groundwater; however, five years is a short period to reveal how the long-term pumping of large quantities of native groundwater will impact the system. In order to be at all definitive the pumping rate must be much larger than the current Cadiz Company pumping for agriculture. There is an additional practical problem; water for storage from the Colorado River is probably only available during the

first decade of project operation. This consideration will probably preclude pumping large quantities of native groundwater during the first five years.

The major uncertainty in pumping native groundwater by the Cadiz Project is the recharge—is it 50,000 or some larger figure, or is it 5,000 ac-ft/yr? A five-year project in which a large amount of indigenous groundwater is pumped may provide an indication of whether the proposed pumping is sustainable. The Cadiz Company is reportedly currently pumping approximately 5,000 ac-ft/yr and has been doing so for more than a decade. The impacts of the current pumping appear to be acceptable

At issue is what happens if the pumping of indigenous groundwater is increased dramatically—up to the 50,000 ac-ft/yr of the projected recharge in the Draft EIR/EIS. Unless the pumping in the pilot project is much larger than the current level of pumping by the Cadiz Company, the pilot project will be inconclusive at best, and possibly misleading. The pilot project pumping needs to approach the larger estimate of annual recharge to be meaningful

A pilot project that calls for pumping so large a level of native groundwater is inconsistent with the proposal to store large amounts of Colorado River water in the first decade of the project when it is anticipated surplus water will be available from the Colorado River. Beyond 2015 surplus water from the Colorado River may be quite limited.

A SUSTAINABLE PROJECT

Many of the objections to the Cadiz Project are based upon the analysis that the project as proposed will mine a large quantity of indigenous groundwater. Given our current understanding of the groundwater system in the area, only a project that pumped a smaller quantity of local groundwater while storing Colorado River water could be sustainable indefinitely.

As suggested above, the recharge to the Cadiz/Fenner valley aquifers is probably of the order of 5,000 ac-ft/yr. This is approximately equal to the quantity of groundwater being pumped for irrigation by the Cadiz Company. The current agricultural pumping has, or will capture the natural discharge that probably occurred as evaporation from the dry lakes under virgin conditions. The agricultural pumping been going on for more than decade and appears to have little, or no significant adverse impacts.

A Cadiz Project in which the quantity of groundwater pumped currently for irrigation is acquired by the project, and not exceeded, is probably sustainable. This would be pumping by the project instead of for agriculture—the irrigation by the Cadiz Company would cease.

Accordingly, I recommend a sustainable Cadiz Project in which the total pumping of native groundwater from the Cadiz/Fenner Valleys be restricted to an average of 5,000 ac-ft/yr.

CONCLUSIONS AND RECOMMENDATION

From my analysis I reached the following conclusions:

1. Valley aquifers is of the order of 5,000 ac-ft/yr, not 50,000 ac-ft/yr as suggested in the Draft EIR/EIS.
2. Water table groundwater systems respond slowly to perturbations. Impacts occur at long times into the future. This poses a challenge for monitoring and control. The delayed reaction of the groundwater system combined with the fact that the subtle indications of overdraft tend to be masked or easily confused with fluctuations due to other causes will profoundly undermine the early warning system that has been proposed The weight of evidence indicates that the recharge to the Cadiz/Fenner for the project. Furthermore, trigger levels of what constitutes an early warning sign of adverse consequences have not been specified. One is left with only verbal assurances that careful monitoring will inform the project staff when bad consequences are anticipated. What triggers a response and what the response will be is left unspecified.
3. Models are useful tools in the monitoring. They can be used to assess long-term impacts. However, future predictions made using models carry a degree of uncertainty inherent in the analysis. Given 1) the fact that a model analysis indicates an unwanted future adverse impact, and 2) the uncertainty inherent in the analysis, the question arises ***will such an analysis be sufficiently persuasive to modify or halt the mining of native groundwater—especially given the project investment?***
4. A five-year pilot project is a short time in which to collect sufficient data to evaluate the long-term viability of the project. The major uncertainty is the magnitude of the recharge. The Cadiz Company currently pumps approximately 5,000 ac-ft/yr without apparent adverse impacts. In order to assess the recharge issue the pumping must be much larger than the current Cadiz Company pumping. To be definitive the five-year pilot period must involve pumping an order of magnitude greater than the current pumping; even at the higher pumping rate the results may not be definitive. To assess the recharge the pilot project must entail mostly pumping indigenous groundwater during its five-year life. This appears to be in conflict with the availability of surplus water for storage from the Colorado River.
5. The Cadiz Project could probably be sustainable if one limited the magnitude of pumping of native groundwater to approximately the current rate of pumping by the Cadiz Company—5,000 ac-ft/yr. In a sustainable mode the project would acquire the irrigation pumping of the Cadiz Company—irrigation in the area would cease. This rate of pumping of native groundwater is equal to 250,000 ac-ft over the 50-year life of the project. ***It is my recommendation that the project be made sustainable with the pumping of native groundwater restricted to an average rate of 5,000 ac-ft/yr.***

REFERENCES

Avon, L. and Durbin, T.J., 1994, *Evaluation of the Maxey-Eakin method for estimating recharge to ground-water basins in Nevada:* Water Resources Bulletin, V. 30, no. 1.

Boyle Engineering Corp., 1996, *Trends in groundwater levels vicinity of Cadiz Land Company production well field Cadiz, California:* Prepared for Rail-Cycle.

Bredehoeft, J.D., 1994, *Microcomputer codes for simulating transient ground-water flow: in two and three space dimensions:* U.S. Geological Survey Open-File Report 90-559.

Bredehoeft, J.D., 2000, *Comments on Draft and Supplemental EIR/EIS, Cadiz groundwater storage project—Cadiz & Fenner Valleys, San Bernardino County, California:* prepared for the Western Environmental Law Center, Taos, New Mexico.

Dettinger, M.D., 1989, *Reconnaissance estimates of natural recharge to desert basins in Nevada using chloride-balance calculations:* Journal of Hydrology, v. 106.

Durbin, T., 2000, *Comments on Draft EIR/EIS Cadiz groundwater storage project Cadiz and Fenner Valleys, San Bernardino County, California:* Prepared for County of San Bernardino, February 21, 2000.

Friewald, D.A., 1984, *Ground-water resources of Lanfair and Fenner Valleys and vicinity, San Bernardino County, California:* U.S. Geological Survey Water Resources Investigation Report 83-4082.

Konikow, L.F. and J.D. Bredehoeft, 1978, *Computer model of two-dimensional solute transport and dispersion in ground water:* U.S. Geological Survey, Techniques in Water Resources Investigations, Book 7, Chapter C2.

La Moreaux and Associates, 1995, *Technical comments on groundwater recharge and projected drawdown computations for Bristol-Cadiz Valley:* LaMoreaux and Associates, Tuscaloosa, AL.

Maxey, G.B., and T.E. Eakin, 1949, *Ground water in White River Valley, White pine, Nye, and Lincoln Counties, Nevada:* Nevada State Engineer, Water Resources Bulletin 8.

Metropolitan Water District and Bureau of Land Management, 1999, *Cadiz groundwater storage and dry-year supply program: Environmental Planning Technical Report, Groundwater Resources Volumes I and II. Report No.1163.*

Metropolitan Water District and Bureau of Land Management, 1999, *Cadiz groundwater storage and dry-year supply program: Supplement to the Draft EIR/EIS, Report No.1169.*

U.S. Geological Survey, 2000, *Review of the Cadiz groundwater storage and dry-year supply program Draft Environmental Planning Technical Report, groundwater resources, volumes I ands II:* Memorandum from J.F. Devine (USGS) to M.S. Brady (Field Manager BLM, Needles, CA), February 23, 2000.

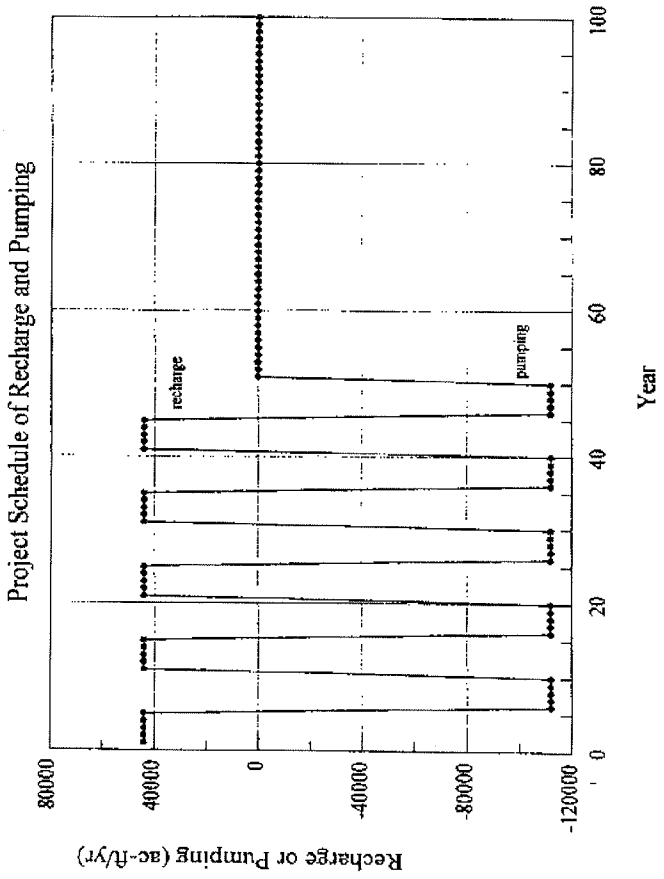


Figure 1. Hypothetical schedule of pumping and recharge.

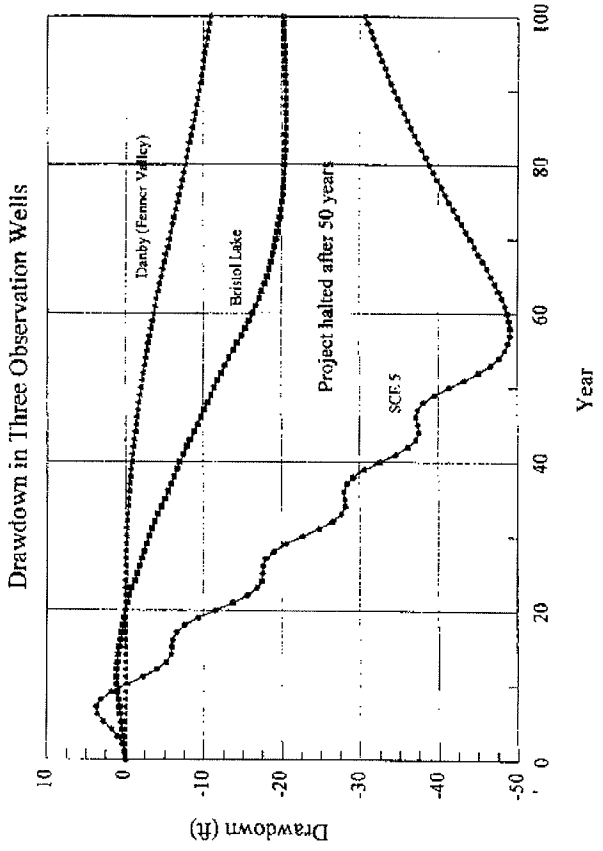


Figure 3. Computed drawdown in three hypothetical observation wells.

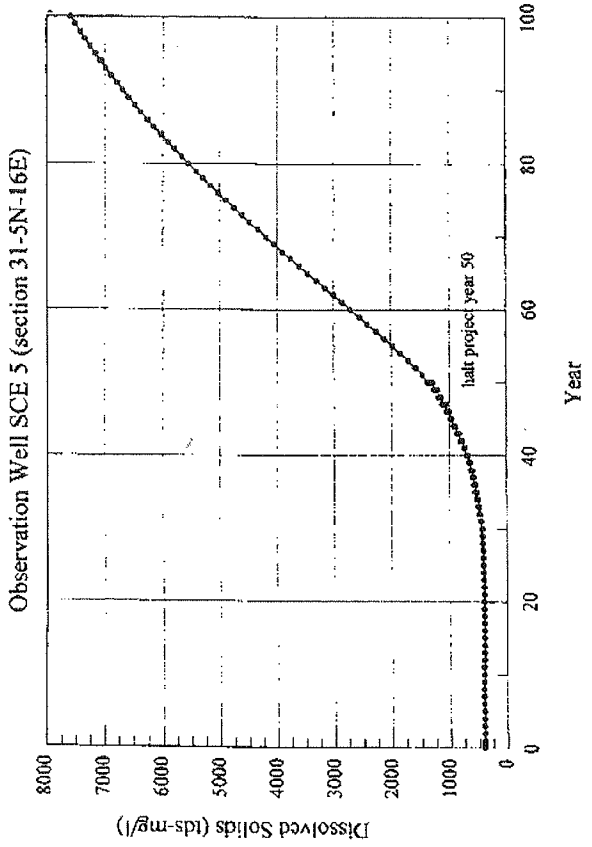


Figure 4. Computed plot of TDS in observation well SCE 5.

ATTACHMENT B

Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes I and II

Technical Memorandum

Prepared by the United States Geological Survey

for the U.S. Department of the Interior, Bureau of Land Management

February 23, 2000

In Reply Refer To:
Mail Stop 423

Feb. 23, 2000

MEMORANDUM

To: Molly S. Brady, Field Manager
Bureau of Land Management, Needles, California

From: James F. Devine */Signed/*
Senior Advisor for Science Applications

Subject: Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes I and II.

As requested by the U.S. Department of the Interior, Bureau of Land Management, the U.S. Geological Survey has reviewed the subject draft report. This draft report was written in support of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Impact Report/Draft Environmental Impact Statement/SCH. No. 99021039 (referred to as Draft Report in this review). This memorandum presents USGS comments.

GENERAL COMMENTS:

The Metropolitan Water District of Southern California has proposed a water storage project known as the Cadiz Groundwater Storage and Dry-Year Supply Program (Cadiz Project). The aim of the Cadiz Project is to ensure the reliability of Southern California's existing water supply via the Colorado River Aqueduct by storing Colorado River water in the Fenner, Bristol, and Cadiz watersheds during wet years and withdrawing stored water along with indigenous ground water during dry years. The proposed project would utilize the ground-water basin underlying the Cadiz and Fenner valleys for storage of part of Metropolitan's Colorado River supplies during wet years for later recovery and use during dry years. One of the stated project objectives is to provide up to 2.0 million acre-feet (maf) of indigenous ground water for transfer out of the watershed. In the Draft Report, indigenous ground water is defined as water that naturally recharges the ground-water system on a long-term average. A watershed model and water balance calculations, developed as part of the Draft Report, estimated that the quantity of indigenous water ranges from 20,000 to 71,000 acre-feet per year. A ground-water flow model was used to evaluate the impacts of the proposed project; the model assumed that the annual recharge to the Fenner, Bristol, and Cadiz watersheds was 50,000 acre-feet per year. The review of the Draft Report shows that the watershed model and water-balance studies presented in the Draft Report overestimate the natural recharge to the basin by 5 to 25 times the values estimated

by this review team using similar methods. It is the opinion of the review team that the regional watershed model, water-balance studies, and ground-water flow and transport models were used without adequate data to support the results and the conclusions presented in the Draft Report. The assumptions and methods applied in the development and calibration of both the watershed and ground-water flow models, which are essential for predicting the environmental impacts of the proposed project, are not defensible. The ground-water flow model was developed using an overestimate of natural recharge. This calls into question the usefulness of using the results of the ground-water flow model for predicting the environmental impact of this project. Until more appropriate fluxes and boundary conditions are used, the environmental impact of this study is yet unknown. The following discussion highlights the analysis and rationale for the above statements.

A watershed model was used to calculate "recoverable water" in the basin. Recoverable water was defined in the Draft Report as the total amount of surface runoff and infiltrating water that reaches the regional water table (ground-water recharge or indigenous ground water). The Draft Report estimates that the total amount of recoverable water for the entire watershed ranges from 20,000 to 58,000 acre-feet per year, with a median value of 39,000 acre-feet per year. The watershed model is a detailed daily water budget model: daily precipitation, infiltration, runoff, vegetation interception, evapotranspiration, soil moisture, and percolation are addressed. However, the model does not address bedrock permeability, and this may become an important factor for upland areas, such as the Providence Mountains, where low permeability granitic and metamorphic rocks underlie shallow soils. The model simulates the greatest amount of percolation in these areas; however, the bedrock permeability may be less than the simulated percolation rates. If this is the case, the model should be simulating runoff instead of percolation. Another major problem is that the model does not incorporate any routines to route water through the surface drainage network and estimate downstream flows and subsequent percolation. The fact that runoff occurs does not imply that the water will percolate farther downstream in the basin and eventually become recharge. Vegetation in desert environments is very efficient at extracting soil water from great depths. For example, creosote has been reported to extract water from depths as great as 18 feet below land surface. The model will overestimate the recoverable water (annual recharge) to the watershed because the watershed model does not address bedrock permeability and assumes that all runoff from a soil area becomes recharge.

Two types of data were used in the Draft Report to support the watershed model results: chloride mass balance data and isotopic data. The chloride mass balance approach was not properly applied and greatly overestimates water availability in the basin. In the Draft Report, the total area of the Fenner watershed was assumed to contribute recharge; however, studies by Prudic (1994) and Izbicki et al. (1998) indicate that recharge has not occurred on the valley floors of the neighboring Ward Valley and Mojave River basin for thousands of years. Dettinger (1989) estimated that some recharge might occur in alluvial basins in Nevada as a result of precipitation, runoff, and infiltration at elevations in excess of 4,000 feet. If one assumes that recharge only occurs at elevations in excess of 4,000 feet in the Fenner watershed, this would reduce the area of potential recharge from 718,000 acres to 126,000 acres. Another problem with the chloride mass balance approach, as applied in the Draft Report, is that the assumed chloride concentration of precipitation (3.5 milligrams per liter) is much higher than the values used by other investigators (0.4 to 0.8 milligram per liter) (Dettinger, 1989; Prudic, 1994). If one assumes that

only the area of the watershed with elevations in excess of 4,000 feet can contribute recharge and that the chloride concentration of precipitation is 0.8 milligram per liter (Prudic, 1994), then the estimated recharge for the Fenner watershed, using the chloride mass-balance approach, is 1,710 acre-feet per year. This value is more than 20 times less than the value of 40,000 acre-feet per year estimated in the Draft Report.

The occurrence of active ground–water recharge in the Fenner, Bristol, and Cadiz watersheds is reported in the Draft Report to be supported by isotopic evidence of geologically "recent" (Holocene) age of ground water. Carbon-14 data from observation wells in Fenner Gap range from 18 to 25 percent modern carbon and have apparent ages ranging from 11,500 to 14,000 years before present. The Draft Report suggests that water-rock reactions have occurred and ground-water ages are younger than the apparent ages indicate. On the basis of carbon-13 data provided as part of the Draft Report, it is apparent that reactions have occurred between ground water and aquifer materials; however, it is still possible to interpret the carbon-14 data. A complete interpretation of possible rock-water reactions and resulting corrections in carbon-14 data was beyond the scope of this review; however, an estimate of corrected carbon-14 ages for the Fenner Gap samples was made on the basis of data and rock-water reactions interpreted from other studies. As described in the review comments for section 9.3, the corrected carbon-14 ages range from 5,500 to 10,600 years before present. As a group, the isotopic data show that there is limited recharge under present-day climatic conditions and that ground water sampled at Fenner Gap was recharged thousands of years ago.

The USGS, as part of this review, estimated recharge in the Fenner, Bristol, and Cadiz watersheds using a modified Maxey-Eakin model (1949). The model assumptions and results are included as an attachment to this review. The USGS completed two models for the region. The first model used an elevation-precipitation correlation based on a network of 114 precipitation stations in the Great Basin and the Mojave Desert and represents the regional elevation-precipitation correlation. The second model used an elevation-precipitation correlation for four stations in or near the Cadiz watershed. This model provides unrealistically high estimates of precipitation for elevations of 5,000 feet and higher and does not correctly represent the relation of precipitation with elevation on a regional basis (see attachment). Recharge estimates obtained using the first model provided reasonable estimates of spatially distributed recharge based on a comparison of recharge estimates obtained for various locations throughout the southern Nevada and south-central Great Basin regions. The estimates obtained from the first model were consistent with previous estimates of recharge in the Mojave Desert region, and were more than one order of magnitude less than the recharge estimates obtained from the Draft Report for the three watersheds included in the Cadiz study area. For example, the Draft Report estimated median value of 39,077 acre-feet per year for the three Cadiz area watersheds is 15 times greater than the USGS model (model 1) estimate of 2,550 acre-feet per year. Recharge estimates obtained using the second model were based on unjustifiably high maximum precipitation rates of 500 to 750 millimeters per year for the higher elevations of approximately 6,500 to 7,500 feet. Although precipitation estimates obtained using the second model can be considered reasonable for elevations of approximately 4,000 feet and less, the relatively high precipitation estimates obtained for the summit areas of the Granite and New York Mountains are more representative of expected precipitation rates for elevations of 10,000 feet and higher in the southern Basin and Range Province. Even when using the very unrealistic precipitation rate

for the Cadiz area, the total basin recharge estimated by the second model is still approximately 5 times less than the total basin recharge simulated in the ground-water flow model developed for this Draft Report. This result indicates that the modified Maxey-Eakin model cannot provide the recharge magnitudes indicated in the Draft Report, even when attempts are made to account for uncertainty in precipitation estimates (the original Maxey-Eakin model would estimate even less recharge). In summary, the median recharge rates estimated by the Draft Report watershed model are most likely 15 times higher than the values estimated by the preliminary Maxey-Eakin models developed by the USGS.

The water-balance studies in the Draft Report estimated long-term recharge by estimating discharge by soil evaporation on the Bristol and Cadiz dry lakes. Prior to ground-water development in the watershed, natural ground-water recharge was equal to natural ground-water discharge or, in this case, soil evaporation from Bristol and Cadiz dry lakes. The Report multiplied an assumed soil evaporation rate by the area of the dry lakes. This method assumes evaporation occurs over the entire area of the lakebed (41,600 acres for Bristol and 29,788 acres for Cadiz) and neglects any contribution by surface-water runoff on the lakebed. The total evaporation estimated in the report ranged from 20,000 to 71,000 acre-feet per year. The final value used in the ground-water model developed for the Draft Report was 50,000 acre-feet per year; therefore, the average evaporation rate used in the Draft Report was 0.7 foot per year. As part of this review, the USGS measured the area of the lakebeds to be 58,457 acres, about 13,000 acres less than the Draft Report value. Water-level data from wells constructed on the lakebed indicate that the depth to water exceeds 10 feet throughout most of Bristol dry lake (Moyle, 1967). Kunkel and Chase (1969) estimated that the annual rate of evaporation from bare soil on China Lake in Indian Wells Valley decreased to negligible amounts at water-level depths of more than 7 feet below land surface. An ongoing study by the USGS in Death Valley has measured rates of about 0.17 feet/year on a salt playa (salt crust) where the depth to water was less than 1 foot (Guy DeMeo, USGS, WRD, Las Vegas, Nevada, written communication, 2000). If one uses the Death Valley number for the evaporation rate (0.17 foot per year), and multiplies that by the area of dry lake playa surface digitized from the geologic map (58,457 acres), the estimated evaporation is 9,900 acre-feet per year. This value probably overestimates the evaporation, because it uses the total area of the lakebeds and ignores any contribution from surface runoff. The total evaporation used in the ground-water flow model (50,000 acre-feet per year) is unreasonable on the basis of depth to water and soil characteristics, and needs to be significantly reduced. Multiple depth monitoring wells are needed on the dry lakes to determine the depth to water. The evaporation from the lakebeds needs to be measured using energy-budget methods (Laczniak et al., 1999) or salt crust accumulation methods (Feth and Brown, 1962) to better quantify this water loss.

As has been stated above, the quantity of natural ground-water recharge to the Fenner, Bristol, and Cadiz watersheds and discharge (evapotranspiration) from Bristol and Cadiz dry lakes has been grossly overestimated. A direct result of these overestimates of recharge and discharge is that the ground-water flow model developed as part of the Draft Report is incorrect because it was calibrated using overestimated recharge and evapotranspiration values. Specifically, the aquifer parameters (e.g., hydraulic conductivity, transmissivity, and the extinction depth for soil evaporation from the dry lakebeds) are overestimated. In general, the consequences of an incorrect model are inaccurate simulations of steady-state and transient conditions (water levels

and simulated fluxes) and unreasonable predictions of water levels and fluxes in response to the proposed put/take scenarios. The model needs to be recalibrated before it can be used to predict water-level changes, solute movement, and land subsidence resulting from the planned recharge/pumpage operation. The operating scenarios described for the Cadiz Project's 50-year term of operations indicate a transfer of 1.3 to 2.0 million acre-feet of indigenous ground water out of the watershed. The Draft Report assumes that 2.5 million acre-feet of natural ground water will recharge the watershed over the 50-year term of the project; therefore, the Draft Report predicts that there will be no long-term ground-water-level declines. However, if the natural recharge is less than the quantity of indigenous ground water transferred out of the watershed, water-level declines will be greater than currently simulated by the model. The ground-water flow model needs to be recalibrated with lower values of natural ground-water recharge. After the model has been recalibrated, the model needs to simulate the long-term effects (100 to1,000 years) of the proposed project on water levels and ground-water discharge to Bristol and Cadiz dry lakes. The model grid will need to be expanded to evaluate the long-term impact of ground-water withdrawls on spring discharge and water levels in Fenner Valley.

The brines present beneath the dry lakes have a greater density than freshwater. Consequently, a density-dependent solute transport model is needed to accurately simulate the movement of the brine. A nondensity-dependent model, MT3D, was used to simulate the brine movement for this Draft Report. This model cannot simulate a density-dependent solute transport problem and, therefore, any results and conclusions regarding the water levels and movement of brine near the dry lakes are questionable.

In summary, the results of the watershed model, chloride mass-balance studies, isotopic data, water balance (evaporation at the dry lakes), and ground-water flow and solute transport models presented in the Draft Report greatly overestimate natural ground-water recharge and discharge. Data presented in the Draft Report and all previous studies done in the area are consistent with small amounts of recharge to desert basins. The 50,000 acre-feet per year of natural ground-water recharge to the Fenner, Bristol, and Cadiz watersheds is 5 to 25 times the values estimated by the review team. Such a large error in such an important component of the model invalidates the flow and solute model results and predictions. No matter what the actual recharge value is, if the project pumps more water than it recharges, there will be less ground-water discharge at the dry lakes. Over the long-term, this will cause water levels beneath the dry lakes to decline. A density-dependent solute-transport model is needed to evaluate the long-term impacts of the project on the brine levels. The Draft Report does not address how water-level declines will impact the dry lakes. With a decrease in ground-water discharge, will the mining operation at the dry lakes be impacted? Will lower water levels cause the upper sediments to dry out and result in a dust problem? The failure of the model to simulate the water levels beneath dry lakes invalidates the model's ability to predict any impacts resulting from the recharge/pumping operation on water levels and solute transport beneath the dry lakes. With less recharge in the model, water-level declines resulting from the pumping phase of the project will be greater than currently estimated. This will undoubtedly cause the high salinity water beneath Bristol dry lake to move towards the pumping wells, assuming there does not exist a ground-water barrier between the well field and Bristol dry lake. If ground-water pumpage of indigenous ground water exceeds the natural recharge to the watershed, there will be long-term impacts on water

levels and natural ground-water discharge (evaporation and spring discharge) from the watershed.

As part of this review, the U.S. Geological Survey was requested to recommend ground-water monitoring and management strategies for the Cadiz Project. Preliminary recommendations are included in this summary and throughout the review document. Following are some of the more significant recommendations. Prior to the initiation of this project, better estimates of natural recharge and discharge need to be made. Infiltration of precipitation and streamflow should be quantified by collecting soil-moisture, chemical, and isotopic data in areas of potential recharge. A long-term ground-water-level and quality monitoring network needs to be established to help determine the impacts from the project. The network should include multiple-well monitoring sites to monitor water levels and water quality with depth. Monitor wells will be needed on the dry lakes to determine if the lakes are hydraulically connected to the regional aquifer. Monitor wells will be needed above the current water table to sample the recharge water during the put phase of the project, when water levels will rise in response to the artificial recharge. Wells will also be needed about 100, 250, and 500 feet below the current water table to monitor the movement of the recharge water. Microgravity measurements could be collected to estimate water levels in areas where well data are sparse. A revised ground-water flow model could be used to optimally locate the monitor well sites. Springs within the predicted long-term (100-year) drawdown cone should be monitored for flow and water quality. Velocity logs and downhole sampling should be completed on the production wells to help determine the principal zones contributing water to the wells. This information will be important for recalibrating the ground-water flow model and designing the proposed well field. Soil evaporation from Bristol and Cadiz dry lakes should be measured using energy-budget or salt accumulation methods prior to and during the proposed project to help determine the impact of the project on the dry lakes. Interferometric synthetic aperture radar (INSAR) could be used to monitor land movement (inflation or subsidence) that may occur as a result of the proposed project (Galloway et al., 1998). The INSAR images could be used to help locate potential barriers or changes in aquifer properties.

SPECIFIC COMMENTS:

2.0--INTRODUCTION

Page 15, 2.2, Purpose and Scope. Is this the purpose and scope for the entire project or just for the pilot study? In this part of the report one would expect the purpose and scope for the entire project. Much of the material that follows has to do with determining the hydrogeology of the area. The pilot test study is a small part of Volumes I and II.

Page 16, 2.4, Previous Investigations. The authors list previous investigations but do not list the major findings of the reports. For example, Friewald (1984) estimated underflow through Fenner Gap to be 300 acre-feet per year, significantly less than the value of 30,000 acre-feet per year presented in the Draft Report. The report states that Prudic (1994) estimated percolation rates and ages of water in the unsaturated sediments in the Mojave Desert. The Draft Report neglects to report that Prudic (1994) estimated that the age of water at the depth of 10 meters is between 16,000 and 33,000 years. In addition, percolation rates below a depth of 10 meters at

the Ward Valley site (the basin directly east of Fenner Valley) were on the order of 3 to 5 centimeters per 1,000 years. Prudic's results indicate that there is no recent recharge at the sites that he studied. The Draft Report presents a list of companies involved with investigations in the Bristol and Cadiz dry lake areas but does not discuss the findings of these studies. The reports by P.E. LaMoreaux & Associates, Inc. (1995) and Boyle Engineering Corporation (1996) question the quantity of ground-water underflow reported by Cadiz Land Company, Inc. (20,000 acre-feet per year) and suggest that the quantity of underflow is significantly less (3,000-4,000 acre-feet per year). The results of these studies need to be presented and evaluated.

Page 19, 2.5, Data Sources. The Draft Report states that it used data from Moyle (1967), but later in the Draft Report, Moyle's (1967) measurements of depth to water beneath the dry lakes were not used in the computation of evaporation from the dry lakes. The report utilizes data by Shafer (1964) later in the Draft Report to substantiate paleo river channels. This report is not readily available; therefore, it would be beneficial to reproduce some of the key elements of the Shafer (1964) report in this document.

3.0--DESCRIPTION OF AREA

Page 29, 3.2, Drainage Boundaries and Surface Stream System. The Draft Report considers Bristol, Cadiz, and Fenner one drainage system because all surface and ground water are reported to drain to a central location. However, it should be noted that the surface-water drainages of Bristol and Cadiz are separated by the coalesced alluvial fans of the Calumet Mountains to the south and the Marble Mountains to the north. Rosen (1992) reports that both basins have completely separate internal drainage. The ground-water basins are not well defined; however, northwest-southwest regional faulting may separate the Bristol and Cadiz ground-water systems. Sparse water-level data from Moyle (1967) suggest that there may be a barrier to ground-water flow on the eastern end of Bristol Dry Lake. Additional data are needed to better define the ground-water flow system. Data are not presented in the report to show that Bristol and Cadiz basins are closed ground-water basins.

The Draft Report includes the southern third of Lanfair Valley in the Fenner watershed. The southern third of Lanfair Valley is indeed part of the surface-water drainage system; however, it is probably not part of the Fenner ground-water basin. Friewald (1984) includes the southern third of the Lanfair Valley as part of the Lanfair ground-water basin. Ground water that recharges at the flanks of the New York Mountains moves to the east in Lanfair Valley and discharges at Piute Spring on the eastern part of the valley (Friewald, 1984). The Woods and Hackberry Mountains and the Vontrigger Hills form the southern boundary to the Lanfair ground-water basin. Surface-water drainage occurs along the Watson Wash; however, available data do not indicate that ground water follows the same drainage. Geophysical data or well data are needed to define the thickness of the basin-fill deposits beneath the Watson Wash to determine if ground water can move through the narrow gap between the Woods and Hackberry Mountains. The Draft Report references a study by Viceroy Gold Corporation (1990) as a basis for including the southern third of Lanfair Valley in the Fenner ground-water basin. Because this reference is not readily available, the data presented in the Viceroy (1990) study should be included in the Draft Report to substantiate including the southwestern third of Lanfair Valley in the Fenner ground-water basin. In any case, the quantity of ground-water discharge from Lanfair

Valley to Fenner Valley must be small because of the limited extent of the aquifer in the mountain gaps.

The Draft Report cites Izbicki et al. (1998) to imply that infiltration from washes during storm events is a source of recharge to Fenner basin. The work described in that paper was done in the western part of the Mojave Desert in washes that drain the Cajon Pass area. This area is far wetter than the Fenner watershed. In addition, the wash studied has some unique geologic features that may not be applicable to the washes draining the Fenner Basin. Furthermore, Izbicki et al. (1998) indicate that the quantity of flow and the amount of recharge from the wash are small and that travel times through the thick unsaturated zone are as long as several hundred years.

Page 30, 3.3, Climate.

Page 31, 3.3.2, Precipitation.

Page 34, 3.3.6, Evaporation. Please show graph of monthly evaporation rates.

4.0--GEOLOGY

Page 35, 4.1, Regional Geologic Setting. The depression that forms the Bristol watershed is believed to be the result of regional movement along the fault (Rosen, 1989). What is the age of these faults and do they cut the water-bearing deposits?

Page 35, 4.2, Stratigraphy. Grouping the geologic formations into only three groups (bedrock, loose alluvial sediments, and fine-grained sediments underlying Bristol and Cadiz dry lakes) is an oversimplification. Inspection of the geologic and geophysical logs presented in the Draft Report indicates that the alluvial sediments become more fine-grained and indurated with depth. Most of the loose alluvial sediments as described in the Draft Report lie above the water table. The Draft Report presents figure 17 showing the estimated bedrock elevations of the Bristol, Cadiz, and Fenner watersheds and cites Maas (1994) as the source of the data. How were these bedrock elevations determined? What geophysical techniques were utilized? Borehole data, showing the elevation where bedrock was encountered, should be included on figure 17. Figure 19 in the Draft Report shows the estimated depth to bedrock in the Fenner Gap area. This map does not contour the depth to bedrock correctly in the areas where well data are available. For example wells MW-7 encountered bedrock at a depth of about 500 feet. Figure 19 has a contour of 1,500 feet passing near this well. Figure 19 overestimates the depth to bedrock in Fenner Gap and the map is incorrectly contoured. Well data need to be shown on the map. Symbols shown on the map need to be included in the explanation. The data used to construct the simplified seismic cross section (figure 20) should be included with the Draft Report.

The statement that most of the sediment is Holocene is questionable. Numerous studies have shown that Pleistocene soils are widespread and common at the surface in the Mojave Desert, and where they are not present at the surface they are commonly present just a few meters beneath Holocene alluvial fan sediment. See McDonald et al. (1995) for one of many nearby examples. Several photographs in Volume 1 nicely illustrate the argillic and calcic horizons in

the area, and the section on paleontology describes calcic materials in the area of the well field. Unpublished geologic mapping by USGS identifies widespread Pleistocene soils in the area. For example, much of the valley between the Marble and Clipper Mountains is underlain by stage IV calcic horizons within one meter of the surface. Argillic horizons are important hydrologically, and their presence is hinted at by the non-linear rate of percolation in the percolation pond experiments.

Page 37, 4.3, Structure. The Draft Report states that more than a dozen faults (figure18) is evidence of Quaternary movement in the Fenner watershed. How do these faults affect the movement of ground water? Why weren't these faults considered in the development of the ground-water model described later in the Draft Report? Rosen (1989) is cited as saying that subsidence of the Bristol dry lake continues to the present. This would suggest that the faults cut the aquifer system, and are potential barriers to ground-water flow. These faults could have a major impact on the storage and recovery operation if they are barriers or partial barriers to ground-water flow.

Figure 18 does not include the Iron Mountains Fault, which may connect to the northwest with the Bristol-Granite Mountains Fault and thereby pass near the well field at Cadiz. In addition, this figure is incorrectly ascribed to the reference by Miller and Howard (1985); that paper included the Iron Mountains Fault and did not show many of the connections of faults across the Bristol-Danby trough. The faults shown in figure 18 must correctly reflect the cited source, which shows the Iron Mountains fault as Quaternary. The steep slope on the buried basement surface under the proposed well field could be support for a connection of the Iron Mountains and Bristol-Granite Mountains faults. The well field accordingly may straddle a buried fault only a few meters beneath the surface, which may have hydrologic implications and seismic hazard implications.

The Draft Report cites geothermal heating (up to 90°F) in the Fenner Gap and suggests that the heating may be caused by convection of ground water with a zone of brecciated bedrock in the Fenner Gap. What is the flowpath for the ground water to move into the brecciated bedrock? The presence of the geothermal water would preclude a significant quantity of underflow of ground water through the alluvial deposits in Fenner Gap. If there were a significant quantity of underflow through the gap, one would expect cooler temperatures associated with winter recharge of precipitation and runoff (around 60°F).

5.0--GEOHYDROLOGY

Page 39, 5.1, Groundwater Basins. The Draft Report assumes that Bristol, Cadiz, and Fenner basins are closed; however, hydrologic data are not presented in the report to substantiate this statement. Does ground water move from Dale dry lake to Cadiz or from Cadiz ground-water basin to the southern part of Ward Valley? Water-level and geologic data are needed to support the statement that the basins are closed.

The Draft Report assumes that the topographic divides form the margins of the ground-water basins. This assumption will result in the overestimation of the size of the ground-water basins, because most of the margins of the basin consist of nonwater-bearing consolidated rocks. The

ground-water basins should be defined by the contact of the consolidated rocks and the saturated basin fill.

Page 39, 5.2, Aquifer Systems. Sediments in the basins may, and almost certatinly does, include the early Miocene volcanic rocks and associated sediments, which are shown on the geologic maps and described in the geologic history, but ignored in the treatment of materials in the basins. Volcanic rocks dip northeast from the Marble Mountains and roughly north from the Ship Mountains. It seems likely that some of this section is present in deeper parts of the ground-water basin.

The upper alluvial unit is unlikely to be just Quaternary sediments as defined. Quaternary sediments have accumulated at rates of a few meters per ten thousand years, and even in sites of rapid deposition are unlikely to be 800 feet thick, as described in the Draft Report. Regardless of their exact thickness, numerous buried soil horizons are to be expected within a thick Quaternary section.

The Draft Report divides the basin into an upper alluvial aquifer, lower alluvial aquifer, and a bedrock aquifer. It is unclear how the upper and lower alluvial aquifers were delineated. The report states that the average thickness of the upper aquifer is 500 feet. Does this thickness include the unsaturated alluvium? Inspection of the geophysical and lithologic logs presented in the Draft Report indicates that the deposits become poorly sorted with a higher percentage of fine grained deposits at about 300 to 400 feet below land surface in the Fenner Gap (MW-3, MW-6, and MW-7). Inspection of the short- and long-normal resistivity logs indicates that there is little separation between the logs. The lack of separation suggests that the sediments are fine-grained or indurated. The spontaneous potential log also shifts at this point in the borehole, indicating a change in water chemistry or sediments. This change in character on the logs is probably the contact between the upper alluvial sediments and the lower alluvial sediments. The long-normal resistivity averages about 40 ohm-m above the contact and less than 20 ohm-m below the contact. The water table is about 300 feet below land surface in the Fenner Gap; therefore, the saturated thickness of the upper alluvial aquifer is on the order of only 100 feet in the Fenner Gap. The lower aquifer would then extend from 400 feet below land surface to the top of the bedrock. As indicated on the lithologic logs and shown on plate 3 of Draft Report, these lower sediments contain high percentages of silt and clay and are less permeable than the overlying deposits.

The Draft Report states that the upper aquifer is very permeable. This statement is based on pumping well PW-1. Well PW-1 is located downgradient of the Fenner Gap, and is probably in the Bristol Trough as described by Jachens et al. (1992). Inspection of the lithologic and geophysical logs for PW-1 indicates that well encountered relatively permeable deposits to a depth of 650 feet. Inspection of the short and long normal resistivity logs shows significant separation to this depth, suggesting permeable deposits. Below 650 feet the logs merge together and decrease in resistivity, suggesting less permeable deposits. The long normal resistivity decreases from about 50 ohm-m above 650 feet below land surface to less than 30 ohm-m below 650 feet. The water table at PW-1 is about 275 feet below land surface. These interpretations indicate that the saturated thickness of the upper alluvial aquifer is about 375 feet at well PW-1 compared with 120 feet at well MW-3.

The lower alluvial aquifer is reported to yield water freely to wells. This statement is supported in the Draft Report by the statement that the "Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gallons per minute." The Draft Report needs to present the lithologic and geophysical logs, well-construction information, and specific-capacity data to support this statement. As indicated later in the water-quality section of this review, the water chemistry of the Cadiz agricultural wells is significantly different than the chemistry in the Fenner Gap wells, suggesting that the Cadiz wells are pumping water from the upper alluvial aquifer.

The Draft Report indicates that the recent drilling in Fenner Gap indicates that the Paleozoic rocks that underlie the Fenner Gap comprise a third aquifer unit. The data that support this statement need to be presented in the Draft Report. Well CI-2 is perforated in the "bedrock aquifer." What is the specific capacity of this well?

5.3 Groundwater Recharge, Flow Direction, and Flow Rate

Page 40, 5.3.1, Groundwater Recharge. See comments regarding the infiltration from washes inferred from Izbicki et al. (1998) in the section 3.2 comments. The report cites several references as reporting that the principal recharge to Bristol and Cadiz dry lakes is seepage of ground water into the lakebed sediments from adjacent alluvial deposits. Did these references estimate the quantity of ground-water seepage?

The Draft Report states that the occurrence of active ground-water replenishment within the Bristol, Cadiz, and Fenner watersheds is supported by (1) the existence of a regionally consistent hydraulic gradient, (2) isotopic evidence for a geologically "recent" age of the ground water, and (3) stable ground-water elevation recorded in wells located between Fenner Gap and Bristol dry lake despite continuous ground-water pumping by Cadiz agricultural operations for more than 15 years. What does a regionally consistent hydraulic gradient indicate? The gradient is dependent on the aquifer hydraulic conductivity and the quantity of ground-water flow. If the hydraulic conductivity is poorly defined, then the gradient doesn't indicate the quantity of flow. Please refer to the comments about isotopic evidence for geologically "recent" (Holocene) age for ground water in comments for Section 9.33. It is stated that the ground-water elevations have been "stable"; however, data indicate predevelopment water-level elevations of about 600-625 feet while figs. X-4 to X-15 show current water-level elevations of about 580 feet or less. This indicates there has been drawdown in the area under relatively low pumping rates. The report by Boyle Engineering Corporation (1996) states that the measured drawdowns in the Cadiz wells indicate that the perennial yield of the basin is less than 4,000 acre-feet per year.

The estimated average amount of recoverable water (surface runoff and ground-water recharge) available to Project area is reported to range from 15,000 to 37,000 acre-feet per year. What is the breakdown of quantities of surface runoff and ground-water recharge? How was the surface water routed from Fenner Gap to Bristol and Cadiz dry lakes? Was the surface-water drainage divide between Bristol and Cadiz dry lakes considered? The validity of these numbers will be discussed in the review of Section 6.0. Based on model results presented in Section 8, the amount of ground water available to the Project area on an annual basis is estimated to be 30,000

acre-feet per year. The validity of this number will be discussed in the review of Section 8. These numbers should not be presented in this part of the Draft Report.

Page 41, 5.3.2, Groundwater Flow Direction. The data used to construct the water-level elevation map (figure 21) needs to be included in the Draft Report. The data points need to be presented on the map. Does the map represent water levels collected at the same time or is it a collection of different time periods? The map does not accurately represent the water levels measured in the Fenner Gap area. For example the water level reported for the Siam well 5N/15E-4X1 is 641 feet but the map indicates a water level of 670 feet. Well 6N/15E-29Q has a measured water level of about 690 feet; however, on the map the water level is about 750 feet. These are just two examples of many problems on the contour map. With the scarcity of data, many of the contour lines should be queried. What impacts do the faults have on the ground-water flow direction? One would think that the northwest/southeast trending faults might be barriers to flow. In addition, geothermal heating (presented in Section 4.3) indicates that the faults are impacting the flow system. The Draft Report states that ground water flows through Fenner Gap and then migrates to Bristol and Cadiz dry lakes. If the water levels for the Cadiz agricultural wells (presented in the Draft Report) are plotted on the map, there is a water-level depression related to the 15 years of agricultural pumping (water-level elevations range from 590 feet on the north end of the agricultural fields to 530 feet on the south end of the fields. How has this agricultural pumping changed the predevelopment movement of ground water? Water levels beneath the fields are currently lower than historical water-level measurements beneath Bristol dry lake (Moyle, 1967), indicating that ground water moving southward through Fenner Gap will be captured by the irrigation wells.

The Draft Report refers to a "paleowash" identified by a seismic survey in the vicinity of Danby (Shafer, 1964). The seismic data should be presented in the Draft Report. How deep was the "paleowash"? The Draft Report states that water levels support a "paleowash." The water-level data simply indicate the direction of ground-water movement. Fenner Gap is a discharge point from Fenner Valley, therefore, ground water is moving towards this discharge point. How was it determined that no ground water moves through Skeleton Pass? Are there any water-level or geologic data to support this statement? The water-level contour map (figure 21) indicates that ground water moves through Skeleton Pass.

Page 42, 5.3.3, Groundwater Flow Rate. How were the ground-water flow rates determined? Supporting data need to be presented. These data should be presented in chapter 9.

5.4 Groundwater Discharge

Page 42, 5.4.1, Evaporation. Ground-water levels along the east end of Bristol dry lake are as much as 50 feet below land surface (Moyle, 1967; and this Draft Report). Surface evaporation from these depths would be very small. This suggests that ground-water discharge from Fenner Valley also is small. The evaporation estimates are discussed in great detail in the review of s Section 6.6.2.

Page 43, 5.4.2, Ground-water Pumping in Area. The volume of water pumped by Cadiz agricultural operations cited in the second and third paragraphs appears to be contradictory.

Page 44, 5.5, Ground-water Storage. Ground-water storage values are presented here without supporting documentation. These values should not be presented until the method is discussed. These values will be discussed in the review of Section 6.4.

Page 44, 5.6, Ground-water Quality. The Draft Report states that the quality of fresh ground water varies only minimally throughout the Bristol, Cadiz, and Fenner watersheds. Inspection of data presented in the Draft Report and the USGS database indicate that there is more variation than is indicated in the Draft Report. For example, there is even a large variation in water chemistry of wells in Fenner Gap (table 20), ranging from a total dissolved solids (TDS) of 267 nilligrams per liter (mg/L) in well CI-1 to 1,040 mg/L in well MW-3. The total dissolved-solids map (figure 23) needs to have the data (well and TDS values) plotted on the map. The data as plotted on the map indicate that the TDS upgradient of Fenner Gap has a higher concentration (350-400 mg/L) than downgradient of the gap (300 mg/L). If underflow from Fenner Valley is the main source of recharge to the Cadiz agricultural wells, how can the TDS be higher in the recharge water than in the Cadiz wells (less than 300 mg/L in table 3)? The presence of the high TDS values at the dry lakes would indicate that there should be springs along the freshwater/saltwater interface. This conceptual model can be observed at Death Valley. Are springs present around the dry lakes?

Page 45, 5.7, Interrelationship of Bristol, Cadiz and Fenner Watersheds with Other Groundwater Basins. As stated previously in this review, water-level and geologic data are needed to support the statement in the Draft Report that the basins are closed.

6.0--EVALUATION OF WATER RESOURCES

Page 46, 6.1, Evaluation of Recoverable Water Using a Watershed Model. The watershed model is reviewed below by section. In addition, we have presented some recharge estimates for the watershed using alternative modeling approaches. A description of these alternative models and the model results are presented as an attachment to this review.

General comments on approach--A watershed model was used to calculate "recoverable water" in the basin. Recoverable water is defined in the Draft Report as the total amount of surface runoff and infiltrating water that reaches the ground-water surface. The two terms were not discussed separately in the text of the Draft Report; however, they were separated in model results presented in Appendix F.

The watershed model incorporates the Thornthwaite equation to estimate daily potential evapotranspiration and an additional routine to estimate soil infiltration. The Thornthwaite equations yields estimates of potential evapotranspiration that are smaller than estimates produced using other approaches (Dingman, 1994) and, as a result, this model will tend to overestimate infiltration and runoff when compared to other methods. The model then calculates infiltration by subtracting surface runoff and vegetation interception from daily precipitation. The model does not account for soil water storage and subsequent withdrawal by plants. Vegetation in desert environments is very efficient at extracting soil water from great depths. For example, creosote has been reported to extract water from depths as great as 6 meters below

land surface. Numerous studies show that infiltration to depths below this thick root zone does not occur in desert basins--and soluble salts such as chloride accumulate just below the root zone (Phillips, 1994; Prudic, 1994; Izbicki et al., 1998). The amount of infiltrating water that reaches the water table approaches zero in most of the basin and water-potential data from other studies in desert basins suggest that water (in the form of vapor) may move upward from the water table to the root zone in many areas (Prudic, 1994). No field data or other evidence supporting infiltration to depths below the root zone for any of the soil groups is presented in the Draft Report. These issues are discussed in greater depth in the review of Section 6.7 --'"Estimates of ground-water recharge using a chloride mass balance approach."

A small amount of infiltration and subsequent recharge may occur in desert basins where water accumulates in topographic depressions. These areas include natural topographic depressions, such as certain playas (Osterkamp and Wood, 1987), man-made depressions, such as bomb-blast craters at the Nevada Test Site (Tyler et al., 1992; Pohl, 1996), and intermittent streams (Scanlon, 1994; Izbicki et al., 1998; Nimmo, 1999). As a group, these studies uniformly conclude that infiltration and subsequent ground-water recharge from these areas is small. The model does not incorporate any routines to route water through the surface drainage network and estimate downstream flows and subsequent infiltration. The existence of runoff does not imply that that water will infiltrate farther downstream in the basin. Although isotopic data are cited in the Draft Report as evidence of infiltration from washes, review of Section 9.3.3 "Evaluation of Groundwater Age Using Isotopes," suggests that the isotopic data presented in the Draft Report actually show that the amount of water from infiltration of surface flows is small. No other field data or evidence of infiltration from washes is presented in the Draft Report. An estimate of the "recoverable water" in the basin using data from the Draft Report and data from studies in similar areas is presented in the "Conclusion" section of this review.

The watershed model is a detailed daily water budget model: daily precipitation, infiltration, runoff, vegetation interception, evapotranspiration, soil moisture, and percolation are addressed. The model results provide an estimate of the recoverable water. It appears that the model does not account for bedrock permeability, and this may become an important factor for upland areas with shallow soils underlain by low permeability granites and metamorphics. For example, soil unit D defines an important watershed modeling unit that is used to subdivide the watershed model into areas of similar characteristics. For soil unit D, these are predominantly upland areas with shallow soils and thus the permeability of the underlying bedrock may have an important effect. It may be incorrect to assume that the hydrologic response for soil unit D will be similar for all locations covered by this soil type (even if the soil area is subdivided on the basis of the isohyets). There may be important differences in the hydrologic response of this model unit between areas underlain by low permeability bedrock and areas underlain by high permeability bedrock. It would be important to incorporate these differences into the watershed model, at least for soil unit D, because the model unit defined by this soil class on average has the highest computed recharge rates.

Page 47, 6.2, Description of the Bristol, Cadiz and Fenner Watershed Model. Each of the three basins is subdivided into hydrologic or modeling response units. For the Fenner watershed, five sub-areas are defined on the basis of soil types (A, B, C, and D) and an additional subdivision based on precipitation isohyets for subdivision for D. The long-term isohyetal map

is based on precipitation records from Twentynine Palms, Amboy, Needles, Mitchell Caverns, Mountain Pass, Kelso, and Yucca Grove. There are additional stations in the region surrounding the Cadiz study area that could have been used in the watershed modeling to obtain a more accurate representation of daily precipitation (e.g., Iron Mountain, Searchlight, Joshua Tree, Baker, Eagle Mountaint, and Parker).

Page 49, 6.2.1, Delineation of Model Subareas. The Bristol, Cadiz, and Fenner watersheds define the total watershed model area. A total of 11 subareas are defined for the three watershed areas. How were topographic effects such as differences in slope, aspect, and drainage characteristics, taken into consideration in the subarea boundaries?

Most recharge is simulated in the watershed model as occurring in soil group D. These soils should have limited rates of percolation (recharge) and high rates of runoff because of the impervious bedrock that underlies this soil type. If these soils have high runoff potential and are underlain by low-permeability bedrock, why are the highest recharge rates occurring at these locations (according to the watershed model)? There is no justification in the report for all the recharge occurring in the bedrock areas.

6.3 Model Parameter Determination

Page 52, 6.3.2, Soil Curve Number and Surface Runoff. No comments.

Page 54, 6.3.3, Temperature and Evapotranspiration. Thornthwaite's formula is cited but no reference is given. There is no way to know if this equation considers the lack of vegetation. The alpha coefficient (ratio of soil moisture to field capacity) is not the appropriate function for soil evapotranspiration. The method selected comes from Thornthwaite and Mather (see Hanks and Ashcroft, 1980, fig 4.6, pg. 115). A more appropriate function for the Mojave region is the modified Priestley-Taylor function (Flint and Childs, 1990), but only when vegetative cover is accounted for (Stannard, 1993). The assumptions in the Draft Report would underestimate evapotranspiration and therefore overestimate recharge.

Page 56, 6.3.4, Infiltration, Vegetation Interception, Soil Moisture, and Percolation. The estimates of potential evapotranspiration, 0.12 to 0.434 inches per day, seem high. The assumption that if soil moisture exceeds field capacity precipitation will percolate downward to replenish ground-water storage is questionable without accounting for the bedrock permeability under shallow soils, which is where most of the model calculated recharge comes from. Low-permeability bedrock holds excess soil moisture in the root zone where it may be removed by evapotranspiration processes. The rate of recharge in these situations is limited to the permeability of the bedrock and must be accounted for. Also see the equation for percolation on p. 57, which needs to account for bedrock permeability.

Page 57, 6.3.5, Assumption for Soil Thickness, Initial Soil Moisture, Field Capacity, and Apparent Specific Gravity. The estimates of field capacity are below the range that would be calculated from the STATSGO database, 13 to 17% for soil type D in the Providence Mountains area. For the same general area as soil type D, estimates using the STATSGO database would be 17--24%. The soil thickness for the shallow soils seems reasonable, but the soil thickness for the

deeper soils is in error. Although taxonomically the soils may be less than 2 meters (6 feet), the rooting depth, and therefore the evapotranspiration depth is much deeper, perhaps as much as 6 meters (20 feet). This is particularly important for channels.

6.4 Sensitivity and Uncertainty of Model Parameters. The model sensitivity analysis does not test the entire reasonable range of field capacity and soil thickness. These are two of the most sensitive parameters. If the true range of these two parameters were tested, the model would show a larger range and significantly less water would be simulated as being recharged.

6.5 Validation of Watershed Model Methodology. This section is much too brief. There needs to be more information provided on the Big Sandy Valley watershed so that basin characteristics can be compared. Western Arizona has a much different climate characteristic than southeastern California because of an increase in average elevations eastward towards Arizona and increased moisture input from the Gulf of Mexico, primarily during the Southwestern Summer Monsoon. In general, the climate is wetter and cooler, with more precipitation occurring as snow and a higher frequency of intense storms during the monsoon season. These differences in precipitation characteristics must be understood and accounted for before a model that is calibrated in Big Sandy Valley can be assumed to be a calibrated model in the Cadiz study area. In addition to differences in climate, differences in basin characteristics, such as topography, vegetation, soils, and geology, may cause non-transferability of a calibrated model. In general, there is an important transition from granitics and metamorphic rocks in southeastern California to sedimentary and volcanic rocks moving eastward onto the Colorado Plateau. Also, there is an increase in vegetation density with an increase in coniferous vegetation type and also in grasses moving eastward onto the Colorado Plateau.

The comparison of a recoverable water estimate between average simulated and measured watershed outflow is not very meaningful in terms of model calibration, especially when calibrating a model to be used in a different basin. The best way to determine if the hydrologic characteristics and processes in a watershed have been adequately represented by a model is to compare the hydrographs of simulated and measured daily watershed outflow because the timing, duration, and intensity of runoff events are much more indicative of watershed characteristics than mean outflow rates.

6.6 Water Balance for the Bristol, Cadiz, and Fenner Watersheds. How was it determined that the basins are closed basins? Show data that supports that there is no inflow or outflow from upgradient and downgradient basins.

Page 59, 6.6.1, Outflow Terms-Groundwater Pumping. Agricultural pumping is estimated at 5,026 acre-feet per year. Were return flows considered in the budget or are the fields drained?

Page 60, 6.6.2, Evaporation Loss from Dry Lakes. The Draft Report states that a wide range of methods are used for determining evapotranspiration rates in playa settings. Because of the importance of accurately determining this number, there should have been an effort to use an energy balance (Czarnecki, 1997; Laczniak and others, 1999) or salt scraping method (Lines, 1979, described below) to estimate the evaporation from the playa.

Page 60, 6.6.2.1, Determination of Evaporation Area. The Draft Report assumes that evaporation occurs over the entire surface area of Bristol and Cadiz dry lakes on the basis of the assumption of shallow depths to water. The report references Moyle (1967) as support for "shallow" depths to water. Plotting the water levels presented in Moyle (1967) indicates that the depth to water exceeds 10 feet throughout most of Bristol dry lake. Water levels beneath the eastern third of the dry lake range from 30 to 54 feet below land surface. Kunkel and Chase (1969) revised estimates of Lee (1913) for bare-soil evaporation from different depths to ground water in Indian Wells Valley, California. In their study they estimated that the annual rate of evaporation from bare soil decreased to negligible amounts at water-level depths of more than 7 feet below land surface. The Draft Report sites "puffy" soil as evidence of capillary movement of shallow water. How did this study differentiate between shallow perched water (remnant from local runoff--see Volume 1, figure 10--Photograph of Bristol Dry Lake during Flood Conditions) and regional ground-water evaporation? The total area of Bristol and Cadiz dry lakes is reported to be 41,600 and 29,788 acres, respectively (table 8, Volume1). However, the value calculated utilizing the geologic data presented by the Department of Defense (1998) and digitizing the geologic map of Kupfer and Bassett (1962) is 40,972 acres for Bristol and 17,485 acres for Cadiz. What is the reason for the large discrepancy in values for Cadiz dry lake? In any case, on the basis of the water-level data presented in Moyle (1967) the area used to calculate the evaporation is too large. Also it should be determined if there is a perched water body at the lakebed. If the water body is perched, then the evaporation from the lakebed can not be used to calculate discharge from the regional aquifer.

Page 60, 6.6.2.1, Estimated Evapotranspiration Loss. The Draft Report neglects to account for direct recharge of precipitation and runoff on the dry lakes, and assumes all the evaporation is from ground water that has originated north of Fenner Gap. As shown on figure 10 of Volume 1 (Photograph of Bristol Dry Lake During Flood Conditions), the dry lakebeds become lakes during rainfall events. In a study of the Bonneville Salt Flats, Turk (1973, p. 73) found that infiltration rates ranged from 2.5 to 4.0 feet per day on the salt crust and from 0.4 to 1.4 feet per day in areas of clay and silt. Clearly the infiltration of ponded water on the lakebeds needs to be addressed in the water balance. The Draft Report references Todd (1980) for the evapotranspiration rates used in table 8 to calculate total evapotranspiration. Todd (1980) states that for water tables within 1 meter of ground surface, evaporation is largely controlled by atmospheric conditions; but below this depth, soil properties become limiting and the rate decreases markedly with depth. Todd (1980) presents data only to about 7 feet below land surface (about 2% of pan evaporation). As stated above, Moyle's (1967) data indicate that the depth to water beneath most of Bristol dry lake exceeds 10 feet. Therefore, one should use values less than 2% (0.26 feet per year) to estimate the total evaporation. As stated in Todd (1980), evaporation is limited by soil properties at depths greater than 3 feet. The presence of a salt crust further limits the evaporation.

In a study of the Bonneville Salt Flats, Lines (1979) scraped halite (NaCl) that had accumulated on the surface of the dry lakebed sediments to determine the evaporation of ground water from the barren surface. Lines (1979, p. 86-89) estimated that the evaporation during May-December 1976 ranged from about 0.0025 to 0.00042 inch per day. The estimates were made using the weight of halite that had accumulated at land surface on 2 square-foot plots and the concentration of NaCl in the evaporating shallow brine, which averaged about 295 grams per liter. Ground-

water levels at the study plots declined during the summer and fall, but ranged from 0.21 to 2.21 feet below land surface. Similarly, Feth and Brown (1962, p. 100-101) scraped salt from dry mudflats near the edge of the Great Salt Lake during the summer of 1954, and they determined that ground-water evaporation rates at land surface averaged about 0.003 inch per day. Assuming an average evaporation rate of 0.003 inch per day from the surface of Bristol and Cadiz dry lakes (total of 71,388 acres from table 8 or 58,457 acres from the Mojave Desert Ecosystem Program (1998)) and that evaporation is negligible during the winter (December through February), evaporation of ground water from the two dry lakes could be no more than about 6,500 to 5,300 acre-feet per year depending on what value is used for the lakebed area. An ongoing study by the USGS in Death Valley has measured rates of about 0.17 feet per year on a salt playa (salt crust) where the depth to water was less than 1 foot and 0.27 feet per year on a bare soil with some salt mix where the depth to water was 1 to 2 feet (Guy DeMeo, USGS, WRD, Las Vegas, Nevada, written communication, 2000).

Clearly the values for evaporation and areas of potential evaporation are too large as presented in table 8. If one uses the Death Valley number for the evaporation rate (0.17 feet per year) and multiplies that by the area of the dry lake playa surface digitized from the Kupfer and Basset (1962) geologic map (58,457 acres), the estimate evaporation is 9,900 acre-feet per year. The evaporation rate estimated in the report (20,000 to 71,000 acre-feet per year) is unreasonable on the basis of depth to water and soil characteristics, and needs to be significantly reduced. The area of potential evaporation also needs to be reduced significantly.

Page 61, 6.6.3, Total Outflow. The total outflow is stated to be 76,000 acre-feet per year. As stated above, the estimate of evaporation from the dry lakes is too high and needs to be recalculated using lower evaporation rates and smaller areas of potential evaporation. Therefore, this estimate for total outflow is too large. If there was in fact this much ground-water discharge at the dry lakes, one would expect to see springs and vegetation similar to Ash Meadows in Nevada (see Laczniak and others, 1999). To put things in perspective, the estimated evapotranspiration along the entire reach of the Mojave River (Victorville to Afton Canyon) is about 17,000 acre-feet per year (Lines and Bilhorn, 1996). The Mojave River area has areas of perennial flow and riparian habitat.

6.7 Estimates of Groundwater Recharge Using a Chloride Mass Balance Approach. The chloride mass balance approach and associated equations presented in this section are derived from regional recharge studies of the High Plains aquifer (Wood and Sanford, 1995). This is a much different environment than Bristol, Cadiz, or Fenner basins. Although semi-arid, the High Plains receive between 13 and 22 inches per year of precipitation, areal recharge occurs through the unsaturated zone. In contrast, precipitation in the study area is about 7 inches per year and the assumptions associated with the approach as described in the Draft Report are not valid (Wood, 1999). Violation of these assumptions is discussed in the Draft Report; however, this is not a matter of using an approach, violating a few assumptions and qualifying the results--it is a matter of using a completely wrong approach.

There is an alternative chloride mass-balance approach for arid regions where assumptions needed to use the Wood and Sanford (1995) approach are not valid. In contrast to estimates of recharge described in the Draft Report, when properly applied the chloride mass-balance

approach is used to estimate the time since recharge has last occurred. Phillips (1994) described the use of the chloride mass balance approach for alluvial basins in the arid portions of the Southwestern United States. In the Mojave Desert, the approach has been applied near the study site at Ward Valley (Prudic, 1994; National Research Council, 1995), at the Nevada Test Site (Tyler et al., 1995), and in the western part of the Mojave Desert (Izbicki et al., 1998). Although the hydrology at specific sites differ, the general conclusions from these studies is that chloride has been accumulating in the unsaturated zones for 13,000 years in western part of the Mojave Desert (Izbicki et al., 1998) to as long as 58,000 years in Ward Valley adjacent to Fenner Valley. This is a different result than the 40,000 acre-feet of annual recharge estimated using the chloride mass-balance approach for Fenner Valley in this Draft Report.

Although the data needed to calculate the time since recharge were not collected as part of this study, the report indicates that chloride and other soluble salts have accumulated in the unsaturated zone beneath Fenner Valley. On the basis of increased dissolved solids and chloride concentrations as high as 933 mg/L measured in monitoring wells after water from the test recharge basins in Fenner Gap through the unsaturated zone to the water table, a large amount of chloride has accumulated in the unsaturated zone at the test site and it has been a long time since recharge has occurred through the unsaturated zone at this location. Data from this Draft Report, and from all other studies done in the Mojave Desert, are consistent and indicate that only negligible recharge occurs on the alluvial valley floors of desert basins. In addition, there is a large body of literature from other parts of the American Southwest, Australia, and arid zones throughout the world that supports this conclusion.

Dettinger (1989) estimated that some recharge may occur to alluvial basins in Nevada as a result of precipitation, runoff, and infiltration at higher altitudes. The chloride mass-balance approach described by Wood (1999) may (with great uncertainty) be applied to these areas to estimate an upper limit on recharge to Fenner basin. Assuming that recharge in the Fenner basin only occurs from precipitation at altitudes greater than 4,000 feet (Dettinger, 1989), recharge to Fenner basin is about 1,710 acre-feet per year. This value was estimated using the chloride mass balance approach as follows:

$$Q = [(P^{*}Cl_p) / Cl_{gw}] A_{4000}$$

where P is average annual precipitation about 10 inches per year (0.83 feet per year) (this Draft Report);
Cl_p is the chloride concentration in precipitation from the Mojave Desert, about 0.8 mg/L;
Cl_{gw} is the chloride concentration in ground water from Fenner Gap monitoring wells, about 49 mg/L. This value excludes low chloride concentrations in water from agricultural wells operated by Cadiz Inc. (this Draft Report); and
A_{4000} is the area of the basin above 4,000 feet, about 126,000 acres.

The average chloride concentration used in this calculation is subject to uncertainty. The value used in these calculations is the value used for bulk precipitation in chloride mass-balance calculations for Ward Valley (Prudic, 1994). This value is higher than the volume-weighted mean chloride concentration measured in precipitation at National Atmospheric Deposition

Program (NADP) site at Red Rock, Nevada. This site has been operated for 14 years and is the best data for the region. However, data from the NADP sites are wet-fall only (rain, snow, etc.); these data do not include dry-fall (dust, particulates, ect.). This value also is higher than the chloride concentration for bulk precipitation of 0.4 mg/L measured for precipitation by Dettinger (1989) to estimate ground water recharge in 16 basins in Nevada. This value is lower than the chloride concentration of 3.5 mg/L used in this Draft Report to estimate recharge in Fenner Valley.

At best, recharge estimates calculated using the chloride mass balance approach described by Wood and Sanford (1995) provide an upper limit on ground-water recharge from higher altitudes in the Fenner basin. Dettinger's (1989) work was for basins farther north in Nevada and may not be directly transferable to Fenner Valley. For example, there may not be large quantities of recharge at altitudes greater than 4,000 feet in the southern California Desert and chloride may be accumulating in the unsaturated zone in that part of the basin. No data are provided in the Draft Report to demonstrate that infiltration to depths below the root zone and subsequent ground-water recharge occur in the study area at altitudes greater than 4,000 feet.

If the chloride mass-balance method is applied but the deposition rate is 0.8 mg/L, which is what has been recommended for Ward Valley, and if you assume that all the recharge comes from soil type D then the method alone would calculate a recharge of 3,000 acre-feet per yearr. Even if you use the entire Fenner watershed area, rather that soil type D, the recharge would be 9,000 acre-feet per year. The 3.5 mg/L accumulation number used is much higher than most other researchers would use.

6.8 Groundwater Storage Estimates

Page 64, 6.8.1, Groundwater Storage Estimates for the Fenner Watershed. Estimates of ground-water storage using this methodology are misleading. Although there are large amounts of ground water in storage, much of this water is difficult to extract owing to decreased permeability with depth. In addition, the water chemistry of the deeper sediments in most desert basins contains high concentrations of fluoride, arsenic, and other trace elements.

Page 64, 6.8.1.1, Procedure. As stated earlier in the review, there appears to be a problem with the depth to bedrock map. Where checked with borehole data presented in the Draft Report, the depth to bedrock map overestimated the depth to bedrock. The specific yield values will decrease with depth in the aquifer, because of cementation and compaction of the sediments.

Page 65, 6.8.1.2, Parameters Used for Storage Calculation. Same comments as above.

Page 66, 6.8.1.3, Results. Need a statement indicating that not all of this could be extracted economically and the water chemistry of this water may be greater than drinking-water standards for some constituents.

Page 67, 6.8.2, Groundwater Storage Estimates for the Project Area. The estimate is based on the depth to bedrock map presented in the Draft Report (figure 17). As stated above, this map appears to overestimate the depth to bedrock.

7.0--FENNER GAP PILOT INFILTRATION TEST

Overall the largest weakness with this section is the lack of a numerical model. A pre-experiment model, using the soil parameters estimated from field and laboratory analysis, should have been conducted. This step is a critical part to any large-scale field experiment. The results would demonstrate the adequacy (or inadequacy) of the estimated parameters. Modeling of the unsaturated zone is a much more difficult part of the study than modeling of the saturated zone. The non-linearity of the relation between water content and water potential is critical in understanding the response of the system to continual ponding. The hydrologic characterization of the unsaturated (vadose) zone is still a critical part of site characterization. The demonstration of adequate data and understanding are needed to show how the system will respond to long-term ponding (and infiltration) and pumping. Post-experiment modeling (history matching) would help to further develop the hydrologic properties of the unsaturated zone using standard inverse methods.

7.1 Pilot Spreading Basin. What is the rationale for requiring 200 feet of a saturated alluvial aquifer? Should not the requirement be for a specified unsaturated alluvial thickness because the artificial recharge and mounding will occur above the water table? Again a model would be helpful in defending, or providing rationale for assessing, the thickness required for the saturated or unsaturated zone.

7.3 Pilot Test Field Testing. Report should include plots of the pumping-test data. Show the type-curve matches for determining aquifer characteristics (Ttansmissivity and Storage). How were the gypsum blocks isolated in the boreholes? Were bentonite seals placed in the holes to prevent preferential flow through the borehole?

Page 76, 7.3.4.1, Principle of Operation. The resistance between the two probes is calculated from voltage measurements made in the gypsum blocks. The resistance is converted to water potential using a calibration equation. This section incorrectly states that the sensors measure water potential which is converted to Kohms (this appears to be just a misstatement). Heat dissipation probes, which are a much better measures of water potential, should have been used. They would provide data necessary for modeling.

Page 77, 7.4, Eight-Month Infiltration Test Monitoring. Was the model used to simulate the drawdown at the pumping well and the mounding beneath the ponds? This would be useful to help calibrate the model on a local scale. The model could then be used to predict water-level changes resulting from the larger scale project.

Page 77, 7.4.1, Climatological Data. What is the "evapotranspiration monitor" on the weatherstation and why were solar radiation measurements, the driving force for evapotranspiration, not measured during the study period?

Page 77, 7.4.4.2, Single-Ring Infiltrometer Field Tests. Is the reference to Bouwer (1998) the 1989 reference? The method employed is not as straight forward as other infiltrometer methods.

A long-term measurement (greater than 6 hours), where lateral flow is less important, would give a better measure of the expected conditions in the similar, but larger, ponded area.

7.5 Water Quality Monitoring

Page 83, 7.5.2, Sampling Procedure. Some wells may not have been completely purged prior to sample collection using the procedure described in the Draft Report. For example, monitoring well CI-1 is 420 feet deep and the depth to water is about 300 feet. Given a casing diameter of 2 inches, about 19 gallons of water are in the casing. According to procedures described in the Draft Report, only 6 liters of water (about 1.5 gallons) were removed from each well prior to sample collection. The sampling procedure increases uncertainty associated with the interpretation of chemical and isotopic data presented in the Draft Report.

Page 85, 7.5.3.2, Baseline Analyses-General Suite. Comments for this section also include comments on results of chemical analyses presented in table 12 and Appendix U.

Results of chemical analyses show that background water quality from the Fenner Gap monitoring wells has a relatively wide range in dissolved solids from 267 to 1,040 mg/L. On the basis of Stiff diagrams presented in Appendix U most water is sodium bicarbonate or sodium bicarbonate-sulfate in chemical composition. No baseline water-quality samples from monitoring wells in Fenner Gap had a calcium bicarbonate composition and high pH (greater than 9.0) that would be expected for water from Schuyler Wash that infiltrated through a thick unsaturated zone to recharge the underlying ground water. As a result, chemical data are not consistent with large amounts of infiltration from the wash as interpreted in the Draft Report. It is interesting to note that after water from the test recharge ponds infiltrated through the unsaturated zone to the water table, water from the monitoring wells became increasing calcium bicarbonate in chemical composition (table 22).

Page 85, 7.5.3.3, Baseline Analyses-Isotopes. Comments for this section are included in comments for section 9.3.3 "Evaluation of groundwater age using isotopes."

8.0--CADIZ GROUNDWATER MODEL

8.1 Model Development. Please clearly explain for what purpose the models were developed.

Page 94, 8.1.1, Conceptual Model. The conceptualizations of model layers 2 and 3 are not clear. Semiconfined is insufficient information. In MODFLOW, are these layers confined or confined/unconfined (LAYCON=2 or 3)? On the basis of Plate 3, there may be continuous clay layers; you choose to assume them to be discontinuous.

Page 95, 8.1.2.1, MODFLOW Model. Please clearly explain and defend the nonuse of the fault (HFB) package given the high degree of faulting in the study area. The northwest/southeast trending faults may be barriers to ground-water flow and should be incorporated into the model.

Page 97, 8.1.2.2, MT3D Model. Please clearly explain and defend the use of MT3D, a nondensity-dependent transport model, to model brine transport. Water with high TDS

concentrations (about 300,000 mg/L beneath Bristol dry lake) has a greater density than freshwater. This greater density will affect the physics of the flow system; therefore, in order to estimate the potential impact of the proposed project on the movement of the high-density brine one must use a density-dependent ground-water flow and transport model. To determine the potential impacts of the proposed project on the salt playas, a density-dependent transport model is needed.

Page 98, 8.1.2.3, Pre- and Post-Processors. No comments

Page 98, 8.1.3, Model Size, Grid Geometry and Boundary Conditions. Please show a typical model cross-section.

8.1.4 Flow Model Aquifer Parameters

Page 99, 8.1.4.1, General. Please use specific yield instead of effective porosity (effective porosity is used later in the report as a porosity). It is stated much later in the report that layer 2 is confined/unconfined; therefore, the top elevation of this layer is required. I assume that layer 3 is confined, although it is never stated. Define "mathematically superimposing" and "appropriate gridding algorithm."

Page 100, 8.1.4.2, Elevations of Aquifer Boundaries. Move this section to Section 8.1.3. How were the elevations determined? As stated earlier in the review, the bottom elevation of the upper aquifer in Fenner Gap is too low.

Page 100, 8.1.4.4, Hydraulic Conductivity and Transmissivity. Note that Jacob's method is valid only for confined aquifers; therefore, is not applicable to layer 1 data. The use of the screened interval to calculate K can overestimate the K value. The well efficiency is not normally used to estimate T from specific capacity data (see Driscoll, 1987) and will overestimate T. Please provide a reference for the E-log sequential method and show example calculations. How were K-values adjusted using clay percentages and what is the basis for this adjustment? Give specific clay percentages used in table 14. Show point estimates of hydraulic conductivity and transmissivity on contour maps (figures 61-64) for comparison. Overlaying figures 60, 62 and 63, the hydraulic conductivity and transmissivity contours do not appear to be consistent. A map with the model grid and associated parameter values for all layers needs to be presented in the Draft Report.

Data for the aquifer tests presented in table 14 need to be presented in the Draft Report or be in a published document. The USGS logged well 5N/14E-13 shown in the table 14. Inspection of the geologic log for this well indicated that the sediments were poorly sorted, gravelly sand and silt with increasing silt content with depth. On the basis of this lithologic description, it is difficult to justify an average hydraulic conductivity of 699 gallons per day per foot squared ($gpd/ft^{2)}$. An average value of 100 gpd/ft^2 would be the highest that one would expect for these materials. What was the pumping rate for this test? Also, why is this well assigned to layer 2 when the well is perforated at the water table? According to Plate 3, most of this well is perforated in layer 1. The upper estimate of the layer-2 transmissivity seems too high. From your description of the layer-2 materials, the hydraulic conductivity values may be in the range

of 1 to 10 gpd/ft^2 (Freeze and Cherry, 1979). The layer-3 transmissivity values are too high. For sandstone the transmissivity values should range between 0.4-4000 gallons per day per foot (gpd/ft) and for carbonate rocks the transmissivity values should range between 4-4000 gpd/ft (Freeze and Cherry, 1979).

In general, the hydraulic conductivity and transmissivity values are too high, which allows the high flux rates that are assumed in the model. The pumping-test data presented in the Draft Report for well PW-1 (Appendix M) indicate a specific capacity of about 200 gpm/ft. The empirical equation used to estimate transmissivity from specific capacity in a unconfined aquifer is to multiply the specific capacity (gallons per minute per foot) by 1,500 to give transmissivity (gpd/ft) (Driscoll, 1987, p. 1021). Using this equation for the well PW-1 data indicates that the transmissivity of the aquifer near well PW-1 is 300,000 gpd/ft. Dividing this estimated transmissivity by the perforated interval of the well (500 feet) will give an estimate of the average hydraulic conductivity--in this case 600 gpd/ft^2. This value is about 70% of the value estimated on table 14 (851 gpd/ft^2). On table 14, it is assumed that well PW-1 is only perforated in 36 feet of layer 1. On plate 3 of the Draft Report it appears that layer has been placed at an elevation of 300 feet, which would indicate that well PW-1 is perforated in about 300 feet of layer 1. In table 14, the hydraulic conductivity of layer 1 is assumed to be 2.7 times the hydraulic conductivity of layer 2. Assuming this ratio is correct, the estimated hydraulic conductivity values at PW-1 are 800 and 300 gpd/ft^2 for layers 1 and 2; respectively. It is clear that the adjusted hydraulic conductivities estimated for this well in table 14 (1,835 gpd/ft^2 for layer 1 and 680 gpd/ft^2 for layer 2) are too large. Using lower values would decrease the allowable flux rate.

Page 103, 8.1.4.5, Vertical Leakance. Vertical leakance (VCONT) is calculated using vertical K values not horizontal K values. Assuming anisotropies of 1 to 2 orders of magnitude may greatly reduce the calculated VCONT values. Lower VCONT values can lead to greater stratified flow than is currently being modeled.

8.1.5 MT3D Model Aquifer Parameters

Page 104, 8.1.5.2, Aquifer Thickness. Thickness of aquifer units in the Fenner Gap needs to be reduced.

Page 105, 8.1.5.3, Longitudinal and Transverse Dispersivity. The longitudinal dispersivity value of 50 feet seems small. Gelhar et al. (1992) report that at the field scale (greater than 1,000 meters), longitudinal dispersivity values of about 100 meters (greater than 300 feet). Anecdotally, other researchers have used longitudinal dispersivity values on the order of their grid spacing. The use of small dispersivity values will sharpen the solute front and allow less spreading than would a larger value.

Page 105, 8.1.5.4, Total Dissolved Solids Concentrations. Review of the data in table 22 shows that prior to artificial recharge in the Fenner Gap area dissolved solids concentrations in some wells were as high as 1,040 mg/L. This is higher than the 300 to 400 mg/L reported in the Draft Report. It is not clear from the Draft Report why wells having high dissolved-solids water

were sampled only one time or why this water was not analyzed for stable isotope or carbon-14 activity.

8.1.6 Recharge and Discharge

Page 106, 8.1.6.2, Subsurface Inflow. Show locations of injection wells on a figure. Into which layer was water injected?

Page 106, 8.1.6.3, Areal Recharge. Show recharge cells on a figure.

Page 106, 8.1.6.4, Ground-water Pumping. Pumping information does not match data presented on page 43.

Page 107, 8.1.6.5, Evapotranspiration. Show the ET cells on a figure. Justify the use of an extinction depth of 100 feet; this value seems to be much too large; it should be less than 10 feet for bare-soil evaporation. Using a too large extinction depth allows much more flux to leave the system than if a smaller value were used. State the values of the ET surface and the maximum ET used in the model.

8.2 Model Calibration

Page 107, 8.2.1, Selection of Calibration Period. The discussion of the calibration period makes no sense. Why is the precipitation record important? It seems that the pumping record would have a greater impact on the ground-water system. How is 1958-85 a steady-state condition? How is this implemented in the model? Compare the simulated steady-state water levels with measured, predevelopment water levels.

Page 108, 8.2.2, Discussion of Calibration Process. What do you mean by "Therefore, for the purposes of this model, the model-generated water levels beneath Bristol and Cadiz dry lakes were not used and were considered boundary conditions"? If the simulated water levels beneath the lakes are 40 to 80 feet below measured water levels, this indicates that the simulated initial conditions are much too low and the model should be recalibrated. Note that most of the calibrated water levels in the northern part of the model area (e.g., figures X-13 and X-15) are 20 to 40 feet higher than measured water levels. This information, coupled with the lower-than-measured lake water levels, indicates a simulated gradient greater than measured conditions. This implies that even though overestimated T values are used in the model, the model could not transmit the estimated inflows without increasing the simulated hydraulic gradient.

Page 109, 8.2.3, Discussion of Model Calculated Recharge and Discharge. The report states that the model simulated recharge term (50,000 acre-feet per year) is supported by the stable water level trends. As described below, the water levels were not stable. The model could not simulate 50,000 acre-feet per year discharge without having an unreasonable evaporation extinction depth (100 feet) and the resulting simulated water levels at the dry lakes were 50 feet too low. In addition, the simulated water-level gradient through the Fenner Gap was greater than the measured gradient, even using unreasonably high transmissivity values. The model results indicate that the conceptual model is incorrect.

Page 110, 8.2.4, Discussion of Model-Generated Water Levels. Show the simulated steady-state water levels. Published data indicate that steady-state water levels were about 600-625 feet around the project area; these data are 40 or more feet higher than the initial water levels shown in figures X-4 to X-15. This indicates that the steady-state water levels were underestimated throughout the model domain. Show measured water levels on simulated water-level contour figures. The model underestimates the water-level declines at the Cadiz agricultural well field. The model fit appears reasonable at the scale plotted; however, if the measured data ranges only on the order of 25 feet for the period of simulation, one should not plot it on a scale that has a range of 400 feet. The model results need to be replotted on a reasonable scale and consideration should be given to predevelopment water-level measurements in the area (Moyle, 1967). As stated previously, the model does a poor job of simulating the water-level gradient north of Fenner Gap.

The model needs to be recalibrated, starting with steady-state conditions. The model needs to be able to simulate the observed water levels and gradients. Matching the water levels at Cadiz and Bristol dry lakes will be an important element of the calibration process. Initial calibration might include using the MODFLOW drain function to simulate discharge at the dry lakes.

8.2.5 Discussion of Water Budget

Page 112, 8.2.5.1, Water Balance Analysis. The water budget is meaningless because the model does not correctly simulate the water levels beneath the dry lakes.

Page 113, 8.2.5.2, Natural Recharge to the Cadiz Project Wellfield. The value of 30,000 acre-feet per year of recharge is based on an invalid model. As stated above, the gradient simulated by the model is too high through the Fenner Gap, even using unreasonably high transmissivity values. Earlier in the report it is stated that all the recharge originates from the mountains in Fenner Valley. If 30,000 acre-feet per year is simulated as moving through Fenner Gap, where does the model simulate the remaining 20,000 acre-feet per year recharge to the system?

8.3 Evaluation of Project Operational Scenarios Using the Cadiz Groundwater Model. The following sections discussing the operational scenarios (Sections 8.3.1-8.3.6) were not reviewed, because the model needs to be recalibrated before using it to predict future scenarios.

8.4 Evaluation of Subsidence

Page 116, 8.4.2, Description of Subsidence Simulation Model. As most readers will not be familiar with Helm's model, please present the model with all assumptions.

Page 116, 8.4.3, Model Input Data Parameters. Were the proposed spreading basins included as one of the modeled sites? The overburden of the water may cause increased subsidence. Please show sites where model was applied on a figure.

Page 117, 8.4.3.1, Idealized Lithologic Log Development. What is an "idealized lithologic log"? Please show one.

Page 117, 8.4.3.2, Water levels. Where in the column are the boundary conditions defined?

Page 118, 8.4.3.5, Preconsolidation Stress. State the value of preconsolidation head used in the subsidence model. Compaction occurs after the head drops below the preconsolidation head; therefore, the timing of compaction is affected by the choice of this value.

Page 119, 8.4.4, Model Output. Please show the time varying subsidence for all 19 sites.

SECTION 9.0--RESULTS

9.1 Results of Evaluation of Water Resources

Page 120, 9.1.1, Results of Watershed Model. The Draft Report estimates that the total amount of recoverable water for the entire watershed ranges from 20,000 to 58,000 acre-feet per year, with a median value of 39,000 acre-feet per year. As discussed in great detail in the review of Section 6.0, there are major problems with the watershed model assumptions and results. The watershed model is a detailed daily water-budget model: daily precipitation, infiltration, runoff, vegetation interception, evapotranspiration, soil moisture, and percolation are addressed. However, the model does not address bedrock permeability, and this may become an important factor for upland areas with shallow soils underlain by low-permeability granites and metamorphics. For example, soil unit D defines an important watershed modeling unit that is used to subdivide the watershed model into areas of similar characteristics. For soil unit D, these are predominantly upland areas with shallow soils and thus the permeability of the underlying bedrock may have an important effect. The estimates of field capacity used in the model (13 to 17 %) are below the range that would be calculated from the STATSGO database for soil unit D in the Providence Mountains area. Estimates using the STATSGO database, for the same general area as soil unit D, would be 17 to 24 %. The soil thickness for the shallow soils seems reasonable, but the soil thickness for the deeper soils is in error. Although taxonomically the soils may be less than 2 meters, the rooting depth, and therefore the evapotranspiration depth, is much deeper. As shown in figure 26 of the Draft Report, field capacity and soil thickness are very sensitive parameters for the watershed model. Increasing the field capacity and/or the soil thickness will reduce the model-calculated recharge. Therefore, the range of recoverable water calculated by the watershed model used in the Draft Report would be larger (the low end would be lower and the high end would remain the same) and the resulting median value would be lower.

To test the reasonableness of the recharge values simulated by the Draft Report watershed model, the USGS developed two Maxey-Eakin water-balance models. The model development and model results are included as an attachment to this review. The median recharge rate estimated by the watershed model (39,077 acre-feet per year) is 3 to 15 times higher than the values estimated by the preliminary Maxey-Eakin models developed by the USGS (2,550 to 11,800 acre-feet per year). The quantity of recharge estimated with the watershed model appears to be an overestimate of the recharge and, therefore, the recharge rates should be reevaluated.

Page 121, 9.1.1.4, Groundwater Storage Capacity. This value is misleading in that it assumes that all of the water can be removed and that all of the water is of suitable quality. Table 10b of the Draft Report overestimates the thickness of layer 2 and overestimates the specific yield of the bedrock aquifer.

Page 121, 9.2, Geology of Fenner Gap. There are inconsistencies in the measured thickness of alluvium and the values and the depth to bedrock contour map presented in the Draft Report (figure 19). As indicated in the Draft Report, the difference in bedrock elevation between wells 5/14-13 and CI-2 suggest the presence of a fault. This fault and other faults in the area should be studied to determine if they are barriers or partial barriers to ground-water flow. These faults may compartmentalize the proposed recharge and change the proposed recharge/pumpage operation.

9.3 Geohydrology of Fenner Gap

Page 125, 9.3.1, Bedrock Aquifer. It is unclear from the data presented in the Draft Report that there is a bedrock aquifer in the study area. Additional geohydrologic and geochemical data need to be collected to determine the significance of the bedrock aquifer.

9.3.2 Alluvium

Page 129, 9.3.2.1, Geohydrologic Characteristics. The Draft Report presents results of a pumping test conducted for well PW-1. It is apparent from inspection of the data that water levels are being affected by leakage. Water levels made during the test indicate that actual drawdowns are less than those predicted by the Theis curve at larger values of time. This type of deviation generally reflects the presence of a lateral recharge boundary or a leaky aquifer. Because there are no apparent recharge boundaries, the departure from the curve probably is the result of leakage of ground water from overlying or underlying sediments. The transmissivity and storage coefficient of an aquifer affected by leakage may be solved by conventional methods of analysis on the basis of the Theis equation if the data are collected at or close to the pumped well. In general, drawdown data collected early in an aquifer test are affected by leakage to a lesser degree than data collected at a later time (Neuman and Witherspoon, 1972, p. 1291). Analysis of drawdown data collected from wells at a distance from the pumped well, and at later times tends to overestimate the transmissivity of the aquifer. Therefore, early time data (in this case 0.1 to 10 minutes after commencement of pumping) should be analyzed from the pumping well and close observation well. Data collected during the recovery phase will be affected by leakage and will overestimate the transmissivity.

Page 130, 9.3.2.2, Baseline Water Quality. Inspection of the trilinear diagram of water-quality samples for wells in the Fenner Gap indicate that there is a wide range of water quality in the gap. The Draft Report states that the difference is the result of development problems. However, when one inspects the data a definite pattern appears. Most of the wells in the gap are perforated only 100 feet below the water table. In general, these wells are sampling the upper alluvial aquifer. Wells in the southeastern part of the gap (wells MW-3, 5, and 6) have TDS values in excess of 500 mg/L and have high percentages of sodium. These wells may be

influenced from poor quality water from the underlying and surrounding bedrock. The thermal water sampled in Fenner Gap indicates upward flow from the underlying bedrock, possibly along fault zones. The two deepest wells (5/14-13 and PW-1) have the lowest TDS values (328 to 294 mg/L) of the wells sampled. These wells also have similar water chemistry, having a higher percentage of sulfate and calcium then samples from the other wells. As stated in the Draft Report, these wells appear to be on the downthrown (southwestern) side of a northwest-southeast trending fault. Wells CI-3 and MW-2 are probably also on the southwestern side of the fault; however, they have similar chemistry to the wells on the upthrown (northeastern) side of the fault. In addition, these wells are screened only in the upper 100 to 200 feet of the aquifer. This suggests that wells PW-1 and 5/14-13, which are perforated 500 to 300 feet beneath the water table, yield a large percentage of their water from the water-bearing deposits that are more than 100 feet below the water table. A velocity log and downhole sampling should be completed in these wells to identify the major water-bearing zones. In Fenner Gap, apon the northeastern side of the fault, water-bearing deposits are not as prevalent at depths of more than 100 feet below the water table. As shown on plate 3 of the Draft Report, a silt and clay layer is present at about 150 feet below the water table at wells PW-1 and CI-3. This fine-grained layer must separate the two types of water. It is interesting to note that the hydraulic head in well PW-1 is about 5 feet higher than the head in the nearby CI-3 well. The land-surface elevations should be resurveyed to verify this difference.

The source of water to the upper aquifer on the downgradient side of the fault probably is underflow through the Fenner Gap in the permeable deposits directly beneath the water table because the TDS and water types are similar. However, the source of water to the lower aquifer on the downgradient side of the fault cannot be solely underflow from Fenner Gap. The lower aquifer downgradient of the fault contains lower TDS and has different chemistry compared with upgradient wells in the Fenner Gap (see figure 80 in the Draft Report). Recharge along the Orange Blossom Wash may be the source of this water. Additional geochemical and isotopic data are needed from the deep wells to help answer this complex hydrologic puzzle.

Page 133, 9.3.3, Evaluation of Groundwater Age Using Isotopes. Comments presented for this section also include comments for isotopic data and correspondence from M. Lee Davisson of Lawrence Livermore National Laboratory from Appendix T.

General Comments--A number of controversial land uses have been proposed for the study area and adjacent basins--including the Bolo Landfill (RailCycle) and the low-level radioactive waste disposal site at Ward Valley. Because of the high profile of these proposed sites, the region has been extensively studied and there are a large amount of isotopic data collected in the study area and adjacent basins. Much of this previous work concluded that recharge in the area is small. Although data from these studies are readily available, it does not appear in the Draft Report. These data are important and have been included as part of this review (figure 1).

Comments on interpretation of oxygen-18 and deuterium data--The ∂D and ∂^{18}O isotopic compositions of precipitation collected by Friedman et al. (1992) at Mitchell Caverns and at Amboy (near Bristol dry lake and closer to the study site) are different. Data from Mitchell Caverns plots on the meteoric water line. Data from Amboy plot on a line parallel to, but below, the meteoric water line. The isotopic composition of precipitation data at Amboy relative to the

meteoric water line is typical of precipitation in summer-dominated precipitation regimes of the Mojave Desert and across much of the arid southwestern United States. The isotopic composition of water from Mitchell Caverns is typical of water from cooler, higher altitude sites. The similarity in isotopic composition (both in absolute magnitude and position relative to the meteoric water line) of ground water sampled as part of the Draft Report in the Fenner Gap areas to precipitation at Mitchell Caverns suggests that the ground water originated as recharge from precipitation that fell at a higher altitude rather than from locally derived precipitation. This is consistent with the interpretation presented in the Draft Report and is not consistent with infiltration from Schulyer Wash. Mitchell Caverns and other higher altitude locations are many miles from the study site and ground-water flow paths through alluvial aquifers are long.

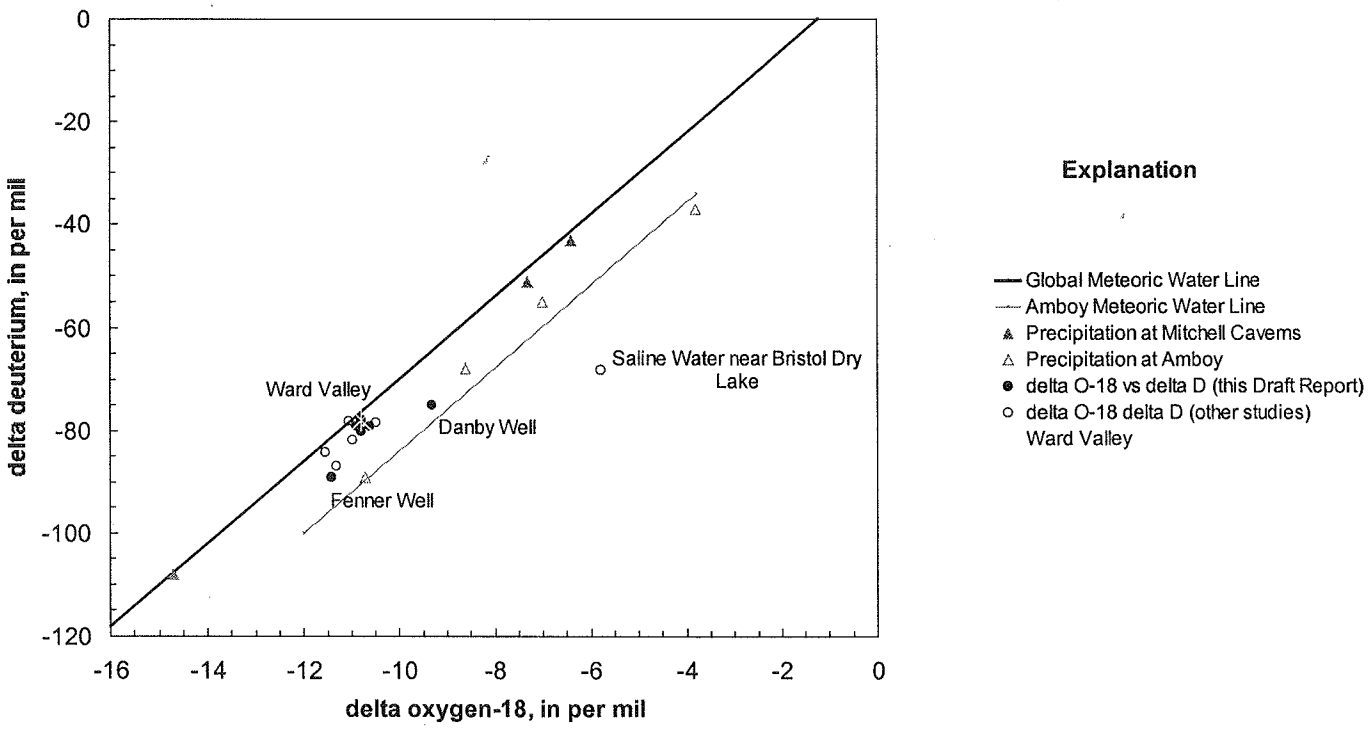


Figure 1.--Delta oxygen-18 and delta deuterium data from Fenner Valley and vicinity.

Water from the Danby well (this Draft Report) plots below the meteoric water line along the local meteoric water line at Amboy. Its position along the Amboy meteoric water line suggests a locally derived origin for water from this well. This is consistent with the interpretation presented in the Draft Report and the ∂D and $\partial^{18}O$ composition of water from the Danby well is cited as evidence of infiltration from washes that drain Fenner Valley. However, if infiltration is occurring along the wash, why is there no isotopic or chemical evidence of water from this source in the Fenner Gap wells? Similarly, data from an upgradient well along the wash at Essex

(LaMoreaux & Associates, 1995) show no evidence of infiltration from the wash. Friewald (1984) described several wells in Danby were that drilled for the railroad between 1901 and 1927. One the basis of water-level data collected by Friewald (1984), the depth to water at this site is about 250 below land surface. At that time, at least one of these wells yielded water from above the regional water table and could not be representative of water from the regional aquifer. It is possible that the Danby well sampled as part of this Draft Report is old, its casing has failed, and water from the well is not representative of the aquifer. Izbicki (1998) estimates that several hundred years are required for water from washes to infiltrate through thick unsaturated zones and reach the water table. Tritium would not be expected in ground water at this site regardless of its source. A failed casing and leakage of surface water into the well also would explain the presence of tritium in water from the Danby well sampled as part of this Draft Report. The Danby well may not be representative of water from the aquifer. Because of the uncertainty of the validity of this sample, the data should not be used as evidence of infiltration from the wash and should not be considered as part of the interpretations in this Draft Report. Proper identification of the well, inspection of the well, and inspection of the integrity of its casing are required to verify or reject this sample.

The Draft Report claims that the natural variability in the isotopic composition of water in the Fenner Gap area is small and consistent with one large source of ground-water recharge. However, on the basis of the large variability in chemical quality of water from wells, this variability has not been adequately addressed with samples collected as part of the Draft Report. Water-chemistry data indicate large differences in the chemical quality of water even in the small area near the recharge site. These large differences in chemistry would not be expected near a large source of ground-water recharge. They are in fact consistent with water from a number of smaller sources converging at a single location. It is not clear from the Draft Report why wells with high dissolved-solids water were sampled only one time or why this water was not analyzed for stable isotope or carbon-14 activity.

As a group the data from wells that were sampled in Fenner Gap are isotopically similar to data collected at the Ward Valley (National Research Council, 1995) and near the proposed Bolo Landfill (LaMoreaux & Associates, 1995). The most negative (lightest) samples are from a well along the eastern edge of Fenner Valley, sampled by Gleason et al. (1984). This sample plots along the local meteoric water line at Amboy and, on the basis of its location, would not be expected to receive recharge from the higher altitudes in the Providence Mountains near Mitchell Caverns. Saline water from a well near Bristol dry lake plots farthest from the meteoric water line as a result of evaporation. These data give an estimate of variations in the natural isotopic composition of water from wells in the study area--additional data are required for further interpretation.

The similarity of the ∂D and ∂^{18}O isotopic compositions of water from wells to present-day precipitation is interpreted in the Draft Report as evidence of recharge during present-day climatic conditions. Given the wide range and seasonality in the ∂D and ∂^{18}O composition of present-day precipitation measured by Friedman et al. (1992), care must be used when interpreting changes in ∂D and ∂^{18}O isotopic compositions of water in terms of paleoclimatic signals. Unlike many other areas of the world, in the western part of the Mojave Desert (Izbicki et al., 1995) and in parts of coastal California (Izbicki et al., 1992), correlations between carbon-

14 ages and the ∂D and $\partial^{18}O$ isotopic composition of ground water do not show a large shift toward more negative values (lighter) with increasing age. The reasons for this are unclear but may be related to the marine influence on climate and precipitation in southern California. Paleoclimatic studies have shown that, unlike most of the world, the temperature of the Pacific Ocean off the California coast during the Pleistocene (CLIMAP, 1976) was similar to present-day temperatures (Pisias, 1979).

Comments on the interpretation of tritium data--On the basis of data collected at Santa Maria and correlation with samples collected at Ottawa Canada (International Atomic Energy Agency, 1981), tritium in present-day precipitation in coastal California is expected to be about about 2 tritium units (TU) or about 6.4 picoCurries per liter (pCi/L) (Izbicki, 1992; Michel, 1989). Tritium in precipitation increases with increasing distance from the ocean; Michel (1989) estimated tritium concentrations in southern California to be about 3.3 TU in 1983. On the basis of samples of stormflow runoff collected at different sites in the Mojave Desert (U.S. Geological Survey, unpublished data), tritium in present-day precipitation in the Mojave Desert may be about 6 TU, slightly higher than Michel's estimate and slightly lower than the estimate in this Draft Report. Tritium in precipitation at Santa Maria reached a peak concentration of about 1,200 TU in 1962. Correcting for radioactive decay to the present time (about 3 half-lives) produces an estimate of about 150 TU. This is lower than the value reported in this Draft Report. The actual tritium concentrations in precipitation at the site probably are between the decay-corrected Santa Maria value and the value presented in the Draft Report. However, even after allowing for radioactive decay, tritium is readily measurable in environmental samples if the proper analytical techniques are used.

The tritium data for the Danby well (Stephens & Associates, 1992) has significant error associated with the measurement. The precision of the tritium analysis for this well is poor and the analytical techniques used were not intended for environmental studies of recharge processes. Analytical techniques that incorporate gas scintilation, electrolytic enrichment, or the recently developed helium-ingrowth procedures allow for detection limits of 0.2 TU or lower. The Draft Report interprets data from the Danby well as recently recharged water, and the ∂D and $\partial^{18}O$ isotope data suggest that the water is locally derived. Unfortunately, the well sampled is not identified by State well number. There are several old wells in the Danby area; water-level data (Friewald, 1984) suggest that at least some of the wells do not measure water representative of the aquifer. As previously discussed, Izbicki (1998) estimated that several hundred years are required for water from washes to infiltrate through thick unsaturated zones and reach the water table. Tritium would not be expected in ground water at the Danby well regardless of its source. Data from this well should not be considered as part of the interpretations in this Draft Report unless the sampled well is identified and the integrity of its casing verified.

Comments on the interpretation of carbon-14 data--Carbon-14 data from observation wells in Fenner Gap range from 18 to 25 percent modern carbon and have an apparent ages ranging from 11,500 to 14,000 years before present. In Appendix T, M. Lee Davisson suggests that water-rock reactions have occurred and that ground-water ages are younger than apparent ages indicate. However, he still believes that the ground-water age is early Holocene to late Pleistocene. The Draft Report dismissed the carbon-14 data and interpretations provided by M. Lee Davisson and suggested that carbon-14 data are not interpretable because reaction between ground water and

aquifer materials (primarily dissolution of carbonate minerals) during recharge and subsequent movement through the aquifer have altered the carbon-14 activity of the ground water.

In areas where the recharge rate is small and infiltrating water passes through a thick unsaturated zone prior to ground-water recharge, the Draft Report is correct in stating that carbon-14 activities are altered and may not be interpretable. However, in areas where large amounts of recharge occurs, the unsaturated zone is leached of chloride and other soluble salts, and carbonate minerals have not accumulated. The estimates of recharge presented in the Draft Report are large and, if correct, would leach soluble salts and, therefore, extensive accumulations of carbonate minerals would not be present in the unsaturated zone in these area. These conditions allow interpretation of rock-water reactions and their effect on carbon-14 activities.

On the basis of carbon-13 data provided as part of the Draft Report, reactions have occurred between ground water and aquifer materials. However, it is possible to interpret carbon-14 data and correct ground-water ages to account for the dissolution of carbon from aquifer materials that do not contain carbon-14. Numerous studies in the literature demonstrate corrections for rock-water interactions and the application of carbon-14 data to ground-water recharge studies. A complete interpretation of possible rock-water reactions and resulting corrections in carbon-14 data is beyond the scope of this review. However, an estimate of corrected carbon-14 ages for water from wells sampled in Fenner Gap can be made on the basis of data and rock-water reactions interpreted from other studies. Given the following,

1. Organic carbon typically has $\partial^{13}C$ compositions ranging from -21 to -28 per mil, depending on the source. Ground water in most desert aquifers contains dissolved oxygen. As a result, sulfate reduction and oxidation of organic material to bicarbonate cannot occur and contributions from organic material in the aquifer are limited.

2. Inorganic carbon in carbonate minerals present as caleche or as cement in desert aquifers typically has a $\partial^{13}C$ of about -4 per mil in areas where marine limestones are present the $\partial^{13}C$ of inorganic carbon may be as low as 0 per mil (Izbicki et al., 1995). For the purposes of calculations presented in this review, dissolution or isotopic exchange between ground water and carbonate minerals is the primary source of carbon that does not contain carbon-14 to ground water in desert aquifers. This assumption is consistent with the geochemical framework presented in the Draft Report.

3. Detailed sample collection and geochemical modeling studies done along flowpaths in the western part of the Mojave Desert show that the $\partial^{13}C$ composition of infiltrating water in active recharge areas is close to equilibrium with atmospheric $\partial^{13}C$ and has a value near -13 per mil (Izbicki et al.,, 1995) at the time of recharge. For the purposes of calculations presented in this review, the carbon-14 value of infiltrating water at the time of recharge is assumed to be 100 percent modern carbon. Carbon-14 activities in surface runoff and recently recharge water in the Mojave Desert is actually between 95 and 90 percent modern carbon (La Mareaux & Associates, 1995; Izbicki et al., 1995). Lower initial carbon-14 activities will result in older corrected ground-water ages.

Assuming a closed system and conservation of mass, a calculation can be made to estimate the fraction of the dissolved inorganic carbon dissolved from aquifer materials using the following equation:

$$C_m f_m = C_r f_r + C_w f_w$$

where: C_m is the measured $\partial^{13}C$ composition of the ground water. When using this approach, the fraction carbon measured in the ground water, f_m, is 1;
C_r is the $\partial^{13}C$ composition of the rock--assumed to be -4 per mil;
f_r is the fraction of the dissolved inorganic carbon from the rock;
C_w is the initial $\partial^{13}C$ composition of ground water at the time of recharge--assumed to be -13 per mil;
f_w is the fraction of the dissolved inorganic carbon from the recharge water. (To solve the equation f_w is written as $f_w = f_r - 1$).

Once the fraction of carbon from the aquifer materials is known, the corrected carbon-14 activity can be calculated using the following equation:

$$^{14}C_m = {}^{14}C_r f_r + {}^{14}C_w f_w$$

where: $^{14}C_m$ is the measured carbon-14 activity of the water. The fraction of carbon measured in the water is 1.
$^{14}C_r$ is the carbon-14 activity of the rock--assumed to be 0 because the rock has great age.
$^{14}C_w$ is the carbon-14 activity of the water corrected for mineralogical reactions. The fraction of the carbon-14 from the recharge water was calculated from the previous equation.

Results of these calculations are summarized in table 1.

Although subject to considerable discussion and additional interpretation if more data were available, the fraction of dissolved inorganic carbon from rock dissolution and corrected carbon-14 numbers are consistent with interpretations presented in the Draft Report by M. Lee Davisson of Lawrence Livermore National Laboratory. Corrected carbon-14 ages presented in table 1 also are consistent with corrected carbon-14 ages between 9,300 and 12,700 years before present estimated for the proposed Bolo Station Landfill Site (La Moreaux & Associates, 1995) in Cadiz Valley to the south of the study area and with corrected carbon-14 ages between 4,500 and 22,000 years before present estimated for Ward Valley east of the study area (National Research Council, 1995). Younger water, recharged 2,300 years before present, was sampled in parts of Cadiz Valley upgradient from the proposed landfill near the mountain front.

Mixing of younger ground water infiltrated from washes with older ground water also is cited as a source of error associated with carbon-14 measurements. In the Draft Report, the $\partial^{18}O$ and ∂D composition of water infiltrated from washes is believed to be characterized by samples from the Danby well. Water from this well has a unique ∂D and $\partial^{18}O$ isotopic composition and plots along the local meteoric water line for Amboy. If the Draft Report is correct in its interpretation,

∂D and $\partial^{18}O$ data suggest that water infiltrated from wash must be only a small component of the water sampled from wells at Fenner Gap. If a mixture is present, the Draft Report is correct in stating that carbon-14 measurements in water from wells represent an average age of the water; therefore, if even a small amount of comparatively young water from the wash infiltrated to the water table it would mix with ground water that would have to be even older than the corrected ages shown in table 1.

Summary--As a group isotopic data from this Draft Report and from studies in adjacent areas are consistent and show there is limited recharge under present-day climatic conditions and that ground water in desert basins was recharged thousands of years ago.

Table 1--Carbon-14 activities and ages for ground water from wells in the Fenner Gap.

Well number	Measured carbon-14 activity (pmc)	Measured carbon-13 (per mil)	Uncorrected Carbon-14 age (years before present)	Fraction DIC from rock (f_r)	Corrected carbon-14 activity (pmc)	Corrected carbon-14 age (years before present)
Assuming a carbon-13 composition of -4 per mil for rock dissolution						
CI-1	19	-7.8	13,600	0.58	45	5,500
CI-2	18	-8.4	14,000	0.51	37	8,300
CI-3	24	-9.4	11,900	0.40	40	7,600
MW-7	25	-10	11,500	0.33	38	8,100
Assuming a carbon-13 composition of 0 per mil for rock dissolution						
CI-1	19	-7.8	13,600	0.40	32	9,500
CI-2	18	-8.4	14,000	0.35	28	10,600
CI-3	24	-9.4	11,900	0.28	33	9,100
MW-7	25	-10	11,500	0.23	32	9,200

9.5 Infiltration

Page 139, 9.5.3, Groundwater Mounding. Was the ground-water model described in Section 8.0 used to simulate the water-level drawdown resulting from the pumping during the test and water-level mounding resulting from the recharge operation? The measured results of this test (figures 103 and 108) would provide excellent data to calibrate the ground-water flow model on a local scale. How were the drawdown and recharge mound figures constructed in such detail (figures 103-108)? The measured data from the wells are too sparse to construct the figures. The symmetry of the drawdown and mounding could be useful for identifying changes in lithology and potential barriers to flow. As postulated in the Draft Report and in this review, a northwest-southeast trending fault lies almost directly beneath the recharge ponds. Since the production well is perforated in the upper and lower aquifers, and the extent of the lower aquifer is limited by the fault to the northeast, one would expect to see a barrier affect in the measured

drawdown. Unfortunately, there are no wells perforated opposite the lower aquifer between the production well and the recharge ponds. A better monitoring network would be needed to define the drawdown and mounding. Microgravity would be a good technique to apply to fill in the gaps during a follow-up recharge activity. The calibrated model could then be used with more confidence, then the poorly calibrated regional model, to help manage the large-scale recharge operation. In addition, a two-dimensional unsaturated zone model could be calibrated with the measured data, to provide information on the unsaturated zone properties.

Page 140, 9.5.4, Water Quality Changes (Includes comments for 9.5.4.1 and 9.5.4.2). Water-quality changes observed in monitoring wells after water infiltrated through the thick unsaturated zone beneath the recharge basins are consistent with leaching of chloride and other soluble salts from the unsaturated zone. As described in previous comments from Section 6.7, accumulation of chloride and other soluble salts is consistent with the lack of recharge in desert basins. The relatively high chloride concentrations measured in observation wells suggest that the salt accumulation was large and that the length of time since recharge has occurred at that site must be long.

The Draft Report does not discuss what happens with this high TDS water. Was the solute-transport model described in Section 8 used to simulate the movement of this TDS plume? It is interesting to note that the TDS contours do not agree with the water-level contours. What are the implications of this high TDS water for the large-scale operation? What will be done with this high TDS during the pump-back operation? Wells CI-3 and MW-2 should have been sampled to determine the transport of the TDS plume.

9.9 Analysis of Project Impacts Using the Groundwater Model

Page 148, 9.9.1, Project Area Water Level Changes. As described in great detail in the review of the model in Section 8.0, the model does not accurately simulate current water levels. Water levels are too high in Area A and too low near the dry lakes. The simulated gradient through the Fenner Gap is higher than the gradient measured in the gap, even using unreasonably high hydraulic conductivity values (in excess on 1,000 gpd/ft^2). Too much recharge is being simulated in the model; therefore, the gradient is too high and an unreasonable evapotranspiration rate is being simulated in the model. The simulation of soil evaporation from the dry lakes using a 100-foot extinction depth is unreasonable. The model needs to be recalibrated before it can be used to predict water-level changes resulting from the planned recharge/pumpage operation.

Water-level contours and drawdown contours need to be presented for each scenario. These contours are needed to show the areal extent of mounding during recharge operations and drawdown during the pumping operation. In addition to simulating scenarios 5 and 6, please make two long-term simulations considering the recovery of the aquifers after the 50-year put/take operations cease. The length of these simulations should be long enough such that there is little change in head between subsequent stress periods. Note that steady-state simulations will not suffice because density-dependent flow and transport takes many years to equilibrate. These simulations are needed to show the long-term affects of the recharge and pumping

operations. If more water is withdrawn than is recharged, it will take many years for the drawdown cone to stabilize, especially if realistic recharge rates are simulated in the model.

Page 148, 9.9.2, Groundwater Supply to Bristol and Cadiz Dry Lakes. Results of the watershed model, chloride mass balance studies, isotopic data, and water balance (evaporation at the dry lakes) presented in the Draft Report greatly overestimate natural ground-water recharge. Data presented in the Draft Report and all previous studies done in the area are consistent with small amounts of recharge to desert basins. The 1,150,000 acre-feet of ground water projected as discharge to Bristol dry lake, under existingl conditions, over a 50-year period is not correct. The actual number is much smaller. Such a large error in such an important component of the model almost certainly invalidates the flow and solute model results and predictions.

As a check on the simulated underflow through Fenner Gap, a simple Darcy's Law calculation was completed using the data presented in the Draft Report. Friewald (1984) and P.E. La Moreaux & Associates (1995) performed similar calculations. Darcy's Law states that Q = KIA where Q is equal to the rate of underflow; K is equal to the hydraulic conductivity, and A is equal to the cross-sectional area. The gradient (I) was determined by measuring the water-level distance between wells MW-7 and MW-1 (612.72-602.47=10.25 feet) and dividing by the measured distance between the wells (5,950 feet; measured on plate 3 of the Draft Report). The resulting gradient is 0.0017 feet per feet. The cross-sectional area was measured along the cross-section D-D' on plate 3. Two areas were measured: the first area (A1) is the area of the saturated unconsolidated deposits from the water table to 100 feet below the water table, and the second area (A2) is the area of the saturated unconsolidated deposits from 100 feet below the water table to the contact with the underlying bedrock. This was done because inspection of the geophysical and lithologic logs indicated that there was a change in the hydraulic properties of the unconsolidated deposits at about 100 feet below the water table. The resulting areas were approximately 486,000 ft^2 for A1 and 3,300,000 ft^2 for A2. If we assume the hydraulic conductivity values estimated for the upper and lower alluvial aquifers, presented earlier in this review (see review comments for Section 8.1.4.4), are representative of the two aquifers (800 gpd/ft^2 for the upper aquifer and 300 gpd/ft^2 for the lower aquifer), we can estimate the underflow through the Fenner Gap. Note that these hydraulic conductivity values were estimated from well PW-1 that is downgradient of a postulated fault, and this well penetrates deposits that are not present in the gap. The calculated underflows are about 740 acre-ft/yr and 1,887 acre-ft/yr for A1 and A2, respectively. Therefore, the combined estimated underflow through the Fenner Gap is about 2,627 acre-feet per year. If one assumes that the hydraulic conductivity estimated from the specific capacity data of well PW-1 is representative for the entire cross sectional area (600 gpd/ft^2; see review comments for Section 8.1.4.4), then the total estimated underflow would be about 4,330 acre-feet per year. These estimates are higher than the 270 acre-feet per year estimated by Friewald (1984) lower or slightly higher than the 3,720 acre-feet per year estimated by P.E La Moreaux & Associates (1995), and significantly less than the 30,0000 acre-feet per year estimated in the Draft Report. The Draft Report must reevaluate the recharge and hydraulic conductivity estimates used in the ground-water flow model.

Regardless of the recharge value, if the project pumps more water than is recharged, there will be less ground-water discharge at the dry lakes. Over the long term, this will cause water levels beneath the dry lakes to decline. A density-dependent solute-transport model is needed to

evaluate the long-term impacts of the project on the brine levels. The Draft Report does not address how water-level declines will impact the dry lakes. With a decrease in ground-water discharge, will the mining operation at the dry lakes be impacted? Will lower water levels cause the upper sediments to dry out and result in a dust problem? As stated previously in this review, the failure of the model to simulate the water levels beneath the playas invalidates the models ability to predict any impacts resulting from the recharge/pumping operation on water levels and solute transport beneath the playas. With less recharge in the model, water-level declines resulting from the pumping phase of the project will be greater, which will undoubtedly cause the high salinity water to move from the Bristol dry lake area towards the pumping wells if there is not a ground-water barrier between the well field and Bristol dry lake.

Page 150, 9.10, Subsidence and Hydrocompaction. As stated previously in the review, the water-level changes predicted by the ground-water model are based on an incorrectly calibrated model; therefore, the predicted subsidence values will also be in error.

Page 151, 9.11, Project Spreading Basins. The entire project should be reevaluated after recalibrating the ground-water flow and solute-transport models.

REFERENCES

CLIMAP, 1976, The surface of the ice-age earth: Science, vol. 191, no. 4232, p. 1131-1137.

Czarnecki, J.B., 1997, Geohydrology and evapotranspiration at Franklin Lake Playa, Inyo County, California: U.S. Geological Survey Water-Supply Paper 2377, 75 p.

Department of Defense, 1998, Mojave Desert ecosystem program: 8 CD-ROM.

Dettinger, M.D., 1989, Reconnaissance estimates of natural recharge to desert basins in Nevada, U.S.A., by using chloride-balance calculations: Journal of Hydrology, vol. 106, p. 55-78.

Dingman, S.L., 1994, Physical hydrology: Prentice Hall, Upper Saddle River, New Jersey, 575 p.

Driscoll, F.G., 1987, Groundwater and wells (2nd ed.): Johnson Division, St. Paul, Minnesota, 1089 p.

Feth, J.H., and Brown, R.J., 1962, Method for measuring upward leakage from artesian aquifers using rate of salt-crust accumulation, *in*: Geological Survey Research 1963; U.S. Geol. Survey Prof. Paper 450-B, p. 100-101.

Flint, A.L., and Childs, S.W., 1991, Modification of the Priestley-Taylor equation for estimating evapotranspiration for soil water limited conditions: Journal of Agricultural and Forest Meteorology, vol. 56, p. 247-260.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice Hall, Englewood Cliffs, New Jersey, 604 p.

Friedman, Irving, Smith, G.I., Gleasom, J.D., Warden, Augusta, and Harris, J.M., 1992, Stable isotope composition of water in southeastern California--Modern precipitation: Journal of Geophysical Research, vol. 97, no. D5, p. 5795-5812.

Friewald, D. A., 1984, Ground-water resources of Lanfair and Fenner Valleys and vicinity, San Bernardino County, California: U.S. Geological Survey Water-Resources Investigations Report 83-4082, 60 p.

Galloway, D.L., Hudnut, K.W., Ingebritsen, S.E., Phillips, S.P., Peltzer, G., Rogez, F., and Rosen, P.A., 1998, Detection of aquifer system compaction and land subsidence using interferometric synthetic aperture radar, Antelope Valley, Mojave Desert, California: Water Resources Research, vol. 34, no. 10, p. 2573-2585.

Gleason, J.D., Veronda, Guida, Smith, G.I., Friedman, Irving, and Martin, Peter, 1994, Deuterium content of water from wells and perennial springs, southeastern California: U.S. Geological Survey Hydrologic Investigations Atlas HA-727, 1 map.

Hanks, R.J., and Ashcroft, G.L., 1980, Applied Soil Physics: Springer-Verlag, p. 159.

International Atomic Energy Agency, 1981, Statistical treatment of environmental isotope data in precipitation: Technical Report Series No. 206, 255 p.

Izbicki, J.A., in review, Testing alternative conceptual models of the movement of water through a thick, heterogeneous unsaturated zone underlying an intermittent stream in the western part of the Mojave Desert, USA.

Izbicki, J.A., Michel, R.L., and Martin, Peter, 1992, ^{3}H and ^{14}C as tracers of ground-water recharge. p. 122-127, *in:* Engman, T., Saving a threatened resource, Proceedings of the American Society of Civil Engineers, Baltimore, MD, August 2-6, 1992.

Izbicki, J.A., Michel, R.L., and Martin, Peter, 1995, Source, movement, and age of groundwater in the Mojave River basin, California. p. 43-56, *in:* Adar, E.M., and Leibundgut, Christian (eds.), Application of tracers in arid zone hydrology, International Association of Hydrological Sciences, Publication No. 232, Wallingford, U.K., 452 p.

Izbicki, J.A., Michel, R.L., and Martin, Peter, 1998, Chloride and tritium concentrations in a thick unsaturated zone underlying an intermittent stream in the Mojave Desert, southern California, USA, p. 81-88, *in*: Brahana, J.V. et al., (eds.), Gambling with groundwater, Proceedings of the International Association of Hydrogeologists, Las Vegas, Nevada, September 28 to October 2, 1998, American Institute of Hydrology, Saint Paul, MN, 753 p.

Izbicki, J.A., Radyk, John, and Michel, R.L., in review, Movement of water through the thick unsaturated zone underlying Oro Grande and Sheep Creek Washes in the Mojave Desert, USA.

Jachens, R.C., and Howard, K.A., 1992, Bristol lake basin—A deep sedimentary basin along the Bristol-Danby trough, Mojave Desert, p. 57-59, in: Reynolds, R.E., Old routes to the Colorado, San Bernadino County museums special publication 92-2, Redlands, CA, 106 p.

Kupfer, D.H., and Basett, A.M., 1962, Geologic reconnaissance map of the southeastern Mojave Desert, California: U.S. Geological Survey Investigations Field Studies Map MF-205.

Kunkel, Fred, and Chase, G.H., 1969, Geology and ground water in Indian Wells Valley, California: U.S. Geological Survey Open-File Report, 84 p.

Laczniak, R.J., DeMeo, G.A., Reiner, S.R., Smith, J.L., and Nylund, W.E., 1999, Estimates of ground-watrer discharge as determined from measurements of evapotranspiration, Ash Meadows are, Nye County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 99-4070, 70 p.

LaMoreaux & Associates, 1995, Isotopic study of groundwater: proposed Bolo Station landfill site and adjacent areas, San Bernardino County, California: LaMoreaux & Associates, Tuscaloosa, AL, 25 p.

LaMoreaux & Associates, 1995, Technical comments on groundwater recharge and projected drawdown computations for Bristol-Cadiz Valley: LaMoreaux & Associates, Tuscaloosa, AL, 20 p.

Lee, C.H., 1913, Use and conservation of the underground reservoirs of California: Western Engineering, vol. 3, p. 189-194.

Lines, G.C., 1979, Hydrology and surface morphology of the Bonneville Salt Flats and Pilot Valley playa, Utah: U.S. Geological Survey Water-Supply Paper 2057, 107 p.

Lines, G.C., and Bilhorn, T.W., 1996, Riparian vegetation an its water use during 1995 along the Mojave River, Southern California: U.S. Geological Survey Water Resources Investigations Report 96-4241, 10 p., 1 oversize plate.

Maas, J., 1994, Depth to basement calculated from gravity data: Cadiz Land Co., Inc.

McDonald, E.V., McFadden, L.D., and Wells, S.G., 1995, The relative influences of climate change, desert dust, and lithologic control on soil-geomorphic processes on alluvial fans, Mojave Desert, California: Summary of results, *in* Reynolds, R.E., and Reynolds, J., eds. Ancient surfaces of the east Mojave Desert, San Bernardino County Museum Association, vol. 42, no. 3, p. 35-42.

Michel, R.L., 1989, Tritium deposition in the continental United States, 1953-83: U.S. Geological Survey Water-Resources Investigations Report 89-4072, 47 p.

Miller, D.M., and Howard, K.A., 1985, Bedrock geologic map of the Iron Mountains quadrangle, San Bernardino and Riverside Counties, California: U.S. Geological Survey Miscellaneous Field Investigations Map MF-1736, scale 1:62,500.

Moyle, W.R., Jr., 1967, Water wells and springs in Bristol, Broadwell, Cadiz, Danby, and Lavic Valleys and vicinity, San Bernardino and Riverside Counties, California: California Department of Water Resources Bulletin 91-14, 17 p., 5 appendixes.

National Research Council, 1995, Ward Valley--An examination of seven issues in earth sciences and ecology: National Academy Press, Washington D.C., 212 p.

Neuman, S.P., and Witherspoon, P.A., 1972, Field determination of hydrologic properties of leaky multiple aquifer systems: Water Resources Research, vol. 8, no. 5., p. 1284-1298.

Nimmo, J.R., 1999, The Darcian approach and practicality: determination of basin-scale recharge measurements from sparse point measurements (abs.): Geological Society of America, Proceedings of 1999 Annual Meeting, October 25-28, Denver, CO, p. 125.

Osterkamp, W.R., and Wood, W.W., 1987, Playa-lake basins on the southern high plains of Texas and New Mexico: Part 1--Hydrologic, geomorphic, and geologic evidence for their development. Geological Society of America Bulletin, vol. 99, p. 215-223.

Phillips, F.M., 1994, Environmental tracers for water movement in desert soils of the American Southwest: Soil Science of America Journal, vol. 58, p. 15-24.

Pisias, N.G., 1979, Model for paleoceanographic reconstructions of the California current during the last 8,000 years: Quaternary Research, vol. 11, p. 373-386.

Pohl, G.M., 1996, Development of a coupled surface/subsurface hydrologic model and stochastic analysis of a vadose zone and saturated zone numerical model: Unpublished Ph.D. Dissertation, University of Nevada, Reno.

Prudic, D.E., 1994, Estimates of percolation rates and ages of water in unsaturated sediments at two Mojave Desert sites, California-Nevada: U.S. Geological Survey Water-Resources Investigations Report 94-4160, 19 p.

Rosen, M.R., 1992, The depositional environment and evolution of Bristol lake basin, eastern Mojave Desert, California, p. 60-64: in: Reynolds, R.E., Old routes to the Colorado, San Bernadino County museums special publication 92-2, Redlands, CA, 106 p.

Scanlon, B.R., 1994, Water and heat fluxes in desert soils, 1--Field studies: Water Resources Research, vol. 30, no. 3, p. 709-719.

Shafer, R.A., 1964, Report on investigations of conditions which determines the potentials for development in the desert valleys of eastern San Bernadino County, California: Unpublished report, Engineering Dept., Southern California Edison Co., 172 p., 12 plates.

Stannard, D.I., 1993, Comparison of Penman-Monteith, Shttleworth-Wallace, and modified Priestley-Taylor evapotranspiration models for wildland vegetation in semiarid rangeland: Water Resources Research, vol. 29, no. 5, p. 1379-1392.

Stephens & Associates, 1992, Evaluation of regional recharge in Cadiz Valley Development Corporation project area, San Bernardino County, California, March 2, 1992.

Todd, D.K., 1980, Groundwater hydrology (2nd ed): John Wiley and Sons, New York, 535 p.

Turk, L.J., 1973, Evaporation of brine, A field study on the Bonneville Salt Flats, Utah: Water Resources Research, vol.6, no. 4, p. 1209-1215.

Tyler, S.W., McKay, W.A., Mihevc, T.M., 1992, Assessment of soil moisture movement in nuclear subsidence craters, Journal of Hydrology, vol. 139, p. 159-181.

Tyler, S.W., Chapman, J.B., Conrad, S.H., and Hammermeister, Dale, 1994, Paleoclimatic response of a deep vadose zone in southern Nevada, USA, as inferred from soil water tracers. p. 351-361, *in:* Adar, E.M. and Leibundgut, Christian, (eds.), Application of tracers in arid zone hydrology, International Association of Hydrological Sciences, Publication No. 232, Wallingford, U.K., 452 p.

Viceroy Gold Corporation, 1990, Castle Mountain Project, San Bernadino County, California, mine plan and reclamation plan.

Wood, W.W., and Sanford, W.E., 1995, Chemical and isotopic methods for quantifying ground-water recharge in a regional semiarid environment: Ground Water, vol. 33, no. 3, p. 458-468.

Wood, W.W., 1999, Use and misuse of the chloride-mass balance method in estimating ground water recharge. Ground Water, vol. 37, no. 1, p. 2-3.

Attachment

Copy To: **Willie Taylor, Director, Office of Environmental Policy and Compliance**
Mike Shulters, District Chief, California
A. Holley, DO, Reston, Virginia

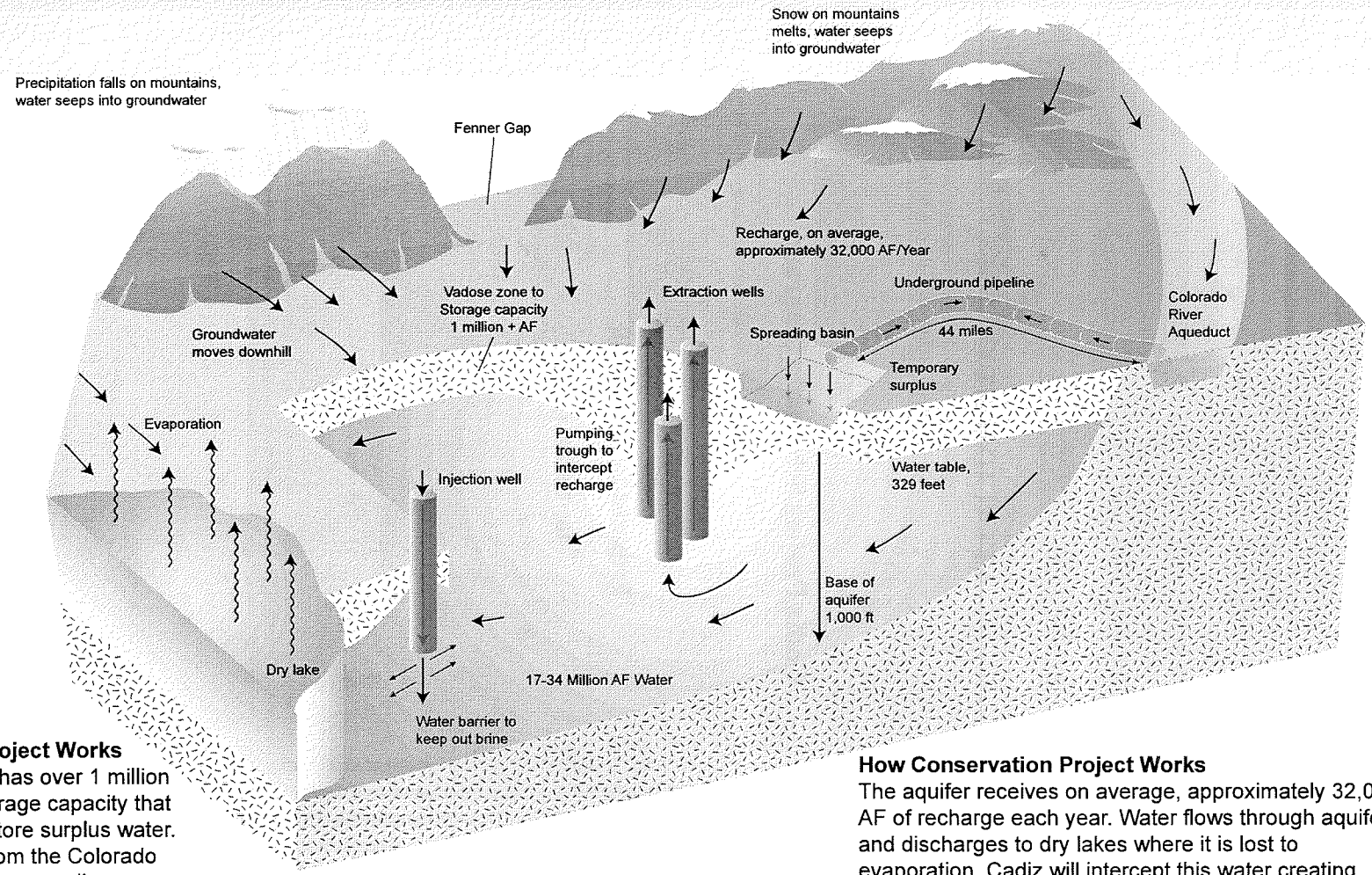
ATTACHMENT C

Cadiz Project Schematic Diagram

Prepared by CH2M Hill

for Cadiz, Inc.

CADIZ WATER CONSERVATION AND STORAGE PROJECT



How Storage Project Works

The aquifer also has over 1 million AF of excess storage capacity that can be used to store surplus water. Water is piped from the Colorado River Aqueduct to spreading basins where it infiltrates through the vadose zone and is stored safely in the aquifer, with negligible evaporative losses.

How Conservation Project Works

The aquifer receives on average, approximately 32,000 AF of recharge each year. Water flows through aquifer and discharges to dry lakes where it is lost to evaporation. Cadiz will intercept this water creating conserved groundwater for local supply. This water can also be piped to the Colorado River Aqueduct. Over a 50-year project duration, more than 1.5 million AF of water will be conserved, water that otherwise would be lost to evaporation forever.

CH2MHILL

UNITED STATES MARINE CORPS
MARINE AIR GROUND TASK FORCE TRAINING COMMAND
MARINE CORPS AIR GROUND COMBAT CENTER
BOX 788100
TWENTYNINE PALMS, CALIFORNIA 92278-8100

IN REPLY REFER TO:
5800
G-4
March 29, 2011

Mr. Tom Barnes, ESA
Santa Margarita Water District
626 Wilshire Blvd., Ste. 1100
Los Angeles, CA 90017

SUBJECT: CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

The Marine Corps Air Ground Combat Center, Twentynine Palms, California, takes this opportunity to submit comments on the Notice of Preparation of a Draft EIR for the above-referenced project. As a neighboring land owner, we are very interested in the potential impacts of this project.

As you may know, the Marine Corps is considering an expansion of the Combat Center and the establishment of new special use airspace to support any such expansion. A Draft Environmental Impact Statement for the Twentynine Palms Land Acquisition and Airspace Establishment project is currently out for public review and comment (the comment period runs from February 25, 2011, to May 26, 2011). A Final EIS is expected by the end of 2011, with a Record of Decision being issued in April 2012. Any acquisition of land must then be approved by Congress.

While the designated Preferred Alternative for the Twentynine Palms Land Acquisition and Airspace Establishment project does not include lands to the east of the current Combat Center boundaries, one alternative still under active consideration (Alternative 3) does include a portion of the Cadiz Inc. held lands. Even though our Alternative 3 does not appear to include the Cadiz Valley Water project's proposed well fields or spreading basins, it does include large amounts of adjacent lands. Therefore, the Marine Corps encourages the EIR to fully consider the land use and other impacts of the Twentynine Palms Land Acquisition and Airspace Establishment project on the Cadiz Valley Water project.

Thank you for the opportunity to comment. Please continue to consider the Combat Center as an interested party to your project.

Sincerely,

B. R. Norquist
Lieutenant Colonel, USMC
Assistant Chief of Staff, G-4

Copy to: Office of General Counsel

STATE OF CALIFORNIA

GOVERNOR'S OFFICE *of* PLANNING AND RESEARCH

STATE CLEARINGHOUSE AND PLANNING UNIT

JERRY BROWN
GOVERNOR

Notice of Preparation

March 1, 2011

To: Reviewing Agencies

Re: Cadiz Valley Water Conservation, Recovery, and Storage Project
SCH# 2011031002

Attached for your review and comment is the Notice of Preparation (NOP) for the Cadiz Valley Water Conservation, Recovery, and Storage Project draft Environmental Impact Report (EIR).

Responsible agencies must transmit their comments on the scope and content of the NOP, focusing on specific information related to their own statutory responsibility, within 30 days of receipt of the NOP from the Lead Agency. This is a courtesy notice provided by the State Clearinghouse with a reminder for you to comment in a timely manner. We encourage other agencies to also respond to this notice and express their concerns early in the environmental review process.

Please direct your comments to:

Tom Barnes
Santa Margarita Water District
626 Wilshire Blvd., Suite 1100
Los Angeles, CA 90017

with a copy to the State Clearinghouse in the Office of Planning and Research. Please refer to the SCH number noted above in all correspondence concerning this project.

If you have any questions about the environmental document review process, please call the State Clearinghouse at (916) 445-0613.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Attachments
cc: Lead Agency

1400 10th Street P.O. Box 3044 Sacramento, California 95812-3044
(916) 445-0613 FAX (916) 323-3018 www.opr.ca.gov

Document Details Report
State Clearinghouse Data Base

SCH# 2011031002
Project Title Cadiz Valley Water Conservation, Recovery, and Storage Project
Lead Agency Santa Margarita Water District

Type NOP Notice of Preparation

Description The proposed project would be executed in two phases: the first phase, the Conservation and Recovery Component (project level evaluation), would capture and conserve the annual natural recharge in the Fenner and northern Bristol Valleys that would otherwise discharge to the Bristol and Cadiz Dry Lakes. The second phase is the Imported Water Storage Component (program level evaluation), and would make up to one million acre-feet of groundwater storage space available, to store water for future withdrawal.

Lead Agency Contact

Name Tom Barnes
Agency Santa Margarita Water District
Phone 213 599-4300 **Fax** 213-599-4301
email cadizproject@esassoc.com
Address 626 Wilshire Blvd., Suite 1100
City Los Angeles **State** CA **Zip** 90017

Project Location

County San Bernardino
City
Region
Cross Streets Cadiz Road and National Trails Hwy
Lat / Long 34° 18' 38" N / 115° 14' 21" W
Parcel No.
Township 5N **Range** 14E **Section** 36 **Base** SBB&M

Proximity to:

Highways Hwy 62
Airports
Railways ARZC; BNSF
Waterways Coloardo River Aqueduct (CRA)
Schools
Land Use Agriculture, Resource Conservation

Project Issues Aesthetic/Visual; Agricultural Land; Air Quality; Archaeologic-Historic; Biological Resources; Drainage/Absorption; Flood Plain/Flooding; Forest Land/Fire Hazard; Geologic/Seismic; Minerals; Noise; Population/Housing Balance; Public Services; Recreation/Parks; Schools/Universities; Soil Erosion/Compaction/Grading; Solid Waste; Toxic/Hazardous; Traffic/Circulation; Vegetation; Water Quality; Water Supply; Wetland/Riparian; Growth Inducing; Landuse; Cumulative Effects; Other Issues

Reviewing Agencies Resources Agency; Colorado River Board; Department of Conservation; California Energy Commission; Cal Fire; Office of Historic Preservation; Department of Parks and Recreation; Resources, Recycling and Recovery; Department of Water Resources; Department of Fish and Game, Region 6; CA Department of Public Health; Office of Emergency Management Agency, California; Native American Heritage Commission; Public Utilities Commission; State Lands Commission; California Highway Patrol; Department of Housing and Community Development; Caltrans, District 8; State Water Resources Control Board, Divison of Financial Assistance; State Water Resources Control Board, Division of Water Quality; State Water Resources Control Board, Division of Water Rights; Department of Toxic Substances Control; Regional Water Quality Control Board, Region 7

Date Received 02/28/2011 **Start of Review** 03/01/2011 **End of Review** 03/30/2011

Note: Blanks in data fields result from insufficient information provided by lead agency.

NOP Distribution List

County: San Bernardino SCH# 2011031002

Resources Agency

- [■] **Resources Agency** Nadell Gayou
- [ ] **Dept. of Boating & Waterways** Mike Sotelo
- [ ] **California Coastal Commission** Elizabeth A. Fuchs
- [ ] **Colorado River Board** Gerald R. Zimmerman
- [ ] **Dept. of Conservation** Jonathan Martis
- [ ] **California Energy Commission** Eric Knight
- [ ] **Cal Fire** Allen Robertson
- [ ] **Central Valley Flood Protection Board** James Herota
- [ ] **Office of Historic Preservation** Ron Parsons
- [■] **Dept of Parks & Recreation** Environmental Stewardship Section
- [ ] **California Department of Resources, Recycling & Recovery** Sue O'Leary
- [ ] **S.F. Bay Conservation & Dev't. Comm.** Steve McAdam
- [ ] **Dept. of Water Resources** Resources Agency Nadell Gayou
- [ ] _____ Conservancy

Fish and Game

- [ ] **Depart. of Fish & Game** Scott Flint Environmental Services Division
- [ ] **Fish & Game Region 1** Donald Koch
- [ ] **Fish & Game Region 1E** Laurie Harnsberger
- [ ] **Fish & Game Region 2** Jeff Drongesen
- [ ] **Fish & Game Region 3** Charles Armor
- [ ] **Fish & Game Region 4** Julie Vance
- [ ] **Fish & Game Region 5** Don Chadwick Habitat Conservation Program
- [ ] **Fish & Game Region 6** Gabrina Gatchel Habitat Conservation Program
- [ ] **Fish & Game Region 6 I/M** Brad Henderson Inyo/Mono, Habitat Conservation Program
- [ ] **Dept. of Fish & Game M** George Isaac Marine Region

Other Departments

- [ ] **Food & Agriculture** Steve Shaffer Dept. of Food and Agriculture
- [ ] **Depart. of General Services** Public School Construction
- [ ] **Dept. of General Services** Anna Garbeff Environmental Services Section
- [ ] **Dept. of Public Health** Bridgette Binning Dept. of Health/Drinking Water

Independent Commissions,Boards

- [ ] **Delta Protection Commission** Linda Flack
- [ ] **Cal EMA (Emergency Management Agency)** Dennis Castrillo
- [ ] **Governor's Office of Planning & Research** State Clearinghouse
- [■] **Native American Heritage Comm.** Debbie Treadway
- [ ] **Public Utilities Commission** Leo Wong
- [ ] **Santa Monica Bay Restoration** Guangyu Wang
- [ ] **State Lands Commission** Marina Brand
- [ ] **Tahoe Regional Planning Agency (TRPA)** Cherry Jacques

Business, Trans & Housing

- [ ] **Caltrans - Division of Aeronautics** Sandy Hesnard
- [ ] **Caltrans - Planning** Terri Pencovic
- [ ] **California Highway Patrol** Scott Loetscher Office of Special Projects
- [ ] **Housing & Community Development** CEQA Coordinator Housing Policy Division

Dept. of Transportation

- [ ] **Caltrans, District 1** Rex Jackman
- [ ] **Caltrans, District 2** Marcelino Gonzalez
- [ ] **Caltrans, District 3** Bruce de Terra
- [ ] **Caltrans, District 4** Lisa Carboni
- [ ] **Caltrans, District 5** David Murray
- [ ] **Caltrans, District 6** Michael Navarro
- [ ] **Caltrans, District 7** Elmer Alvarez
- [ ] **Caltrans, District 8** Dan Kopulsky
- [ ] **Caltrans, District 9** Gayle Rosander
- [ ] **Caltrans, District 10** Tom Dumas
- [ ] **Caltrans, District 11** Jacob Armstrong
- [ ] **Caltrans, District 12** Chris Herre

Cal EPA

Air Resources Board

- [ ] Airport Projects Jim Lerner
- [ ] Transportation Projects Douglas Ito
- [ ] Industrial Projects Mike Tollstrup
- [ ] **State Water Resources Control Board** Regional Programs Unit Division of Financial Assistance
- [ ] **State Water Resources Control Board** Student Intern, 401 Water Quality Certification Unit Division of Water Quality
- [ ] **State Water Resouces Control Board** Phil Crader Division of Water Rights
- [ ] **Dept. of Toxic Substances Control** CEQA Tracking Center
- [ ] **Department of Pesticide Regulation** CEQA Coordinator

Regional Water Quality Control Board (RWQCB)

- [ ] **RWQCB 1** Cathleen Hudson North Coast Region (1)
- [ ] **RWQCB 2** Environmental Document Coordinator San Francisco Bay Region (2)
- [ ] **RWQCB 3** Central Coast Region (3)
- [ ] **RWQCB 4** Teresa Rodgers Los Angeles Region (4)
- [ ] **RWQCB 5S** Central Valley Region (5)
  - [ ] **RWQCB 5F** Central Valley Region (5) Fresno Branch Office
  - [ ] **RWQCB 5R** Central Valley Region (5) Redding Branch Office
- [ ] **RWQCB 6** Lahontan Region (6)
  - [ ] **RWQCB 6V** Lahontan Region (6) Victorville Branch Office
- [ ] **RWQCB 7** Colorado River Basin Region (7)
- [ ] **RWQCB 8** Santa Ana Region (8)
- [ ] **RWQCB 9** San Diego Region (9)

- [ ] Other _____

Last Updated 218/11

Department of Toxic Substances Control

Linda S. Adams
Acting Secretary for
Environmental Protection

Leonard E. Robinson
Acting Director
5796 Corporate Avenue
Cypress, California 90630

Edmund G. Brown Jr.
Governor

March 21, 2011

Mr. Tom Barnes
Santa Margarita Water District
626 Wilshire Boulevard, Suite 1100
Los Angeles, California 90017

NOTICE OF PREPARATION (NOP) OF A DRAFT ENVIRONMENTAL IMPACT REPORT FOR THE CADIZ WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT (SCH# 2011031002), SAN BERNARDINO COUNTY

Dear Mr. Barnes:

The Department of Toxic Substances Control (DTSC) has received your submitted Notice of Preparation for a draft Environmental Impact Report (EIR) for the above-mentioned project. The following project description is stated in your document: "The Project proposes active management of the groundwater basin underlying Cadiz Inc. property in the Cadiz and Fenner Valleys located in the eastern Mojave Desert, San Bernardino County, California. As part of the Conservation and Recovery Component, native groundwater currently being lost annually to evaporation at the Bristol and Cadiz Lakes from the aquifer system underlying the Project area would be captured and conserved through the active management of the groundwater basin. The project would construct extraction wells (wellfield) on the Cadiz property and a 42-mile underground water conveyance pipeline within an active railroad right-of-way that intersects the Colorado River Aqueduct (CRA). The proposed Project would be executed in two phases: the first phase of the Project is the Conservation and Recovery Component, and the second phase is the Imported Water Storage Component".

Based on the review of the submitted document DTSC has the following comments:

1. The EIR should evaluate whether conditions within the Project area may pose a threat to human health or the environment. Following are the databases of some of the regulatory agencies:

Printed on Recycled Paper

- National Priorities List (NPL): A list maintained by the United States Environmental Protection Agency (U.S.EPA).

- Envirostor (formerly CalSites): A Database primarily used by the California Department of Toxic Substances Control, accessible through DTSC's website (see below).

- Resource Conservation and Recovery Information System (RCRIS): A database of RCRA facilities that is maintained by U.S. EPA.

- Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS): A database of CERCLA sites that is maintained by U.S.EPA.

- Solid Waste Information System (SWIS): A database provided by the California Integrated Waste Management Board which consists of both open as well as closed and inactive solid waste disposal facilities and transfer stations.

- GeoTracker: A List that is maintained by Regional Water Quality Control Boards.

- Local Counties and Cities maintain lists for hazardous substances cleanup sites and leaking underground storage tanks.

- The United States Army Corps of Engineers, 911 Wilshire Boulevard, Los Angeles, California, 90017, (213) 452-3908, maintains a list of Formerly Used Defense Sites (FUDS).

2) The EIR should identify the mechanism to initiate any required investigation and/or remediation for any site within the proposed Project area that may be contaminated, and the government agency to provide appropriate regulatory oversight. If necessary, DTSC would require an oversight agreement in order to review such documents.

3) Any environmental investigations, sampling and/or remediation for a site should be conducted under a Workplan approved and overseen by a regulatory agency that has jurisdiction to oversee hazardous substance cleanup. The findings of any investigations, including any Phase I or II Environmental Site Assessment Investigations should be summarized in the document. All sampling results in which hazardous substances were found above regulatory standards should be

clearly summarized in a table. All closure, certification or remediation approval reports by regulatory agencies should be included in the EIR.

4) If buildings, other structures, asphalt or concrete-paved surface areas are being planned to be demolished, an investigation should also be conducted for the presence of other hazardous chemicals, mercury, and asbestos containing materials (ACMs). If other hazardous chemicals, lead-based paints (LPB) or products, mercury or ACMs are identified, proper precautions should be taken during demolition activities. Additionally, the contaminants should be remediated in compliance with California environmental regulations and policies.

5) Future project construction may require soil excavation or filling in certain areas. Sampling may be required. If soil is contaminated, it must be properly disposed and not simply placed in another location onsite. Land Disposal Restrictions (LDRs) may be applicable to such soils. Also, if the project proposes to import soil to backfill the areas excavated, sampling should be conducted to ensure that the imported soil is free of contamination.

6) Human health and the environment of sensitive receptors should be protected during any construction or demolition activities. If necessary, a health risk assessment overseen and approved by the appropriate government agency should be conducted by a qualified health risk assessor to determine if there are, have been, or will be, any releases of hazardous materials that may pose a risk to human health or the environment.

7) If the site was used for agricultural, livestock or related activities, onsite soils and groundwater might contain pesticides, agricultural chemical, organic waste or other related residue. Proper investigation, and remedial actions, if necessary, should be conducted under the oversight of and approved by a government agency at the site prior to construction of the project.

8) If it is determined that hazardous wastes are, or will be, generated by the proposed operations, the wastes must be managed in accordance with the California Hazardous Waste Control Law (California Health and Safety Code, Division 20, Chapter 6.5) and the Hazardous Waste Control Regulations (California Code of Regulations, Title 22, Division 4.5). If it is determined that hazardous wastes will be generated, the facility should also obtain a United States Environmental Protection Agency Identification Number by contacting (800) 618-6942. Certain hazardous waste treatment processes or hazardous materials, handling, storage or uses may require authorization from the local Certified Unified Program Agency (CUPA). Information about the requirement for authorization can be obtained by contacting your local CUPA.

9) DTSC can provide cleanup oversight through an Environmental Oversight Agreement (EOA) for government agencies that are not responsible parties, or a Voluntary Cleanup Agreement (VCA) for private parties. For additional information on the EOA or VCA, please see www.dtsc.ca.gov/SiteCleanup/Brownfields, or contact Ms. Maryam Tasnif-Abbasi, DTSC's Voluntary Cleanup Coordinator, at (714) 484-5489.

If you have any questions regarding this letter, please contact Rafiq Ahmed, Project Manager, at rahmed@dtsc.ca.gov, or by phone at (714) 484-5491.

Sincerely,

Greg Holmes
Unit Chief
Brownfields and Environmental Restoration Program

cc: Governor's Office of Planning and Research
State Clearinghouse
P.O. Box 3044
Sacramento, California 95812-3044
state.clearinghouse@opr.ca.gov.

CEQA Tracking Center
Department of Toxic Substances Control
Office of Environmental Planning and Analysis
P.O. Box 806
Sacramento, California 95812
ADelacr1@dtsc.ca.gov

CEQA # 3165

NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-6251
Fax (916) 657-5390
Web Site www.nahc.ca.gov
ds_nahc@pacbell.net

March 21, 2011

Mr. Tom Barnes
ESA *for the*
Santa Margarita Water District
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017

Re: SCH#2011031002; CEQA Notice of Preparation (NOP); draft Environmental Impact Report (DEIR for the: **"Cadiz Valley Water Conservation, Recovery, and Storage Project;"** located in southeastern San Bernardino County, California

Dear Mr. Barnes:

The Native American Heritage Commission (NAHC), the State of California 'Trustee Agency' for the protection and preservation of Native American cultural resources. The NAHC wishes to comment on the above-referenced proposed Project.

This letter includes state and federal statutes relating to Native American historic properties of religious and cultural significance to American Indian tribes and interested Native American individuals as 'consulting parties' under both state and federal law. State law also addresses the freedom of Native American Religious Expression in Public Resources Code §5097.9.

The California Environmental Quality Act (CEQA – CA Public Resources Code 21000-21177, amendments effective 3/18/2010) requires that any project that causes a substantial adverse change in the significance of an historical resource, that includes archaeological resources, is a 'significant effect' requiring the preparation of an Environmental Impact Report (EIR) per the CEQA Guidelines defines a significant impact on the environment as 'a substantial, or potentially substantial, adverse change in any of physical conditions within an area affected by the proposed project, including ...objects of historic or aesthetic significance." In order to comply with this provision, the lead agency is required to assess whether the project will have an adverse impact on these resources within the 'area of potential effect (APE), and if so, to mitigate that effect. The NAHC Sacred Lands File (SLF) search resulted in; **Native American cultural resources were not identified** within 1.2 mile of the 'area of potential effect (APE), based on the USGS coordinates you provided for the project location. The NAHC "Sacred Sites,' as defined by the Native American Heritage Commission and the California Legislature in California Public Resources Code §§5097.94(a) and 5097.96. Items in the NAHC Sacred Lands Inventory are confidential and exempt from the Public Records Act pursuant to California Government Code §6254.10. The absence of evidence of archaeological items does not indicate that they do not exist at the subsurface and/or when groundbreaking activity occurs.

Early consultation with Native American tribes in your area is the best way to avoid unanticipated discoveries of cultural resources or burial sites once a project is underway. Culturally affiliated tribes and individuals may have knowledge of the religious and cultural significance of the historic properties in the project area (e.g. APE). We strongly urge that you

make contact with the list of Native American Contacts on the attached list of Native American contacts, to see if your proposed project might impact Native American cultural resources and to obtain their recommendations concerning the proposed project. The list includes additional Native American who have been monitoring this project. Consultation with Native American communities is also a matter of environmental justice as defined by California Government Code §65040.12(e). The NAHC recommends *avoidance* as defined by CEQA Guidelines §15370(a) to pursuing a project that would damage or destroy a Native American cultural resources.

Furthermore we recommend, also, that you contact the California Historic Resources Information System (CHRIS) for pertinent archaeological data within or near the APE, at (916) 445-7000 for the nearest Information Center in order to learn what archaeological fixtures may have been recorded in the APE.

Consultation with tribes and interested Native American consulting parties, on the NAHC list, should be conducted in compliance with the requirements of federal NEPA (42 U.S.C 4321-43351) and Section 106 and 4(f) of federal NHPA (16 U.S.C. 470 *et seq*), 36 CFR Part 800.3 (f) (2) & .5, the President's Council on Environmental Quality (CSQ, 42 U.S.C 4371 *et seq.* and NAGPRA (25 U.S.C. 3001-3013) as appropriate. The 1992 *Secretary of the Interiors Standards for the Treatment of Historic Properties* were revised so that they could be applied to all historic resource types included in the National Register of Historic Places and including cultural landscapes. Also, federal Executive Orders Nos. 11593 (preservation of cultural environment), 13175 (coordination & consultation) and 13007 (Sacred Sites) are helpful, supportive guides for Section 106 consultation.

Furthermore, Public Resources Code Section 5097.98, California Government Code §27491 and Health & Safety Code Section 7050.5 provide for provisions for accidentally discovered archeological resources during construction and mandate the processes to be followed in the event of an accidental discovery of any human remains in a project location other than a 'dedicated cemetery'.

To be effective, consultation on specific projects must be the result of an ongoing relationship between Native American tribes and lead agencies, project proponents and their contractors, in the opinion of the NAHC. Regarding tribal consultation, a relationship built around regular meetings and informal involvement with local tribes will lead to more qualitative consultation tribal input on specific projects.

The response to this search for Native American cultural resources is conducted in the NAHC Sacred Lands Inventory, established by the California Legislature (CA Public Resources Code 5097.94(a) and is exempt from the CA Public Records Act (c.f. California Government Code 6254.10) although Native Americans on the attached contact list may wish to reveal the nature of identified cultural resources/historic properties. Confidentiality of "historic properties of religious and cultural significance" may also be protected under Section 304 of he NHA or at the Secretary of the Interior discretion if not eligible for listing on the National Register of Historic Places. The Secretary may also be advised by the federal Indian Religious Freedom Act (cf. 42 U.S.C., 1996) in issuing a decision on whether or not to disclose items of religious and/or cultural significance identified in or near the APE and possibility threatened by proposed project activity.

If you have any questions about this response to your request, please do not hesitate to contact me at (916) 653-6251.

Sincerely,
Dave Singleton, Program Analyst

Attachment: Native American Contact List

Native American Contact List
San Bernardino County
March 21, 2011

Cabazon Band of Mission Indians
David Roosevelt, Chairperson
84-245 Indio Springs Cahuilla
Indio , CA 92203-3499
(760) 342-2593
(760) 347-7880 Fax

Joseph R. Benitez (Mike)
P.O. Box 1829 Chemehuevi
Indio , CA 92201
(760) 347-0488
(760) 408-4089 - cell

Ramona Band of Cahuilla Mission Indians
Joseph Hamilton, Chairman
P.O. Box 391670 Cahuilla
Anza , CA 92539
admin@ramonatribe.com
(951) 763-4105
(951) 763-4325 Fax

Chemehuevi Reservation
Charles Wood, Chairperson
P.O. Box 1976 Chemehuevi
Chemehuevi Valley CA 92363
chair1cit@yahoo.com
(760) 858-4301
(760) 858-5400 Fax

San Manuel Band of Mission Indians
James Ramos, Chairperson
26569 Community Center Drive Serrano
Highland , CA 92346
(909) 864-8933
(909) 864-3724 - FAX
(909) 864-3370 Fax

Fort Mojave Indian Tribe
Tim Williams, Chairperson
500 Merriman Ave Mojave
Needles , CA 92363
(760) 629-4591
(760) 629-5767 Fax

Twenty-Nine Palms Band of Mission Indians
Darrell Mike, Chairperson
46-200 Harrison Place Chemehuevi
Coachella , CA 92236
tribal-epa@worldnet.att.net
(760) 775-5566
(760) 808-0409 - cell - EPA
(760) 775-4639 Fax

Juaneno Band of Mission Indians Acjachemen Nation
David Belardes, Chairperson
32161 Avenida Los Amigos Juaneno
San Juan Capistrano CA 92675
(949) 493-4933 - home
chiefdavidbelardes@yahoo.com
(949) 293-8522

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed sCH#2011031002; CEQA Notice of Preparation (NOP); draft Environmental Impact Report (DEIR) for the Cadiz Valley Water Conservation, REcovery, and Storage Project; located in souteastern San Bernardino County, California.

Native American Contact List
San Bernardino County
March 21, 2011

Tongva Ancestral Territorial Tribal Nation
John Tommy Rosas, Tribal Admin.
Private Address — Gabrielino Tongva
,
tattnlaw@gmail.com
310-570-6567

Santa Rosa Band of Mission Indians
Mayme Estrada, Chairwoman
P.O. Box 609 — Cahuilla
Hemet , CA 92546
srbcioffice@yahoo.com
(951) 658-5311
(951) 658-6733 Fax

Colorado River Reservation
Ginger Scott, Acting Cultural Contact
26600 Mojave Road — Mojave
Parker , AZ 85344 — Chemehuevi
symi@rraz.net
(928) 669-9211
(928) 669-5675 Fax

Augustine Band of Cahuilla Mission Indians
Mary Ann Green, Chairperson
P.O. Box 846 — Cahuilla
Coachella , CA 92236
hhaines@augustinetribe.
(760) 398-6180
760-369-7161 - FAX

Torres-Martinez Desert Cahuilla Indians
Ernest Morreo
PO Box 1160 — Cahuilla
Thermal , CA 92274
maxtm@aol.com
(760) 397-0300
(760) 397-8146 Fax

Morongo Band of Mission Indians
Michael Contreras, Cultural Heritage Prog.
12700 Pumarra Road — Cahuilla
Banning , CA 92220 — Serrano
(951) 201-1866 - cell
mcontreras@morongo-nsn.
gov
(951) 922-0105 Fax

AhaMaKav Cultural Society, Fort Mojave Indian
Linda Otero, Director
P.O. Box 5990 — Mojave
Mohave Valley AZ 86440
(928) 768-4475
LindaOtero@fortmojave.com
(928) 768-7996 Fax

San Manuel Band of Mission Indians
Ann Brierty, Policy/Cultural Resources Departmen
26569 Community Center. Drive — Serrano
Highland , CA 92346
(909) 864-8933, Ext 3250
abrierty@sanmanuel-nsn.
gov
(909) 862-5152 Fax

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed sCH#2011031002; CEQA Notice of Preparation (NOP); draft Environmental Impact Report (DEIR) for the Cadiz Valley Water Conservation, REcovery, and Storage Project; located in souteastern San Bernardino County, California.

Native American Contact List
San Bernardino County
March 21, 2011

Torres-Martinez Desert Cahuilla Indians
Diana L. Chihuahua, Vice Chairperson, Cultural
P.O. Boxt 1160 Cahuilla
Thermal , CA 92274
dianac@torresmartinez.
760) 397-0300, Ext. 1209
(760) 272-9039 - cell (Lisa)
(760) 397-8146 Fax

Augustine Band of Cahuilla Mission Indians
Karen Kupcha
P.O. Box 846 Cahuilla
Coachella , CA 92236
(760) 398-6180
916-369-7161 - FAX

Fort Mojave Indian Tribe
Nora McDowell, Cultural Resources Coordinator
500 Merriman Ave Mojave
Needles , CA 92363
g.goforth@fortmojave.com
(760) 629-4591
(760) 629-5767 Fax

Fort Mojave Indian Tribe
Esadora Evanston, Environmental Coordinator
500 Merriman Ave Mojave
Needles , CA 92363
region9epa@ftmojave.com
(760) 326-1112
(760) 629-4591
(760) 629-5767 Fax

Serrano Nation of Indians
Goldie Walker
P.O. Box 343 Serrano
Patton , CA 92369

(909) 862-9883

Juaneño Band of Mission Indians
Sonia Johnston, Tribal Chairperson
P.O. Box 25628 Juaneno
Santa Ana , CA 92799
sonia.johnston@sbcglobal.
net
(714) 323-8312

Agua Caliente Band of Cahuilla Indians THPO
Patricia Tuck, Tribal Historic Perservation Officer
5401 Dinah Shore Drive Cahuilla
Palm Springs, CA 92264
(760) 699-6907

ptuck@augacaliente-nsn.gov
(760) 699-6924- Fax

Quenchan Indian Nation
Bridget Nash-Chrabascz, THPO
P.O. Box 1899 Quechan
Yuma , AZ 85366
b.nash@quechantribe.com
(928) 920-6068 - CELL
(760) 572-2423

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed sCH#2011031002; CEQA Notice of Preparation (NOP); draft Environmental Impact Report (DEIR) for the Cadiz Valley Water Conservation, REcovery, and Storage Project; located in souteastern San Bernardino County, California.

Native American Contact List
San Bernardino County
March 21, 2011

Ah-Mut-Pipa Foundation
Preston J. Arrow-weed
P.O. Box 160 Quechan
Bard , CA 92222 Kumeyaay
ahmut@earthlink.net
(928) 388-9456

Cahuilla Band of Indians
Luther Salgado, Sr., , Chairperson
PO Box 391760 Cahuilla
Anza , CA 92539
tribalcouncil@cahuilla.net
915-763-5549

Ernest H. Siva
Morongo Band of Mission Indians Tribal Elder
9570 Mias Canyon Road Serrano
Banning , CA 92220 Cahuilla
siva@dishmail.com
(951) 849-4676

SOBOBA BAND OF LUISENO INDIANS
Joseph Ontiveros, Cultural Resource Department
P.O. BOX 487 Luiseno
San Jacinto , CA 92581
jontiveros@soboba-msn.gov
(951) 663-5279
(951) 654-5544, ext 4137

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of the statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code.

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed sCH#2011031002; CEQA Notice of Preparation (NOP); draft Environmental Impact Report (DEIR) for the Cadiz Valley Water Conservation, REcovery, and Storage Project; located in souteastern San Bernardino County, California.

Department of Fish and Game
78-078 Country Club Drive
Bermuda Dunes, CA 92203
Phone: 760-200-9158
Fax: 760-200-9358

TO: Tom Barnes, ESA	DATE: 3/30/2011
CO/DEPT: ESA	FROM: Michael Flores CDFG
PHONE #: (213) 599-4308	NO OF PAGES: 7
FAX #: (213) 599-4301	
RE: Comment letter for NOP to Cadiz Water Project	

COMMENTS:

California Natural Resources Agency
DEPARTMENT OF FISH AND GAME
http://www.dfg.ca.gov
Inland Deserts Region
3602 Inland Empire Blvd., Suite C-200
Ontario, CA 91764
(909) 484-0167

EDMUND G. BROWN, JR., Governor
JOHN McCAMMAN, Director

March 30, 2011

Mr. Tom Barnes
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

Re: Notice of Preparation of an Environmental Impact Report
Cadiz Valley Water Conservation, Recovery and Storage Project

Dear Mr. Barnes:

The Department is responding as a Trustee Agency for fish and wildlife resources [Fish and Game Code Sections 711.7 and 1802 and the California Environmental Quality Act (CEQA) Guidelines Section 15386], and as a Responsible Agency regarding any discretionary actions (CEQA Guidelines Section 15381), such as a Lake or Streambed Alteration Agreement (California Fish and Game Code Sections 1600 *et seq.*) and/or a California Endangered Species Act (CESA) Permit (California Fish and Game Code Sections 2080 and 2080.1).

The site is located in the County of San Bernardino and is bounded on the north by the community of Cadiz, on the south by SR 62, on the east by the Old Woman Mountains, and on the west by wash and Sheephole Valley. Surrounding development consists of the Mojave National Preserve, private landowners and mining interests.

Project Description

Implementation of the proposed project may impact desert tortoise, bighorn sheep, and sensitive plants, including Borrego milkvetch.

Much of the water is captured from lowering the water table and extracting groundwater that flows to the Bristol and Cadiz Dry Lakes via Schuyler Wash. The Department has many specific concerns (see below) in addition to the comments in the later portion of this letter and recommends that these issues be addressed in the CEQA document.

1. Potential impacts from increased concentrations of dust and salts on Cadiz Dunes and the Mojave National Preserve;
2. Potential impacts to Borrego milkvetch;
3. Elimination of the dry lake ecosystem;
4. The creation of giant fissures in the dry lake beds caused by water extraction;
5. The drawing down of the water table and impacts on seeps and springs essential to wildlife;
6. Potential adverse impacts to the local bighorn sheep population;
7. Potential adverse impacts to the desert tortoise;
8. The long-term impacts of water extraction on the groundwater basin;

9. Potential impacts to the Marine Base at 29 Palms which uses water from Bristol Lake;
10. Potential adverse impacts to the ecosystem from the introduction of permanent water recharge basins;
11. Potential adverse impacts to other landowners who use the groundwater;
12. Potential adverse impacts to the Mojave National Preserve ecosystem from lowering of the water table;
13. The necessity of amending the Desert Conservation Plan;
14. The potential from land subsidence due to water extraction;
15. An analysis of how much water would be necessary to maintain the dry lake ecosystem; and,
16. The issue of water rights with respect to the Bureau of Land Management, Mojave Nature Preserve, 29 Palms Marine Base, local residents dependent upon wells, and the State of California; and
17. The necessity for a 1602 Lake and Streambed Alteration Agreement and CESA Incidental Take Permit.

The following information should be provided in the CEQA document to address some of the above concerns:

1. An analysis and graphics showing depth to groundwater of the existing water table and the water table if the project is implemented; and,
2. An analysis of the flow of water to the dry lakes during the rainy and dry seasons and the amount of water necessary to maintain the ecosystem.

The Department advises that any biological habitat assessments or walkovers be conducted within a year of distribution of the CEQA document. Habitat assessments that identify the possibility of listed threatened or endangered plants should also provide the results of any focus surveys in the CEQA document. CEQA documents that rely on future surveys or regulatory compliance (with the exception of pre-construction surveys for burrowing owls or bird nests) as mitigation may not satisfy the Department's obligations under CEQA and may require future supplemental documents processed via CEQA.

The existing condition of the project site designated as "degraded" or "agriculture use" by the lead agency does not preclude the presence of native species, such as grassland species, burrowing owl, foraging raptors, or riparian wildlife species. A basic biological resources survey should still be conducted at these sites and the results included in the CEQA document.

The Department is concerned about the continuing loss of jurisdictional waters of the State and the encroachment of development into areas with native habitat values. The DEIR should contain sufficient, specific, and current biological information on the existing habitat and species at the project site; measures to minimize and avoid sensitive biological resources; and mitigation measures to offset the loss of native flora and fauna and State waters. If the project site contains Federally- or State-listed species, the DEIR should include measures to avoid and minimize impacts to these species as well as mitigation measures to compensate for the loss of biological resources. The DEIR should not defer impact analysis and mitigation measures to

future regulatory discretionary actions, such as a Lake or Streambed Alteration Agreement, CESA Permit, or Federal Endangered Species Act (ESA) Permit.

This particular project has the potential to have significant environmental impacts on sensitive flora and fauna resources, including Federally- and State-listed endangered species. Therefore, the DEIR should include an alternatives analysis which focuses on environmental resources and ways to avoid or minimize impacts to those resources.

To enable Department staff to adequately review and comment on the proposed project, we suggest that updated biological studies be conducted prior to any environmental or discretionary approvals. The following information should be included in any focused biological report or supplemental environmental report:

1. A complete assessment of the flora and fauna within and adjacent to the project area, with particular emphasis upon identifying endangered, threatened, and locally unique species and sensitive habitats.

    a. A thorough assessment of rare plants and rare natural communities, following the Department's November 2009 guidance for Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities. The guidance document can be found at the following link: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/Protocols_for_Surveying_and_Evaluating_Impacts.pdf

    b. A complete assessment of sensitive fish, wildlife, reptile, and amphibian species. Seasonal variations in use of the project area should also be considered. Focused species-specific surveys, conducted at the appropriate time of year and time of day when the sensitive species are active or otherwise identifiable, are required. Acceptable species-specific survey procedures should be developed in consultation with the Department and the U.S. Fish and Wildlife Service.

    c. Rare, threatened, and endangered species to be addressed should include all those which meet the CEQA definition (See CEQA Guidelines, 15380)

    d The Department's California Natural Diversity Data Base in Sacramento should be contacted at (916) 327-5960 to obtain current information on any previously reported sensitive species and habitat, including Significant Natural Areas identified under Chapter 12 of the California Fish and Game Code.

2. A thorough discussion of direct, indirect, and cumulative impacts expected to adversely affect biological resources, with specific measures to offset such impacts.

a. CEQA Guidelines, 15125(a), direct that knowledge of the regional setting is critical to an assessment of environmental impacts and that special emphasis should be placed on resources that are rare or unique to the region.

b. Project impacts should be analyzed relative to their affects on off-site habitats. Specifically, this should encompass adjacent public lands, open space, adjacent natural habitats, and riparian ecosystems. In addition, impacts to and maintenance of wildlife corridor/movement areas, including access to undisturbed habitat in adjacent areas, should be fully evaluated and provided.

c. The zoning of areas for development projects or other uses that are nearby or adjacent to natural areas may inadvertently contribute to wildlife-human interactions. A discussion of possible conflicts and mitigation measures to reduce these conflicts should be included in the environmental document.

d. A cumulative effects analysis should be developed as described under CEQA Guidelines, 15130. General and specific plans, as well as past, present, and anticipated future projects, should be analyzed relative to their impacts on similar plant communities and wildlife habitats.

e. The document should include an analysis of the effect that the project may have on any Habitat Conservation Plan or on other regional and/or subregional conservation programs under Sections 2800-2835 of the California Fish and Game Code. The Department, through the Natural Communities Conservation Planning (NCCP) program is coordinating with local jurisdictions, landowners, and the Federal Government to preserve local and regional biological diversity.

3. A range of alternatives should be analyzed to ensure that alternatives to the proposed project are fully considered and evaluated (CEQA Guidelines 15126.6). A range of alternatives which avoid or otherwise minimize impacts to sensitive biological resources should be included. Specific alternative locations should also be evaluated in areas with lower resource sensitivity where appropriate.

   a. Mitigation measures for project impacts to sensitive plants, animals, and habitats should emphasize evaluation and selection of alternatives which avoid and/or otherwise minimize project impacts. Off-site compensation for unavoidable impacts through acquisition and protection of high-quality habitat should be addressed.

   b. The Department considers Rare Natural Communities as threatened habitats having both local and regional significance. Thus, these communities should be fully avoided and otherwise protected from project-related impacts.

c. The Department generally does not support the use of relocation, salvage, and/or transplantation as mitigation for impacts to rare, threatened, or endangered species. Department studies have shown that these efforts are experimental in nature and largely unsuccessful.

4. A CESA Permit must be obtained, if the project has the potential to result in "take" of species of plants or animals listed under CESA, either during construction or over the life of the project. CESA Permits are issued to conserve, protect, enhance, and restore State-listed threatened or endangered species and their habitats. Early consultation is encouraged, as significant modification to the proposed project and mitigation measures may be required in order to obtain a CESA Permit. Revisions to the California Fish and Game Code, effective January 1998, require that the Department issue a separate CEQA document for the issuance of a CESA permit unless the project CEQA document addresses all project impacts to listed species and specifies a mitigation monitoring and reporting program that will meet the requirements of a CESA permit. For these reasons, the following information is requested:

   a. Biological mitigation, monitoring, and reporting proposals should be of sufficient detail and resolution to satisfy the requirements for a CESA Permit.

   b A Department-approved Mitigation Agreement and Mitigation Plan are required for plants listed as rare under the Native Plant Protection Act.

5. The Department opposes the elimination of watercourses and/or their channelization or conversion to subsurface drains. All wetlands and watercourses, whether intermittent or perennial, must be retained and provided with substantial setbacks which preserve the riparian and aquatic values and maintain their value to on-site and off-site wildlife populations.

   a. Under Section 1600 *et seq.* of the California Fish and Game Code, the Department requires the project applicant to notify the Department of any activity that will divert, obstruct or change the natural flow or the bed, channel or bank (which includes associated riparian resources) of a river, stream or lake, or use material from a streambed prior to the applicant's commencement of the activity. Streams include, but are not limited to, intermittent and ephemeral streams, rivers, creeks, dry washes, sloughs, blue-line streams, and watercourses with subsurface flow. The Department's issuance of a Lake and Streambed Alteration Agreement for a project this is subject to CEQA will require CEQA compliance actions by the Department as a responsible agency. The Department, as a responsible agency under CEQA, may consider the local jurisdiction's (lead agency) Negative Declaration or Environmental Impact Report for the project. However, if the CEQA document does not fully identify potential impacts to lakes, streams, and associated resources (including, but not limited to riparian and alluvial fan sage scrub habitat) and provide adequate avoidance, mitigation, monitoring,

and reporting commitments, additional CEQA documentation will be required prior to execution (signing) of the Streambed Alteration Agreement. In order to avoid delays or repetition of the CEQA process, potential impacts to a lake or stream, as well as avoidance and mitigation measures need to be discussed within this CEQA document. The Department recommends the following measures to avoid subsequent CEQA documentation and project delays:

(i) Incorporate all information regarding impacts to lakes, streams and associated habitat within the DEIR. Information that should be included within this document includes: (a) a delineation of lakes, streams, and associated habitat that will be directly or indirectly impacted by the proposed project; (b) details on the biological resources (flora and fauna) associated with the lakes and/or streams; (c) identification of the presence or absence of sensitive plants, animals, or natural communities; (d) a discussion of environmental alternatives; (e) a discussion of avoidance measures to reduce project impacts, (f) a discussion of potential mitigation measures required to reduce the project impacts to a level of insignificance; and (g) an analysis of impacts to habitat caused by a change in the flow of water across the site. The applicant and lead agency should keep in mind that the State also has a policy of no net loss of wetlands.

(ii) The Department recommends that the project applicant and/or lead agency consult with the Department to discuss potential project impacts and avoidance and mitigation measures. Early consultation with the Department is recommended since modification of the proposed project may be required to avoid or reduce impacts to fish and wildlife resources. To obtain a Streambed Alteration Agreement Notification package, please visit our website at: http://www.dfg.ca.gov/habcon/1600/ or call (562) 430-7924.

Thank you for this opportunity to comment. Please contact Robin Maloney-Rames at (909) 980-3818, if you have any questions regarding this letter.

Sincerely,

Michael Flores
Senior Environmental Scientist

Mojave Desert Air Quality Management District
14306 Park Avenue, Victorville, CA 92392-2310
760.245.1661 • fax 760.245.2699
Visit our web site: http://www.mdaqmd.ca.gov
Eldon Heaston, Executive Director

March 2, 2011

c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

Project: Notice of Preparation (NOP) of a Draft Environmental Impact Report (DEIR) and Public Scoping Meeting Notice – Cadiz Valley Water Conservation, Recovery, and Storage Project

Dear Mr. Barnes:

The Mojave Desert Air Quality Management District (District) has received the NOP of a DEIR for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project. Phase I of the project would extract the amount of water that would otherwise flow into the Bristol and Cadiz Dry Lakes plus the amount needed to maintain hydraulic control in the vicinity of the wellfield. The project would also construct a 42-mile underground water conveyance pipeline sized to convey an annual average of 50,000 acre-feet per year of water from the Fenner Valley groundwater basin to the Santa Margarita Water District and other participating water agencies, for a period of 50 years. The second phase of the project, the Imported Water Componenet, would make available up to one million acre-feet of groundwater storage space to be used as part of a conjunctive use project. Phase II will be evaluated in the EIR on a programmatic basis since it will be implemented at a later date.

The District has reviewed the project and, based on the information available to us at this time, recommends that the project comply with the requirements of MDAQMD Rule 403 – *Fugitive Dust*. If the proposed project includes a pump(s) which is not grid powered, or if there is a back-up generator, District permits may be required.

Thank you for the opportunity to review this planning document. If you have any questions regarding this letter, please contact me at (760) 245-1661, extension 6726, or Tracy Walters at extension 6122.

Sincerely,

Alan J. De Salvio
Supervising Air Quality Engineer

AJD/tw Cadiz Project.doc

East Mojave Landowners Association

March 21, 2011

Hi folks,

There are two items I would like to mention that affect those of us in the East Mojave. First there is still the potential for more burglaries in our area and second the possible loss of water in our area due to the Cadiz Project.

1. The one guy that Sheriff Bob Cunningham mentioned at our meeting (James McDaniels) is still in jail with warrants out for others. But rounding them up is going to be slow. So don't let your guard down just keep your eyes and ears open for anything unusual. Officer Cunningham is on patrol back in our area. Yea!! The Needles captain has moved on and Lieutenant Ross Tarangle is the commander in Needles now. The Needles phone number is 1-760-326-9200 Then #2 on the menu. Ask for the watch commander or press "0" to get a body in Needles. They apparently do not record conversations, just messages left for a specific person. #1 on the menu goes to Victorville Dispatch. 911 should now get Victorville instead of Rialto, but neither is as good as Needles for thefts. Life threatening emergencies should probably do both 911 and Needles.

2. On March 21, 2011, I got word that the Cadiz Water Project is on again and is apparently trying to fly below the radar to get going. There is to be a pipeline to the MWD canal along the Arizona/California railroad right of way. This is done for the easements availability. They are planning to pump 50,000 acre feet of water out of the Cadiz Aquifer that is fed primarily by the Fenner Valley which is fed by most of our properties. By using (Santa Marguerita) a small water district in south Orange County as the lead there were fewer people to get upset. The deadline for comment is March 30, 2011. We have no word on what the Park service is planning to do about this. There is to be a meeting in Joshua Tree on Thursday, March 24, 2011 at 6:00 pm in the Joshua Tree Community Center, 6171 Sunburst St. There will be an environmental assessment and then another comment period after the completion of the assessment. I think this will happen late summer or fall. I feel we should all comment then as well as now.

Action Needed:

Write, Call or email both the Santa Margareta Water District and the Project manager:

Project Manager: Tom Barnes, ESA

626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

Email: cadizproject@esassoc.com this site has a video you can watch to better understand what is going on.

Telephone: 213-599-4300

Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

Attend if possible the second and last meeting in Joshua Tree:

Thursday, March 24, 2011, 6:00 p.m.

Joshua Tree Community Center
6171 Sunburst Street
Joshua Tree, CA

Write, Call or email your government officials:

Senator Dianne Feinstein

United States Senate
331 Hart Senate Office Building
Washington, D.C. 20510

Phone: (202) 224-3841
Fax: (202) 228-3954
TTY/TDD: (202) 224-2501

CONGRESSMAN JERRY LEWIS

2112 Rayburn House Office Building

Washington, D.C. 29515

(202) 225-5861

Fax: (202) 225-6498

For casework concerns, contact Jerry at:

CONGRESSMAN JERRY LEWIS

1150 Brookside Avenue, Suite J-5

Redlands, CA 92373

(909) 862-6030

1-800-233-1700 (within California)

Points to be made:

1. Ask for an extension for the "Notice of Preparation of a Draft EIR (NOP)" so more comments can be thoughtfully presented.
2. Comment that human and animal habitat has not been included. We depend on well water for survival as do the animals
3. 50,000 acre feet can't possibly be sustainable and even ¼ is too much to start. There must a smaller amount to start with very gradual increases only if severely needed not just to see if it works.
4. We should insist that, 1) regular monitoring of water quantity and quality be put in place in several places (ie Round Valley, 4th of July Canyon, Goffs, 7IL area, Lanfair, Budweiser Springs area, etc) prior to any draw down to set a baseline, 2) thresholds be set that would indicate whether or not negative impacts are occurring, and 3) mitigation be built into the project upfront to avoid any loss of water quality or quantity for those who are dependent upon it. Springs, wells and wildlife must be monitored prior to as well as during drawdown.
5. Most all of the water used to fight the wildfire here came from wells in Round valley and Gold Valley. When drawn down by Cadiz then what happens to us? Many of us were worried what effect the fire consumption would have on our wells but the torrential rain just after the fire and the following summer made it impossible to quantify.

Thanks,

Richard MacPherson Chairman EMLA

1-7601-928-2510 or 1-951-682-6924(Riverside)

Hc1 Box 429

Cima, Ca 92323

DEPARTMENT OF PUBLIC WORKS

FLOOD CONTROL • LAND DEVELOPMENT & CONSTRUCTION • OPERATIONS
SOLID WASTE MANAGEMENT • SURVEYOR • TRANSPORTATION

COUNTY OF SAN BERNARDINO

825 East Third Street • San Bernardino, CA 92415-0835 • (909) 387-8104
Fax (909) 387-8130

GRANVILLE M. "BOW" BOWMAN, P.E., P.L.S.
Director of Public Works

March 23, 2011

File: 10(ENV)-3.01

Tom Barnes, ESA
626 Wilshire Blvd., Ste. 1100
Los Angeles, CA. 90017

RE: NOTICE OF PREPARATION (NOP) OF A DRAFT EIR FOR THE CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Dear Mr. Barnes:

Thank you for giving the San Bernardino County Department of Public Works the opportunity to comment on the above-referenced project. The environmental document was circulated to other Divisions within our Department and was found to be adequate.

If you have any questions, please contact Patrick Egle at (909) 387-1865.

Sincerely,

ANNESLEY IGNATIUS, P.E.
Deputy Director

ARI:PE:mb/CEQA Comments to NOP_SMWD_Cadiz Water Conservation.doc

cc: Patrick Egle

GREGORY C. DEVEREAUX
Chief Executive Officer

Board of Supervisors
BRAD MITZELFELT . . . . . First District
JANICE RUTHERFORD . . . . . Second District
JOSIE GONZALES . . . . . Fifth District
NEIL DERRY. . . . . Third District
GARY C. OVITT . . . . . Fourth District

CENTER for BIOLOGICAL DIVERSITY
Because life is good.

protecting and restoring natural ecosystems and imperiled species through science, education, policy, and environmental law

via electronic and US mail

March 28, 2011

Santa Margarita Water District
c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
Telephone: 213-599-4300
FAX: 213-599-4301
cadizproject@esassoc.com

RE: Scoping Comments on the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project

Dear Santa Margarita Water District,

The Center for Biological Diversity ("the Center") submits the following comments on the Notice of Preparation ("NOP") for an Environmental Impact Report ("EIR") for the proposed the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project on behalf of our board, staff, and members of the public with an interest in protecting the native species and habitats in and around the Cadiz Valley.. The Center is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 255,000 members and activists throughout California and the United States, with a number of them living within California and visit and enjoy the Mojave desert in the vicinity of the proposed project.

The remote desert of Cadiz Valley is surrounded by federally designated wilderness near the Mojave National Preserve. The general area is habitat for rare and endangered species, including the federally and state threatened desert tortoise (*Gopherus agassizii*), the very rare white margined beardstongue (*Penstemon albomarginatus*), the California leaf-nosed bat (*Microtus californicus*), desert bighorn sheep (*Ovis canadensis nelsonii*) and other rare species (CNDDB 2011). The proposed project also could affect rare desert riparian areas, springs and seeps – the lifeblood of the desert - outside of the physical boundaries of the project area. The proposed project area is also rich in cultural and historical significance.

The Center offers these comments regarding the scope of issues that need to be addressed in the Draft Environmental Impact Report (EIR). Most importantly, the EIR should clearly identify the purpose and need for groundwater pumping of the aquifer. The purported hydrology that the NOP describes as "The groundwater naturally flows to the Bristol and Cadiz Dry Lakes (Dry Lakes) and is lost to evaporation" need to be scientifically corroborated and the implication

Ileene Anderson, Biologist/Desert Program Director
8033 Sunset Blvd., #447 • Los Angeles, CA 90046-2401
tel: (323) 654.5943 *fax:* (323) 650.4620 *email:* ianderson@biologicaldiversity.org
www.BiologicalDiversity.org

that any natural evaporation is somehow a "problem" to be "solved" needs to be fully examined. In addition, the Draft EIR should adequately demonstrate if and how each project element will fulfill the project's purpose and need, and adequately describe a range of alternatives that could avoid the significant impacts of the project, including a no action alternative. The EIR must also fully identify and analyze how the proposed project and alternatives would impact biological resources and provide minimization and mitigation measures for any impacts that cannot be feasibly avoided. Following are specific issues the Center believes must be addressed in the EIR under the California Environmental Quality Act, Public Resources Code §§ 2100 et seq. ("CEQA"). Up-to-date natural and cultural resource surveys and inventories of the area need to be completed and included in the DEIR. Complete documentation of the hydrology of the area must also be included.

The EIR Must Consider a Range of Alternatives

In general, the EIR should include "a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives," as required by Section 15126.6 (a) of the CEQA Guidelines. The alternatives should include those that would avoid or substantially lessen any of the significant environmentally negative effects of the project and ongoing management [CEQA Guidelines, section 15126.6(1)]. For each alternative, the EIR should provide a discussion on how each alternative would avoid or minimize significant impacts on biological resources.

The EIR should provide a very clear and detailed description of the purpose, goals, and objectives for the project, as this will be critical in determining the most appropriate alternative and to allow for comprehensive analysis of the avoidance and minimization opportunities and if impacts can not be avoided, mitigation for specific issues.

The EIR Must Consider Direct, Indirect and Cumulative Impacts to Biological Resources

The EIR must be prepared to address the direct, indirect and cumulative impacts of the proposed project to threatened, endangered, and sensitive species as well as unique plant communities not only within the boundaries of the proposed project, but also outside of the project area, including the seeps and springs in the adjacent areas upon which desert wildlife species depend.

Not only must the EIR fully disclose and analyze impacts to any listed, candidate, sensitive, or locally rare species, but it also must discuss alternatives that will avoid those impacts. Even if alternatives that completely avoid such impacts may be later found infeasible, the EIR must explore alternatives that minimize impacts to species and any remaining impacts to the species must be mitigated though enforceable mitigation measures. The EIR must also fully disclose and analyze impacts to sensitive vegetation types.

The EIR must include a *quantitative, data-based* analysis of the direct impacts of the proposed Park management from the loss of habitat, as well as the indirect impacts resulting

from pollution, noise, increase in fire, disturbance, invasion of non-native species, growth inducing effects, green house gas analysis and other effects on biological resources.

The analyses must not be comprised only of general, qualitative descriptions of potential impacts, but contain quantitative analyses of effects based on population data obtained from field surveys and local conditions. In addition, the EIR must include a detailed analysis of the cumulative impacts of this project together with other completed, current, and reasonably foreseeable projects in the area.

Wildlife and Plant Species

During the course of the surveys, if other rare or regionally unique species are identified during the data gathering phase for the DEIR, these species also need to be included and analyzed for impacts. The EIR must consider the impacts on each of these species and as well as the cumulative impacts.

Listed Species

The state and federally listed threatened desert tortoise (*Gopherus agassizi*), which is also the state reptile, also occurs within the vicinity of the proposed project, and the area provides an important linkage for this species between northern and southern populations.

Where "take" of a species listed under the federal or California Endangered Species Act is anticipated, the EIR must document *and quantify* past and reasonably foreseeable future take authorizations for that species issued by the U.S. Fish and Wildlife Service ("FWS") and California Department of Fish and Game ("DFG") in order to evaluate the project's direct and cumulative impact on the species. The EIR also must consider the project's impacts on the *recovery* of listed endangered and threatened species that may occur on the site. Any potential impairment of species recovery associated with the project must be considered a potentially significant impact.

Sensitive Species

The EIR should also thoroughly evaluate the impacts of the proposed permitted activities on sensitive and locally rare species (not merely federally and state-listed threatened and endangered species). The preservation of regional and local genetic diversity is very important to the long-term persistence of species. Therefore, we request that all species found at the edge of their ranges or that occur as disjunct locations be evaluated for impacts by the proposed permitted activities.

Raptor species such as golden eagles (*Aquila chrysaetos*), a "fully protected" species under California law and protected under the Migratory Bird Treaty Act, the Bald and Golden Eagle Act and the Lacey Act, likely use the proposed project area as foraging habitat and may nest in adjacent habitat. FWS recently issued a final rule on acquiring permits to "take" golden eagles[1] that maybe required for this project. Guidance is also provided for evaluating impacts to golden eagles which should be used in the EIR. The burrowing owl (*Athene cunicularia*), a state

1 http://www.fws.gov/migratorybirds/baldeagle.htm

species of concern, has potential to occur on the project site and surrounding areas, and surveys must be included for this species. The prairie falcon (*Falco mexicanus*) may also use the project area. All of these raptors require large foraging areas in the desert due to the natural paucity of prey. All species are included as Bird Species of Special Concern in California and are considered the highest priority for conservation (Remsen 1978).

Rare plant communities, including all riparian areas, seeps and springs, need to be avoided for impacts. Any proposed impacts need to be fully analyzed in the CEQA process.

Biological Surveys and Mapping

The Center requests that thorough, seasonal surveys be performed for sensitive plant species and vegetation communities, and animal species under the direction and supervision of the BLM and resource agencies such as the US Fish and Wildlife Service and the California Department of Fish and Game. Full disclosure of survey methods and results to the public and other agencies without limitations imposed by the applicant must be implemented to assure full CEQA, CESA, and ESA compliance. Confidentiality agreements should not be allowed for the surveys in support of the proposed project.

Surveys for the plants and plant communities should follow California Native Plant Society (CNPS) and California Department of Fish and Game (CDFG) floristic survey guidelines[2] and should be documented as recommended by CNPS[3] and California Botanical Society policy guidelines. A full floral inventory of all species encountered needs to be documented and included in the EIS. Surveys for animals should include an evaluation of the California Wildlife Habitat Relationship System's (CWHR) Habitat Classification Scheme. All rare species (plants or animals) need to be documented with a California Natural Diversity Data Base form and submitted to the California Department of Fish and Game using the CNDDB Form[4] as per the State's instructions[5].

The Center requests that the vegetation maps be at a large enough scale to be useful for evaluating the impacts. Vegetation/wash habitat mapping should be at such a scale to provide an accurate accounting of wash areas and adjacent habitat types that will be directly or indirectly affected by the proposed activities. A half-acre minimum mapping unit size is recommended, such as has been used for other development projects. Habitat classification should follow CNPS' Manual of California Vegetation (Sawyer et. al. 2009).

Adequate surveys must be implemented, not just a single season of surveys, in order to evaluate the existing on-site conditions. Due to unpredictable precipitation, desert organisms have evolved to survive in these harsh conditions and if surveys are performed at inappropriate times or year or in particularly dry years many plants that are in fact on-site may not be apparent

---

[2] http://www.cnps.org/cnps/rareplants/inventory/guidelines.php and http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/Protocols_for_Surveying_and_Evaluating_Impacts.pdf

[3] http://www.cnps.org/cnps/archive/collecting.php

[4] http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/CNDDB_FieldSurveyForm.pdf

[5] http://www.dfg.ca.gov/biogeodata/cnddb/submitting_data_to_cnddb.asp

during surveys (ex. annual and herbaceous perennial plants). The proposed project areas can receive monsoonal rains which trigger a suite of late summer/early fall blooming annual plants, some of which are quite rare. Late season surveys should be implemented and the results should be included in the EIR.

Additionally the surveys need to be done to assess cryptobiotic soil crusts – where they exist and how to protect them. Cryptobiotic soils are an essential component of healthy desert soils, providing a protective layer that absorbs the scant precipitation events, provides "safe sites" for seed germination and prevents soil erosion. Because this and essential desert soil component is fragile and not easily restored, a full discussion of the impacts needs to be included, including alternation of the hydrology and the effects on the soil crusts.

Impact Analysis

The EIS must quantitatively evaluate all direct, indirect, and cumulative impacts to sensitive habitats/species, including impacts associated with the drawdown of ground water and its effects on adjacent spring, seeps and phreatophytic vegetation.

The EIR Must Consider Direct and Cumulative Impacts to Water Resources, Soils, and Air Quality

The pumping proposed under the project may impact water resources and water quality. These issues must be fully considered. The project components and water pumping may also affect soils by disrupting soil structure and drying.

The Mojave Desert Air Quality Management District (MDAQMD) is currently exceeding the federal standards for the criteria pollutants PM_{10} and ozone. Off-road vehicle use, military activities and other issues contribute to existing air quality problems. The EIR must fully disclose and analyze the direct, indirect and cumulative impacts of groundwater pumping on soils and the already compromised air quality in the region, and discuss effective alternatives and mitigation measures to avoid, reduce, and mitigate these impacts.

The EIR Must Adequately Describe the Environmental Baseline

Because the proposed project intends to pump groundwater from a desert basin, obviously baseline conditions in water quantity and quality need to be identified. As suggested above, hydrological studies must unequivocally prove that groundwater naturally flows to the Bristol and Cadiz Dry Lakes (Dry Lakes) and is lost to evaporation. Secondly, the proposed project must show the actual amount of recharge that is lost to evaporation. Our sense is that 50,000 afy is well above the annual recharge to the aquifer that is lost to evaporation. If additional water pumping above and beyond the evaporation rate is proposed, it will result in over-drafting of the groundwater basin and will cause significant environmental impacts. Groundwater monitoring must be put in place prior to the draft EIR so that a baseline groundwater scenario can be used to evaluate potential impacts from the proposed project.

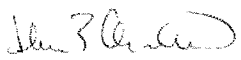
The Imported Water Storage Component needs to clearly identify the parameters of this "second phase". As the project proponent is well aware, a very similar scenario was proposed by the Metropolitan Water District (MWD) and proved infeasible. The NOP states that the potential quantity and schedule for spreading, storage, and extraction for the Water Storage Component will be "explored at the programmatic level in this EIR", we believe that is segmenting the proposed project, which is not allowed under CEQA. The DEIR needs to include the Water Storage Component as a fully developed part of the whole of the project; this component of the project cannot be segmented from the environmental review of the project as a whole.

The EIR Must Analyze the Proposed Project's GHG Emissions and the Cumulative Impacts of Global Warming on Affected Resources

Curbing greenhouse gas emissions to limit the effects of climate change is one of the most urgent challenges of our time. Fortunately, the California Environmental Quality Act ("CEQA"), Cal. Pub. Res. Code §§ 21000 et seq., 14 Cal. Code Regs. § 15000 et seq. ("Guidelines"), set forth a clear and mandatory process to address the Project's greenhouse gas and global warming impacts. The EIR must include a complete and adequate analysis any GHG emissions from any and all actions associated with the project including a full discussion of the impacts from those emissions and a thorough and quantitative analysis of alternatives and mitigation measures to reduce those impacts. In addition, the DEIR must consider how the likely changes in precipitation that are predicted under a warming climate[6] and any cumulative impacts to resources from those changes and the impacts of the proposed project.

Thank you for addressing these comments in the DEIR. Please add us to the distribution list for the EIR and all notices associated with the project.

Best regards,



Ileene Anderson
Biologist/Desert Program Director
Center for Biological Diversity

cc: via email
Kevin Hunting, CDFG KHunting@dfg.ca.gov

6 —Barnett and Pierce 2008

References

Barnett, T.P. and D.W. Pierce 2008. When will Lake Mead go dry? Water Resources Research, Vol 44. 10 pgs.

California Department of Fish and Game. 2010. List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database. http://www.dfg.ca.gov/biogeodata/vegcamp/natural_comm_list.asp .

California Natural Diversity Data Base. Electronic Edition 2011. http://www.dfg.ca.gov/biogeodata/cnddb/

Cowardin, L.M., V. Carter, F.C. Golet, E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service: Washington, D.C. http://www.npwrc.usgs.gov/resource/wetlands/classwet/index.htm

Shuford, W. D., and Gardali, T., editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento. http://www.dfg.ca.gov/wildlife/nongame/ssc/birds.html

Click Here for Full Article

When will Lake Mead go dry?

Tim P. Barnett[1] and David W. Pierce[1]

Received 27 November 2007; revised 22 January 2008; accepted 5 February 2008; published 29 March 2008.

[1] A water budget analysis shows that under current conditions there is a 10% chance that live storage in Lakes Mead and Powell will be gone by about 2013 and a 50% chance that it will be gone by 2021 if no changes in water allocation from the Colorado River system are made. This startling result is driven by climate change associated with global warming, the effects of natural climate variability, and the current operating status of the reservoir system. Minimum power pool levels in both Lake Mead and Lake Powell will be reached under current conditions by 2017 with 50% probability. While these dates are subject to some uncertainty, they all point to a major and immediate water supply problem on the Colorado system. The solutions to this water shortage problem must be time-dependent to match the time-varying, human-induced decreases in future river flow.

Citation: Barnett, T. P., and D. W. Pierce (2008), When will Lake Mead go dry?, *Water Resour. Res.*, *44*, W03201, doi:10.1029/2007WR006704.

1. Introduction

[2] A number of studies over the last 20 years have suggested that there will be a decrease in runoff over the Southwestern United States because of global warming. The decrease will be caused by increasing temperatures and evapotranspiration and decreasing precipitation. The statistical/empirical studies [*Revelle and Waggoner*, 1983; *Nash and Gleick*, 1991, 1993; *Hoerling and Eischeid*, 2007], as well as climate model studies of the last few years [e.g., *Milly et al.*, 2005; *Christensen et al.*, 2004, *Christensen and Lettenmaier*, 2006; *Seager et al.*, 2007] all show a decrease in runoff to the Colorado River (see caveats on climate models below). The estimates of runoff reduction from these studies are remarkably similar, and range between 10% and 30% over the next 30–50 years. The IPCC Working Group II concludes there will be a 10–30% run off reduction over some dry regions at midlatitudes during the next 50 years with very high confidence [*Intergovernmental Panel on Climate Change*, 2008]. Current naturalized flow in the Colorado River is on the order of 15 million acre feet (MAF, 1.233×10^9 m^3) per year measured at Lees Ferry (Figure 1), so these decreases will ultimately result in a runoff reduction of 1.5–4.5 MAF/a from current levels, which we assume leads to similar reductions in Colorado River flow.

[3] The Colorado River is quite literally the life's blood of today's modern southwest society and economy. Given the agreement about both size and timing of runoff reduction, it is important to examine what it will mean to the people of the southwest and, especially, when they might expect water shortage problems to appear. In its recent report on Colorado River Basin water management, the National Academy of Sciences [*Committee on the Scientific Bases of Colorado River Basin Water Management*, 2007] notes future potential problems with availability of water in the region. It calls for a comprehensive analysis of water needs and uses in the region, but provides no analysis of the timing or magnitude of potential problems. *Hoerling and Eischeid* [2007] suggest water availability could soon fall below critical levels but offer no temporal details. *McCabe and Wolock* [2007] estimate climate changes will increase chances of failure to meet water allocation requirements of the Colorado Covenant, but their methods preclude estimates of just when this might happen.

[4] Our intent is to make a first estimate of when and how the human-induced reduced runoff will impact people. We simplistically state the question as "when will Lake Mead go dry?" assuming there are no changes in water management strategies and sector-specific consumptive use. By "going dry," we mean when the live storage (the reservoir space from which water can be evacuated by gravity) in Lakes Mead and Powell becomes exhausted (Figure 2 summarizes the various storage levels in the Lakes). As we shall see below, the answer is both startling and alarming.

[5] It is obvious that once long-term outflow exceeds inflow the system is doomed to run dry. One of our purposes in this work is to point out that currently scheduled depletions (loss of water from consumptive use), along with water losses due to evaporation/infiltration and reduction in runoff due to climate change, have pushed the system into a negative net inflow regime that is not sustainable. Another purpose is to demonstrate how natural variability, i.e., the chance of getting strings of dry years consistent with the historical record, makes the system likely to run dry even with positive net inflow. When expected changes due to global warming are included as well, currently scheduled depletions are simply not sustainable.

2. Methods

2.1. Water Balance Model

[6] The method is a simple water balance approach that keeps track of water going into and out of the major

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, USA.

Copyright 2008 by the American Geophysical Union.
0043-1397/08/2007WR006704$09.00

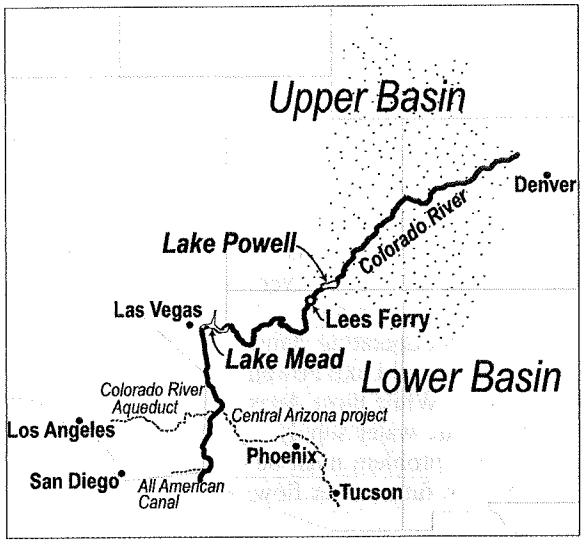


Figure 1. Overview of the region of interest (31.2°–43.7°N, 104.0°–120.3°W), which is historically separated into the "upper basin" (dots) and "lower basin" (gray). Colorado River flow from the upper to lower basins is measured at Lees Ferry.

reservoirs in the Colorado River system. The initial condition for our study (Figure 2) is the amount of water currently in live storage in the Lake Mead/Lake Powell system (25.7 MAF above the dead pool as of June 2007; U.S. Bureau of Reclamation Web page). We consider the two reservoirs as a single storage unit, consistent with the U.S. Bureau of Reclamation (USBR) plan to manage them jointly [*U.S. Bureau of Reclamation*, 2007]. We assume "perfect" management so that the amount of storage in each reservoir above dead pool is manipulated to keep the storage levels approximately the same in both reservoirs (see caveats). The naturalized flow of the Colorado River at Lees Ferry is 15 MAF/a over the period 1906–2005 (USBR Web page, http://www.usbr.gov/lc/region/g4000/NaturalFlow/current.html, accessed 10 January 2008), so we use this as a working number, although on the basis of tree ring reconstructions it is probably too high [*Committee on the Scientific Bases of Colorado River Basin Water Management*, 2007], and does not reflect the drought of the last 7 years (see caveats).

[7] Today the Colorado system is, for all intents and purposes, fully subscribed (see below) so any additional consumptive use in the upper basin as now contemplated (Figure 3), or reduced runoff into the river due to climate change, must be covered by existing storage. We consider human-induced reductions in runoff of 10 to 30%, in accordance with estimates from global climate models and statistical analysis, and take these reductions to be linear in time over the next 50 years (i.e., runoff slowly decreases until it reaches a total reduction of, say, 10% below current levels in 2057). We first do a simple deterministic analysis that does not include the complicating factors of runoff variability, evaporation, and infiltration, in order to more clearly isolate the effect of human-induced climate change on the reservoirs. We then do a probabilistic analysis of the likelihood of the reservoir storage becoming exhausted, using Monte Carlo simulations with a water budget model, and allowing for evaporation and infiltration as well as the stochastic nature of the river flow itself.

[8] We tested the water budget model by comparing it to the results obtained by *Harding et al.* [1995], who modeled a "severe sustained drought" episode on the Colorado River using a sophisticated river network model based on an enhanced version of USBR's Colorado River model, CRSS. The results (Figure 4) show the simulated, combined storage from *Harding et al.* [1995] versus that from the water

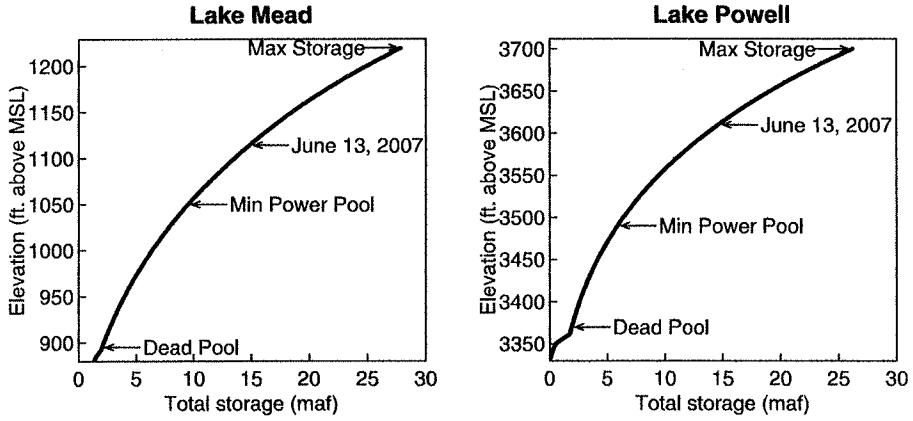


Figure 2. Total reservoir storage in Lakes Mead and Powell (million acre feet) as a function of lake surface elevation above mean sea level (feet). (We retain the units commonly used in the operation of these reservoirs; data are from Colorado River Open Source Simulator, release 1.0, 2007, http://www.onthecolorado.org/cross.cfm). Arrows indicate the maximum storage possible in each lake, the amount present on 13 June 2007, the minimum needed to enable hydroelectric power generation, and the minimum below which no more water can be extracted from the reservoir by gravity ("dead pool"). "Live storage" is all current storage above the dead pool elevation.

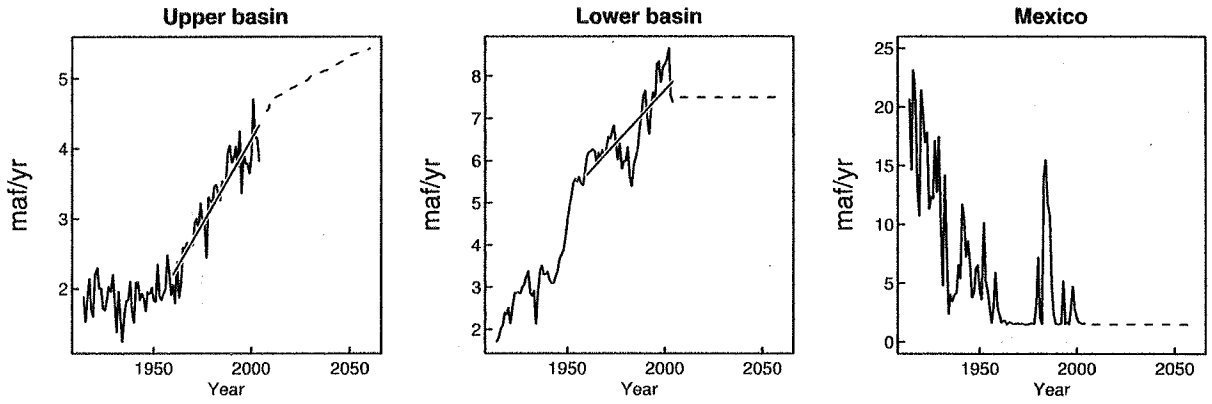


Figure 3. Historical water use (solid line) and scheduled future depletions (dashed line, 2008–2060) of the Colorado River system. Superposed lines for the upper and lower basins show the best fit least squares linear trend over the period 1960–2004. Note the abrupt change in water availability for the lower basin states.

budget analysis used here. The differences are due principally to our neglect of smaller storage units within the Colorado system. At any rate, the agreement suggests the method is adequate to address the large-scale water budget issues considered here.

[9] We tried three different methods to generate synthetic time series of Colorado River flow consistent with the historical record (Appendix A), including a simple first-order autoregressive (AR-1) approximation, fractional Gaussian noise (fGn), and a new Fourier-based technique described in Appendix A. Overall, our results are robust with respect to the method used, as the water budget effects are large compared to differences in detail of the synthetic flows. The plots shown here are made using fGn, since the more familiar index sequential method (ISM) does not correctly sample variability consistent with the historical record (see Appendix A). Synthetic time series generated with fGn also exhibit long-term persistence, which has been shown to be important for correctly simulating the statistics of hydrological processes [e.g., *Phatarfod*, 1989; *Pelletier and Turcotte*, 1997; *Wang et al.*, 2007; *Koutsoyiannis and Montanari*, 2007].

2.2. Future Depletions

[10] Future depletions are taken from published USBR schedules (appendices C and D of *U.S. Bureau of Reclamation* [2007]) over the period 2008–2060. In Figure 3 these are compared to historical water use (obtained from http://www.usbr.gov/lc/region/g4000/uses.html, accessed 14 November 2007). Total scheduled depletions rise from 13.5 MAF/a in 2008 to 14.1 MAF/a by 2030. We also include in the Monte Carlo results water loss due to evaporation and changes due to infiltration (the 1971–2004 average evaporation was 0.894 and 0.516 MAF/a for lakes Mead and Powell, respectively, while infiltration was +0.005 and −0.312 MAF/a (N. Yoder, USBR, personal communication, 2007)). Although the amount of evaporation and infiltration change with lake level, possibly providing a negative feedback as the lake area shrinks, evaporation is also likely to increase in the future as temperatures warm, and infiltration is a second-order quantity compared to the other mechanisms included here. Accordingly, in this work we have simply kept the value of evaporation/infiltration constant at −1.7 MAF/a. As a sensitivity test, we tried scaling evaporation with Lake surface area, and found it made little difference to our results; human-induced reductions in runoff overwhelm the Lake surface area-dependent changes in evaporation.

3. Results

[11] In section 3.1 we begin with deterministic estimates of when the live storage will be depleted by global warming–driven runoff reductions alone, without the outside impacts of evaporation and natural variability in the river flow. This approach is simplistic but gives an immediate feel for the scope of the climate change problem and how it relates to reservoir storage. In section 3.2 we then extend the analysis to more realistic, probabilistic estimates of the same quantities but allowing for the additional impacts of natural climate variability on runoff, as well as the effects of evaporation and infiltration. A summary of the factors included in each calculation is shown in Table 1.

3.1. Deterministic Estimates

[12] The above noted climate models and statistical studies projected decreases in runoff that can be used to compute the future decline in river flow in MAF, year by year. We start by assuming a current steady state where

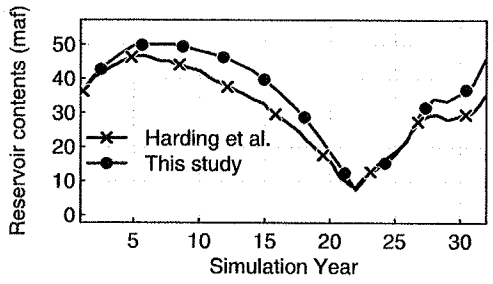


Figure 4. Reconstruction of combined Lakes Powell and Mead storage (MAF) during the "sustained severe drought" episode of the late 1500s from *Harding et al.* [1995] (crosses) and this study (circles).

Table 1. Summary of Factors Included in the Various Calculations[a]

Probabilistic Estimates?	Evaporation and Infiltration Included?	Given in Terms of Net Inflow?	Climate Change Included?	Management Strategies Considered?	Deplete to Power Pool or Dead Pool	Location of Results	10% Chance to Deplete by Year	50% Chance to Deplete by Year
No	no	no	yes	no	dead	section 3.1 (start)	NA[b]	2036
No	no	no	yes	no	power	section 3.1 (end)	NA	2021
Yes	yes	no	yes	no	dead	Figure 5	2014	2028
Yes	yes	no	yes	no	power	Figure 6	2010	2017
Yes	yes	yes	no	no	dead	Figure 7	2014[c]	2028[c]
Yes	yes	yes	yes	no	dead	Figure 8	2013[c]	2021[c]
Yes	yes	no	yes	yes	dead	Figure 9	2025[d]	2048[d]

[a]For simulations that include climate change, the quoted years are for a 20% reduction in runoff over the next 50 years.
[b]NA means not applicable.
[c]For a net inflow of −1.0 MAF/a.
[d]For a cut in requested water deliveries by 25%.

inflow to the reservoirs is equal to their discharge. In reality the Lake Mead is currently being overdrafted by about 1 MAF (T. Labonde and J. Shields, Update for Green River Basin Advisory Group, 2004, available at http://waterplan.state.wy.us/BAG/green/briefbook), so our assumption of steady state is highly conservative. We simply integrate the annual reductions in runoff in time, assuming the changes are temporally linear and levels of consumption are constant, to determine how many years until the existing live storage is gone. We find live storage will be depleted completely 23–40 years from now, or sometime in the span 2030 to 2047, for runoff reductions of 30–10% over 50 years, respectively.

[13] For further discussion, we take the median runoff reduction, from the above studies, as −0.06 MAF per year. This corresponds to a 20% decrease in runoff (3.0 MAF) 50 years from now, and yields approximately 29 years left, or calendar year 2036, before the combined Mead and Powell system is at dead pool elevation. Sensitivity studies showed the dates vary by roughly 10 years around 2036 by assuming larger/smaller 50 year runoff reduction rates or that the 20% runoff reduction will happen soon/later than 2050. The time to dead pool elevation is not very sensitive to the details and assumptions of the runoff estimates. One can also vary the date depending on when one assumes the warming impacts to set in. Recent studies show the global warming impacts have been operative in the Southwest for some decades [*Barnett et al.* 2008], but we make the conservative assumption they start in 2007. Perhaps most important are the initial conditions at the reservoirs for start of the calculations; we used the current state as of June 2007. At this time the system had about 50% of its total possible storage.

[14] In addition to water, both reservoirs are important sources of hydroelectric power. Together the two reservoirs can produce about 10,000 gW h. What do the runoff reductions mean to the availability of that latter resource? As of June 2007 there was a total, between both reservoirs, of approximately 15 MAF of water above the minimum power pool level, which is the reservoir elevation below which the power generation turbines cannot safely operate (Figure 2). Carrying through the same type of analysis as above showed that there is a 50% chance the minimum power pool elevation would be reached in around 2021; only 14 years into the future. At that point (or before), there would be an abrupt drop in the abilities of the reservoirs to generate hydroelectric power.

3.2. Probabilistic Estimates

[15] The previous results neglected the natural variability in river flow associated with weather (wet/dry years) and short-term climate variability (e.g., El Niño/La Niña). Using ten thousand realizations of river flow (statistically consistent with historic variability from 1906–2005 and tree ring flow estimates over approximately the last 1250 years), coupled with the deterministic linear runoff trend described above, allowed us to construct cumulative distribution functions (CDFs) for the depletion of the current live storage. Future depletions were taken from the USBR schedules shown in Figure 3, while evaporation plus infiltration was taken fixed at −1.7 MAF/a, as noted previously.

[16] The results are given in Figure 5 (left). The solid curve shows the likelihood of reservoir storage levels falling to the dead pool elevation with no runoff reduction. In the absence of curtailed water delivery, there is a 50% chance the system will go dry by 2037. This is driven by the sum of depletions (~14 MAF/a by 2030) plus evaporation/infiltration (1.7 MAF/a) being larger than runoff into the system (15.05 MAF/a, the average over the period 1906–2005).

[17] Included also in Figure 5 (left) are the cases where climate change decreases runoff into the river by 10% (crosses) and 20% (circles). The probability of depleting both reservoirs' live storage is 50% by 2028, if we account for natural variability and a 20% decrease in runoff (which would be fully realized in 2057). The results are rather insensitive to changes in runoff reduction. The different methods of modeling the natural variability all give essentially the same results (Figure 5, right).

[18] All of these numbers are somewhat more pessimistic than the deterministic analysis because they include evaporation/infiltration as well as allowing for natural variability in the river flow. The answers, being expressed in probabilistic format, allow the user to determine the risk levels in any decision process they undertake.

[19] The probabilistic analysis for minimum power pool levels is shown in Figure 6. There is a 50% chance the minimum power pool levels will be realized by about 2017, in the absence of management responses. This result is rather insensitive to changes in runoff, at least in the near term. At any rate, the associated drops in power production would be precipitous in time as turbine intakes went dry. It

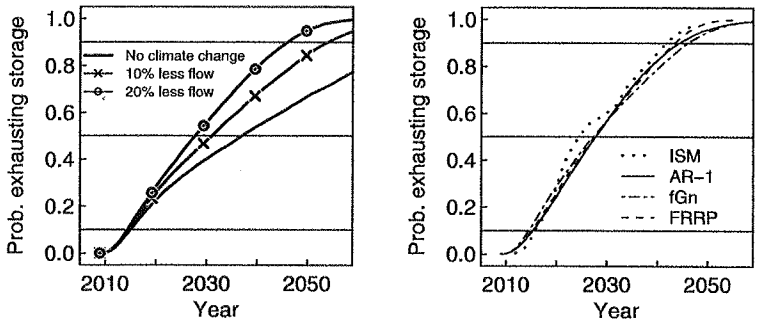


Figure 5. Cumulative distribution function (CDF) showing the probability of Lakes Mead and Powell reservoir levels falling to dead pool elevation by the indicated year. (left) Case where only natural variability is affecting river flow (solid curve) and cases where climate change produces a decrease in runoff of 10% (curve with crosses) and 20% (curve with circles). (right) CDFs obtained with four different methods of simulating natural runoff variability for the case with a 20% reduction in runoff. ISM, index sequential method; AR-1, first-order autoregressive process; fGn, fractional Gaussian noise; FRRP, Fourier reconstruction and randomized phase. See Appendix A for details.

seems clear that the threat to power production on the Colorado is both real and more imminent than most might expect.

3.3. Sensitivity to Net Inflow

[20] Are the results presented here inconsistent with previous results, modeling the severe late 1500s drought, that imply a more resilient water delivery system [*Harding et al.*, 1995]? In that work, even a severe historical drought had only a slight impact on water deliveries to lower basin states. Setting aside climate change for the moment, random weather noise provides a variable amount of water input to the system, which can vary greatly year to year. Water managers strive to deliver a near constant quantity of water every year, using reservoir storage capacity to smooth out these short-term variations. In this section we analyze the system in terms of the *net inflow*, defined as long-term mean flow into the combined Lakes Mead and Powell system minus the long-term mean of consumption plus evaporation/infiltration.

[21] If one considers the system as a whole, the net inflow is negative. The USBR scheduled delivery (Figure 3) starts at 13.5 MAF/a in 2008, which together with evaporation/infiltration of 1.7 MAF/a and a mean Colorado River flow of 15.05 MAF/a (average over 1906–2005) gives a net inflow of −0.15 MAF/a in 2008, dropping to −1.15 MAF/a by 2060 in the absence of climate change. A reduction in runoff by 10 and 20% from human-induced climate change would give net inflow of −2.6 and −4.1 MAF/a, respectively, by 2057. The reservoirs would be dry long before these levels were realized, assuming present consumption continues unchanged. Arguably more realistic would be to use the average mean Colorado River flow over the last 50 years, which would put the current net inflow even more negative, about −0.7 MAF/a, near the current overdraft of 1.0 MAF/a estimated for Lake Mead (see http://waterplan.state.wy.us/BAG/green/briefbook).

[22] Figure 7 (left) shows the CDFs of the system running dry as a function of fixed net inflow (i.e., neglecting any time-evolving contribution from climate change). It is clear that negative net inflow mandates the system running dry, but one might wonder how the system can go dry with zero or positive net inflow. Natural variability generates long periods of wet/dry years, so the system can go dry at one extreme and spill under wet conditions. These situations are equally likely from a statistical point of view when only natural variability is operating. In the absence of a management response to shortages, the system undergoes a random walk constrained only by the limits of maximum reservoir capacity (on the wet side) and completely exhausted storage (on the dry side). The middle plot of Figure 7 shows the probability of filling or going dry by year 2027 (20 years from now) as a function of net inflow. With initial reservoir storage approximately half the capacity, the curves are nearly symmetric.

[23] The CDFs shown in Figure 7 (left) have a strong sensitivity to net inflow; the system becomes rapidly prone to exhausting storage as net inflow drops from +2 MAF/a (which virtually guarantees reliable delivery) to −1 MAF/a, which has a 50% chance of running dry by 2027. So part of the reason our results seem to show a system more sensitive to climate fluctuations than earlier workers is that the

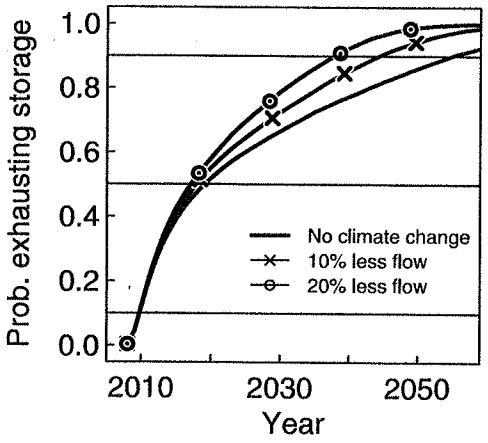


Figure 6. As in Figure 5 (left) but for reservoir storage dropping below the minimum necessary for hydropower generation.

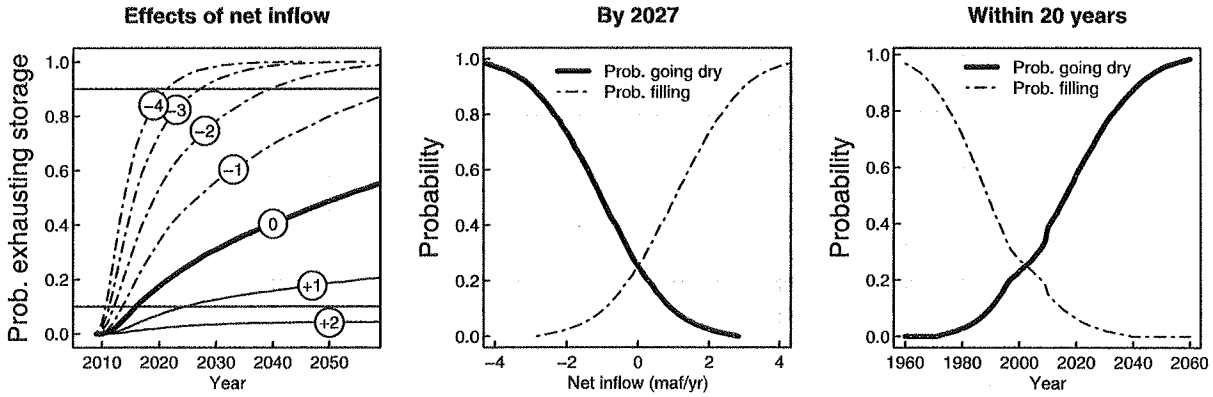


Figure 7. (left) CDFs of Lakes Mead and Powell running dry as a function of net inflow into the system, as indicated on the curves (in MAF/a). Climate change is not explicitly included. (middle) Probability of the system going dry (solid line) or filling up (dash-dotted line) by 2027, for the given net inflow (MAF/a). Climate change is not explicitly included. (right) Probability of the system going dry or filling up within 20 years of the indicated start year, given historical and future depletions and a 20% reduction in runoff due to climate change.

system becomes more unstable as the net inflow approaches zero, i.e., as the river becomes fully subscribed. Yearly depletions to the upper and lower basins have risen steadily since the 1940s (Figure 3), resulting in an increasingly unstable system.

[24] Furthermore, Figure 7 shows that the rate of increase in sensitivity of the system becomes much more rapid as the net inflow approaches zero. For example, consider the probability of the system running dry by 2027 (middle plot, thick line). The chance is negligible for a net inflow of +2 MAF/a or more, which was the case before about 1985. If the net inflow is reduced to +1 MAF/a (approximately the inflow for the late 1980s and early 1990s) the probability only rises to 9%. However, if the net inflow is further reduced to 0 MAF/a, the probability jumps to 25%; and as the net inflow drops to today's value of nearly −1 MAF/a, the probability of the system running dry by 2027 increases to 50%.

[25] We now add reductions in runoff due to climate change to the increasing sensitivity as net inflow approaches zero. The combination acts in a particularly unfortunate way. Even if current net inflow were at a somewhat safe value, such as +1 MAF/a, future reductions in runoff combined with increasing depletions (Figure 3) yield net inflows that drop to levels that render the system highly vulnerable in just a few decades. This is shown in Figure 8, where the left plot illustrates the case with initial (year 2007) net inflow of +1 MAF/a. In the absence of climate change, there is a 20% chance the system would run dry by 2040. However, a human-induced reduction in runoff by 20%, a medium value from the global model estimates, has a strong effect on the probability curve, such that there is then a 45% chance of the system going dry by 2040.

[26] In reality, we likely have a current net inflow between −0.2 and −1 MAF/a depending what base time period one wants to use for estimating mean Colorado River flow. The middle and right plots of Figure 8 show that in this regime, any reduction in river flow due to climate change has a strong effect on an already marginally reliable system, e.g., for a net inflow of −1 MAF, the probability

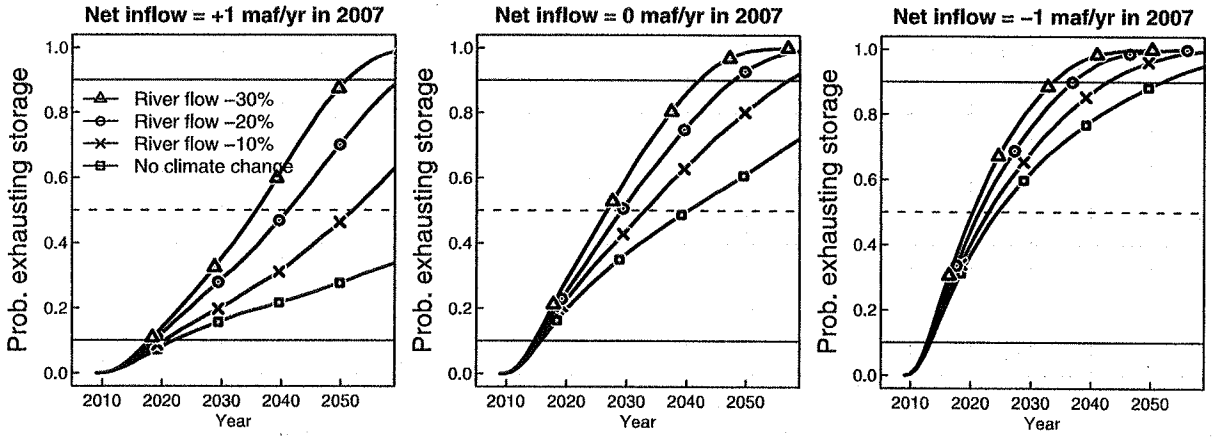


Figure 8. Effect of climate change on chances of Lakes Mead and Powell running dry, for a net inflow of (left) +1, (middle) 0, and (right) −1 MAF/a.

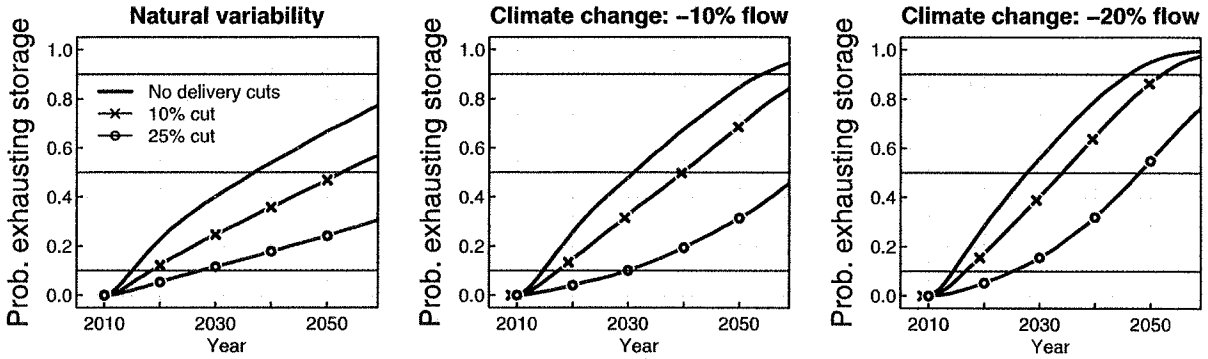


Figure 9. Effects of management strategies on likelihood of the Lakes Powell and Mead system dropping to deal pool elevations (left) for current conditions and when runoff in the Colorado River system drops (middle) 10% and (right) 20% because of climate change. Solid curve, when all requested water deliveries are supplied; curves with crosses and circles, when deliveries are cut 10 and 25%, respectively, when total storage drops below 15 MAF.

that reservoirs are at dead pool by 2021 is 50% (assuming a 20% reduction in runoff).

[27] To further illustrate the evolving reliability of the system, we combine historical and projected future depletions (Figure 3) with the reduction in runoff expected because of climate change to estimate net inflow from 1960 to 2060. Since net inflow is not intended to reflect interannual variability, we have calculated the depletions over the historical era (1960–2004) from the least squares best fit linear trends shown for the upper and lower basins in Figure 3, and taken water releases to Mexico constant at 1.5 MAF/a. Future depletions are taken from the USBR schedules. Using this net inflow, we compute the probability the system will go dry (or fill) within 20 years from the start date, including a 20% reduction in runoff over 2007–2057 due to climate change and (for consistency) a constant starting reservoir level of 25 MAF. The results are shown in the right plot of Figure 7. From 1960 to 1980, there was virtually no chance of the system running dry within 20 years; by 2000, this chance rises to 20%, and to almost 60% by 2020. In contrast, the chances of the lakes refilling drop to under 20% by 2007 and are essentially nil by 2030. At any rate, the early 2000s were marked by a significant transition, when, for the first time, the chance of the system running dry exceeded the chance of the system filling up.

4. Water Shortage Options

[28] Of course, water managers and other decision makers will do everything in their power to see that Lakes Mead and Powell do not go dry. Can the devastating scenarios laid out above be ameliorated, at least for some years, and if so how might this be done? Curtailing consumptive use is one obvious answer. The current USBR strategy for the most severe reservoir elevation reduction they consider, Lake Mead level at 1025 feet (see Figure 2), is to withhold 0.6 MAF of water per year, about 5% of Lake Mead annual releases (including evaporation) (see USBR lower Colorado Shortages Web page). Will this be enough of a reduction to solve the problem?

[29] The magnitude of the problem is illustrated in Figure 9, which shows the CDFs of Lakes Mead and Powell reaching dead pool elevation under two simplified management schemes and three runoff scenarios. The management schemes are not intended to be correct in the complicated details of how water delivery is altered under shortage conditions. Instead, they illustrate the overall sensitivities of system reliability. The curves with crosses and circles show the CDFs for when the system goes dry when water deliveries are reduced by 10% and 25% of current demand, respectively. These consumption reductions are assumed to start when combined reservoir storage falls below 15 MAF. This is equivalent to withholding 1.35 and 3.38 MAF/a on the basis of current demand. The 15 MAF cutoff was chosen as the point in time where the deliveries are to be curtailed because it corresponds to the time minimum power pool levels will be reached in the combined system (see caveats). In the presence of no runoff reduction, the chances are 50% that the dead pool volumes will be reached in 2037, 2053 and some time after 2070 for 0, 10 and 25% reduction in consumptive water delivery, respectively. If the human-induced runoff reduction is 20% then the comparable set of years to reach dead pool are 2028, 2034 and 2048, respectively.

[30] The 10% reduction in water delivery delays for about 6 years the reservoirs reaching dead pool elevations in the case of a 20% reduction in runoff, and about 10 years in the case of a 10% in runoff reduction. So a 10% reduction in consumptive delivery buys some time but does not solve the problem. Inspection of Figure 9 shows the 25% reduction in water deliveries makes a real difference in the sustainability of the reservoir storage. If we now compare the above results to the 5% delivery reduction in the USBR water shortage plan, it is clear the 5% reduction will have little impact on the sustainability of the Colorado reservoir system in a shortage situation.

5. Caveats

[31] There are a number of issues that potentially impact the results obtained above. We point these out here, although going into detail is beyond the scope of the present paper.

[32] 1. The upper basin of the Colorado has water allocations equal to those of the lower basin (7.5 MAF/a). However, they are now using something over 4 MAF/a of

water associated with those rights. Growth in that part of the West suggests this situation is changing and the upper basin is using more of this right (Figure 3). Indeed, the combined water use currently in both basins is roughly 14–15 MAF/a (USBR water accounting Web site, http://www.usbr.gov/lc/region/g4000/wtracct.html), including evaporation and infiltration. This is approximately the currently assumed average flow of the river. Is there water to satisfy increased use in the upper basin and if so, what will its use do to the net water balance of the system?

[33] 2. We implicitly assumed there would be annual releases from Lake Powell tuned to maintain storage parity between it and Lake Mead, e.g., the perfect management scenario noted above. The law of the river only requires a delivery of 75 MAF over a 10 year interval, so in principle, releases from Lake Powell could be curtailed for several years running, as long as they are made up in subsequent years. The impact on Lake Mead of such action would be devastating and, if maintained for even 2 years in the current situation, would preclude meeting consumptive allocations in the lower basin. Our methods, essentially assuming a single large reservoir, will not handle such a situation. We are interested here in longer-term, larger-scale changes and so events like Powell release or no release, which are events of a few years duration, are not considered explicitly. A more sophisticated model would be required to explore this issue.

[34] 3. Tree ring data suggest the long-term flow of the Colorado experiences more variability than has been observed over the last century [*Committee on the Scientific Bases of Colorado River Basin Water Management*, 2007]. These data also suggest prolonged droughts far worse and more extensive than seen in the last 100 years of flow record on the river are possible. Our attempt to estimate natural variability from the last 100 years alone might miss such situations, unless they are included in the methods we use to generate synthetic flows. The results given in Appendix A suggests the methods are robust to inclusion of the entire paleo tree ring record, so lack of representativeness in our model of natural variability does not seem to be a major problem. Note also, the flow reductions we have been seeing over the last 7–8 years are surprisingly close to the global warming–driven reductions in flow estimated by *Hoerling and Eischied* [2007]. They also are likely to occur by chance 10% of the time according to our FRRP statistical model of river flow (Appendix A).

[35] 4. We have assumed that 1.5 MAF will continue to go to Mexico annually per existing treaty.

[36] 5. The average annual river flow we used (15 MAF) is estimated from the 1906–2005 record of naturalized flow. However, this masks the long-term decreasing trend in flow. It might be more realistic to use the average flow over, say, the last 50 years, 14.48 MAF, or over the last 500 years, 13.7 MAF. Introduction of these lower flow estimates into our analysis would considerably speed up all of the dead pool dates cited above [*Weisheit and Harrington*, 2007].

[37] 6. We assumed that the climate model predicted changes in net moisture flux convergence would all end up in river flow. But if a significant fraction of that moisture change were, say, sequestered in the soils, then our estimates of runoff to the river would be too high [cf. *Troch et al.*, 2007]. This would allow more pessimistic estimation of future water shortages.

[38] 7. The climate models which have produced estimates of decreasing runoff have a host of problems of their own in handling the water budget from coarse resolution (little in the way of Rocky Mountains) to the variety of ways they handle soil processes and vegetation representations. However, a recent study of changes in hydrology of the western U.S. over that last 50 years shows several of the models, when run with observed anthropogenic forcings, reproduce extremely well the observed changes in river flow timing, snowpack decline and increasing air temperatures in the western United States [*Barnett et al.*, 2008]. So these models, while not perfect, have a message to tell; a message supported by their ability to reproduce well the last 50 years of multivariate hydrological observations.

[39] 8. The results shown above are based on initial conditions corresponding to the current storage levels of Lakes Mead and Powell, currently about 50% of capacity. If we rerun the simulations from full pool initial conditions, we find the CDFs are shifted to latter times, as one would expect. As a rule of thumb the dates noted above for realization of dead pool levels are pushed 15–20 years into the future.

[40] 9. We also note that the claim that the Colorado is a resilient system that can quickly recover from drought seems to depend on two factors. The *Harding et al.* [1995] simulation of the severe sustained drought of the late 1500s started with a pseudoreservoir level of about 35 MAF. Had that study been started with initial conditions from today, 10 MAF less water, the answer might have been different. Secondly, not only does the system become less reliable as net inflow approaches zero, but the rate of change of system reliability increases strongly as well. This means the system can quickly transition from a resilient to a fragile system as consumptive use of the river increases. This is exactly the regime we are in today.

6. Conclusions

[41] Twenty years of scientific research have shown the flow of the Colorado River is likely to decline 10–30% over the next 30–50 years. It is declining now and has been for some years. We have shown that reduction in runoff into the Colorado River will, within a handful of years, reduce the live storage of water in the Colorado system to nothing and seriously curtail the system's hydropower production, if no consumptive use changes are made. For example, there is a 10% chance that live storage in Lakes Mead and Powell will be gone by about 2013, and a 50% chance by 2021, if current water allocations are maintained. There is a 50% chance that minimum power pool elevations will be reached by 2017.

[42] It seems clear there are a number of management options that can forestall this disaster. Many of these problems and potential solutions were foreseen by Gleick and associates at the Pacific Institute 1–2 decades ago [*Morrison et al.*, 1996; *Gleick et al.*, 2003], and others before them. The new feature of the problem is that the Colorado River will continue to lose water in the future, if the global climate models are correct. Solutions to today's problems might not be applicable into the future [e.g., *Milly*

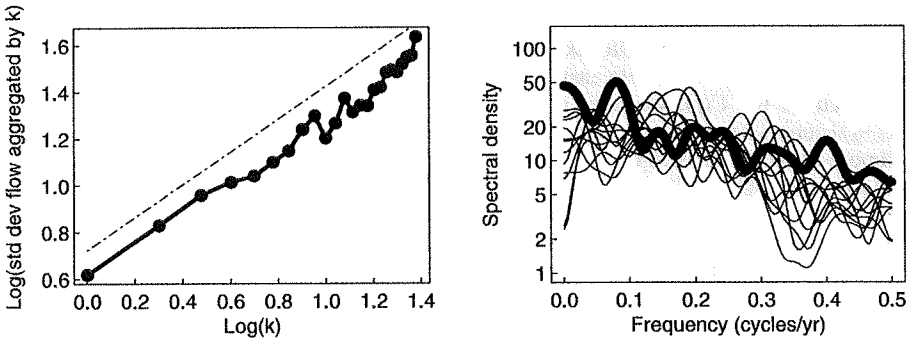


Figure A1. (left) Log of the standard deviation of Colorado River flow (1906–2005) aggregated into k-year blocks, as a function of log(k); the slope of this relationship should equal the Hurst coefficient H. The dash-dotted line has slope 0.7, for reference. (right) Spectrum of independent 100-year chunks of the paleoreconstructed Colorado River flow from *Meko et al.* [2007] (thin black lines) compared to spectrum of the synthetically constructed flow using the Fourier method (thick black line, with gray area showing the 95% confidence interval).

et al., 2008]. The challenge is to determine what combination of agricultural, environmental uses, and personal consumption is achievable in the future, when 10–30% less water must serve substantially more people.

[43] In the future we can count on some flow in the Colorado, albeit 10–30% less in (say) 50 years than the current rate. We need to determine now how that reduced supply of water will be used: Who will get some and who will not? Our call for action now goes beyond the additional study called for by the *Committee on the Scientific Bases of Colorado River Basin Water Management* [2007] because of the magnitude and immediacy of the problem. There is danger that litigation, associated with water right claims and environmental issues, will compound and put off any rational decisions on this matter until serious damage has been done to the diverse users of the Colorado River. Much of this litigation might be avoided if time-dependent water solutions are crafted to reflect today's and tomorrow's water realities. It is laudable that efforts in this direction are now being made. We hope this work will spur solutions, as time is short. The alternative to reasoned solutions to the coming water crisis is a major societal and economic disruption in the desert southwest.

Appendix A: Generation of Synthetic River Flow Time Series

[44] We construct pdfs of the likelihood of the Lake Powell/Mead system going dry using thousands of synthetic time series of Colorado River flow. We explored three different methods for generating these time series. The first method was simply a standard first-order autoregressive (AR-1) model, with the lag-1 correlation taken from the observations.

[45] The second method was fractional Gaussian noise (fGn) (see *Koutsoyiannis* [2002] for an overview), which captures the low-frequency variability of river flow and tendency for strings of wet or dry years better than the AR-1 method. We used the R statistics package "fArma" for this purpose (version 260.72, downloaded from http://cran.r-project.org on 23 November 2007). Various estimation methods reported a Hurst coefficient H between 0.6 and 0.8 for observed naturalized Colorado River flow, 1906–2005; we used $H = 0.7$ to generate the synthetic flows (Figure A1, left). Every century-long synthetic time series was set to have the same mean and standard deviation as the observed flow, which likely underestimates the true variability in runoff.

[46] The third method we used was one of our own devising that we term the "Fourier reconstruction and randomized phase" (FRRP) method. It is similar to the fGn method, but uses the observed power spectrum as the basis for a synthetic reconstruction rather than a fit to a theoretically derived power spectrum. We start with the historical time series of water year total Colorado River flow, $c(t)$. We then transform the time series to frequency space using a Fourier transform:

$$C(f) = \int_{-\infty}^{\infty} c(t) e^{2\pi i f t} dt$$

where C is a (complex-valued) amplitude in the frequency domain, and the frequency, f, is in cycles per water year.

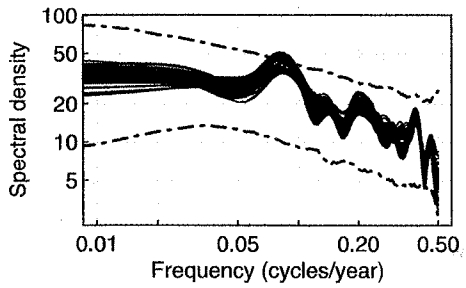


Figure A2. Spectra of 99 simulations of Colorado River flow generated with the ISM method applied to the historically observed time series (solid black lines) and 95% confidence interval of 1000 simulations of Colorado River flow generated with fractional Gaussian noise (dash-dotted line).

Since $c(t)$ is real, the properties of the Fourier transform guarantee that $C(-f) = C(f)^*$, where the asterisk denotes complex conjugate. Since we use a discrete fast Fourier transform (FFT) to calculate the $C(f)$, we have a limited number of $[C(f), C(-f)]$ conjugate pairs in frequency space. For each pair, we choose a random phase θ between $-\pi$ and π. We then calculate a new amplitude $C'(f) = C(f)e^{i\theta}$, which has the same modulus as the original amplitude but a different phase. To preserve the property that the transform of C' back to the time domain result in a real-valued function, we set $C'(-f) = C'(f)^*$. The final synthetic time series is then the inverse transform of the C' amplitudes back to the time domain. Every synthetic time series has, by construction, the same power spectrum as the original time series, and is consistent with spectra of 100 year segments of the historical flow of the Colorado River reconstructed from tree rings over the period 762–2005 [*Meko et al.*, 2007] (Figure A1, right plot).

[47] The three methods of estimating natural variability of the flow are compared in Figure 5 (right) amongst themselves and with the index sequential method (ISM) currently in use by the USBR [*Ouarda et al.*, 1997] for a runoff reduction of 20%. The three methods are essentially equivalent, and more conservative than the ISM approach. It is clear that the water balance, or lack thereof, is driving our results, not the nature of the model used to generate natural variability.

[48] As a final note, we deliberately chose not to use the ISM approach, even though it is familiar to many and widely used in USBR simulations. By continually sampling the historical record in sequence, ISM always includes any outliers than may be in the historical record, yet fails to sample all the variability that is consistent with the observed record but did not chance to occur in the past 100 years. This is illustrated in Figure A2; the spectra of 99 ISM realizations of Colorado River flow (solid black lines) show simultaneously a far narrower range of variability than spectra generated with fGn (95% confidence interval shown by the dash-dotted lines), and yet show consistently more power than would be expected at a frequency of ~0.07 cycles/a because of repeated sampling of the same particular historical sequence. This results in a statistical bias in the estimates of natural variability. Both the fGN and FRRP can produce natural climate variability outside the historical record, and simulate extreme events in ensembles of many thousands of simulations in a consistent way.

[49] **Acknowledgments.** This work was supported under a joint program between the University of California San Diego and Lawrence Livermore Research Lab called LUSCid. At UCSD, the program was run out of the San Diego Supercomputing Center, and work was done at the Scripps Institution of Oceanography. We wish to especially thank Dennis Lettenmaier for his comments and patience and also Mike Dettinger and P. Gleick for suggestions on early drafts of the manuscript. D.W.P. received partial salary support from the California Energy Commission.

References

Barnett, T. P., et al. (2008), Human-induced changes in the hydrology of the western United States, *Science*, *319*, 1080–1083.

Christensen, N., and D. Lettenmaier (2006), A multimodel ensemble approach to climate change impacts on the hydrology and water resources of the Colorado River Basin, *Hydrol. Earth Syst. Discuss.*, *3*, 1–44.

Christensen, N. S., A. W. Wood, N. Voisin, D. P. Lettenmaier, and R. N. Palmer (2004), Effects of climate change on the hydrology and water resources of the Colorado basin, *Clim. Change*, *62*, 337–363.

Committee on the Scientific Bases of Colorado River Basin Water Management (2007), *Colorado River Basin Management: Evaluating and Adjusting to Hydroclimatic Variability*, Natl. Acad., Washington, D. C.

Gleick, P. H., D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolf, K. K. Cushing, and A. Mann (2003), Waste not, want not: The potential for urban water conservation in California, 176 pp., Pac. Inst., Oakland, Calif.

Harding, B. L., T. B. Sangoyomi, and E. A. Payton (1995), Impacts of a severe sustained drought on Colorado River water resources, *Water Resour. Bull.*, *31*, 815–824.

Hoerling, M., and J. Eischeid (2007), Past peak water in the West, *Southwest Hydrol.*, *6*(1), 18–19.

Intergovernmental Panel on Climate Change (2008), Summary for policy makers, in *Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability*, edited by N. Adger et al., Cambridge Univ. Press, New York, in press.

Koutsoyiannis, D. (2002), The Hurst phenomenon and fractional Gaussian noise made easy, *Hydrol. Sci.*, *47*, 573–595.

Koutsoyiannis, D., and A. Montanari (2007), Statistical analysis of hydroclimatic time series: Uncertainty and insights, *Water Resour. Res.*, *43*, W05429, doi:10.1029/2006WR005592.

McCabe, G. J., and D. M. Wolock (2007), Warming may create substantial water supply shortages in the Colorado River Basin, *Geophys. Res. Lett.*, *34*, L22708, doi:10.1029/2007GL031764.

Meko, D. M., C. A. Woodhouse, C. A. Baisan, T. Knight, J. J. Lukas, M. K. Hughes, and M. W. Salzer (2007), Medieval drought in the upper Colorado River Basin, *Geophys. Res. Lett.*, *34*, L10705, doi:10.1029/2007GL029988.

Milly, C., et al. (2008), Stationary is dead: Whither water management, *Science*, *318*, 573–574.

Milly, P., K. Dunne, and A. Vecchia (2005), Global pattern of trends in streamflow and water availability in a changing climate, *Nature*, *438*, 347–350.

Morrison, J., S. Postel, and P. Gleick (1996), Sustainable use of water in the lower Colorado River Basin, Pac. Inst., Oakland, Calif.

Nash, L., and P. Gleick (1991), The sensitivity of stream flow in the Colorado Basin to climatic changes, *J. Hydrol.*, *125*, 221–241.

Nash, L., and P. Gleick (1993), The Colorado Basin and climate change, *EPA 230-R-93-009*, Policy, Plann. and Eval., Environ. Prot. Agency, Washington, D. C.

Ouarda, T., D. Labadie, and D. Frontere (1997), Indexed sequential hydrologic modeling for hydropower capacity estimates, *J. Am. Water Resour. Assoc.*, *33*(6), 1–13.

Pelletier, J. D., and D. L. Turcotte (1997), Long-range persistence in climatological and hydrological time series: Analysis, modeling, and application to drought hazard assessment, *J. Hydrol.*, *203*, 198–208.

Phatarfod, R. M. (1989), Riverflow and reservoir storage models, *Math. Comput. Modeling*, *12*, 1057–1077.

Revelle, R., and P. Waggoner (1983), Effects of carbon dioxide-induced climatic change on water supplies in the western United States, in *Changing Climate*, Carbon Dioxide Assess. Comm., Natl. Acad., Washington, D. C.

Seager, R., et al. (2007), Model projections of an imminent transition to a more arid climate in southwestern North America, *Science*, *316*, 1181–1184.

Troch, P., M. Durcik, S. Seneviratne, M. Hirschi, A. Teuling, R. Hurkmans, and S. Hasan (2007), New data sets to estimate terrestrial water storage change, *Eos Trans. AGU*, *88*(45), 469–470.

U. S. Bureau of Reclamation (2007), Final environmental impact statement, Colorado River interim guidelines for lower basin shortages and coordinated operations for Lake Powell and Lake Mead, Boulder City, Nev. (Available at: http://www.usbr.gov/lc/region/programs/strategies/FEIS/index.html).

Wang, W., P. H. A. J. M. Van Gelder, J. K. Vrijling, and X. Chen (2007), Detecting long-memory: Monte Carlo simulations and applications to daily streamflow processes, *Hydrol. Earth Syst. Sci.*, *11*, 851–862.

Weisheit, J., and M. Harrington (2007), Letter to regional director, lower Colorado region re-DEIS, Living Rivers, Moab, Utah.

T. P. Barnett and D. W. Pierce, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92037, USA. (tbarnett-ul@ucsd.edu)

From: Dick MacPherson [dnkmac@the2h2o.com]
Sent: Monday, March 28, 2011 4:14 PM
To: Cadiz Project
Subject: Cadiz Valley water draw down

Mojave Preserve Landowners Association
March 27, 2100

Project Manager
Mr. Tom Barns , ESA

It is imperative that an extension of the NOP be granted so that many more folks can have the chance to make appropriate comments of the Cadiz Plan. The short notice to the very limited "mailing" list was not acceptable!

We don't feel you can justify 50,000afy of water draw down as sustainable with out drastically effecting our springs and wells which we depend on for our existence. Your own figures don't seem to substantiate that level of draw down. Possibly 5,000afy draw down to start and only after many springs and wells are monitored for at least a year before draw down starts. Draw down increases made possible only after continued monitoring showing no negative effects on quantity or quality of all monitored water sources. All increases, if allowed, to be in small increments only. All monitoring to be provided by a neutral organization funded by you in an escrow account. Our wells and spring provide basic water for a variety of wildlife, agriculture, and humans. Perhaps USGS has the ability to start monitoring now if asked.

The following is a partial list of places that must be monitored prior to any draw down: Springs and or wells in the Granite Mountains on north and south sides, Springs and or wells in the Van Winkle, Horse Hills, and lower Providence Mts. Springs and wells on both sides of the Providence Mts. Springs and wells in Mid Hills, Gold Valley, Round valley, Pinto valley and Fourth of July Canyon. areas, and Caruthers canyon., Springs and wells on all sides of the New York range, wells in the portion of Lanfair Valley that drain south, Springs in the Hackberry Mts., Wells in Goffs and Essex areas, springs in the Clipper Mts., Springs in the Old Woman Mts. on both sides, and possible effected sites in Joshua Tree National Park, and at least 1/3 of the Mojave National Preserve will definitely be effected.

During the 2005 fire, the many thousands of gallons of water were used to fight the fire came from Round Valley and Gold Valley wells. We were worried then that the draw down would effect our wells, but the torrential storms of '05 and '06 after the fire made monitoring impossible. There must be a contingency plan including hauling potable water to the residents effected by low or no water levels in our wells. There must be an appropriate budget and time line established also. There must be a additional fund established for drilling deeper wells for the private land owners and the Park Service if the draw down continues. As You know well drilling is not cheap, so the escrow fund must be well funded. The pumping rate from the Cadiz must be monitored by a neutral, mutually approved agency. That agency must have an escrow account to draw from to monitor the out put from Cadiz and the possible input to Cadiz.

There would appear to be a significant deficit of at least 12,000afy in the recharge rate if your figures are used . Where is that missing water coming from??? What is the time involved in a recharge cycle if in fact the aquifer is capable of recharge?? How old is the water in the "tank", and is it all drinkable water?? We need unbiased proof of these things that effect hundreds of residents of the East Mojave and the thousands of wildlife that depend on that water to live here.

Please send a packet of the information sent to a few and "available " at the meeting where most land owners could not attend. We feel very left out of a vital decision regarding our existence in the East Mojave. (send to Riverside address please)

Sincerely,

Richard MacPherson
Chairman

3660 Valencia Hill Dr.
Riverside, CA 92507
951-682-6924

HCR1 Box 429
Cima, Ca 92323
760-928-2510

cc: Congressman Jerry Lewis; Senator Feinstein; MDHCA; County Supervisor Metzelfelt; MWD

California Office
1303 J Street, Suite 270 | Sacramento, CA 95814 | tel 916.313.5800 | fax 916.313.5812
www.defenders.org

March 29, 2011

Santa Margarita Water District
c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
(Sent by email to: cadizproject@esassoc.com)

RE: Scoping Comments on the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project

Dear Mr. Barnes:

Thank you for the opportunity to review and comment on the Notice of Preparation ("NOP") for an Environmental Impact Report ("EIR") for the proposed the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project These comments are submitted by Defenders of Wildlife ("Defenders"), a non-profit public interest conservation organization with offices in California as well as elsewhere in this country.

Defenders has 950,000 members and supporters nationally, 145,000 of whom reside in California. Defenders is dedicated to protecting all wild animals and plants in their natural communities. To this end, we employ science, public education and participation, media, legislative advocacy, litigation, and proactive on-the-ground solutions in order to impede the accelerating rate of extinction of species, associated loss of biological diversity, and habitat alteration and destruction.

The proposed project is very similar to an endeavor by the Metropolitan Water District of Southern California ("MWD") called the Cadiz Water Project, which was the subject of environmental review under the California Environmental Quality Act ("CEQA") approximately 10 years ago. Ultimately, MWD abandoned its plan for the Cadiz Water Project.

We recommend that the EIR for the proposed project rigorously address the following issues:

1. Purpose and Need; Alternatives: The purpose and need for the project needs to be clearly defined. The NOP indicates the proposed project is intended to augment the current water supply of the Santa Margarita Water District, Three Valleys Municipal Water District, Suburban Water Systems, and Golden State Water Company.

The need to augment the water supply for the four water purveyors needs to be justified, and alternative means to provide additional desired water need to be identified and analyzed. The

National Headquarters
1130 17th Street, N.W.
Washington, D.C. 20036-4604
tel 202.682.9400 | fax 202.682.1331

EIR should include "a range of reasonable alternatives to the project which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives," as required by Section 15126.6 (a) of the CEQA Guidelines. The alternatives should include those that would avoid or substantially lessen any of the significant environmentally negative effects of the project and ongoing management [CEQA Guidelines, section 15126.6(1)]. For each alternative, the EIR should provide a discussion on how each alternative would avoid or minimize significant impacts. Alternatives should include conservation of existing supplies through reduced consumption and recycling, and alternative sources.

2. Groundwater Hydrology. An independent study and assessment of the groundwater hydrology of the Cadiz and Fenner valleys need to be performed in order to determine the amount and quality of groundwater in the affected area; the amount of annual recharge; the amount of evaporation form Bristol, Cadiz and Danby Dry Lakes; and the amount of water used by native vegetation. The effect of climate change of long-term precipitation and groundwater recharge within the Cadiz and Fenner Valleys needs to be addressed in the analysis.

We are aware there are significant differences of opinion on groundwater recharge and sustainable use. One prominent hydrologist, Dr. John Bredehoeft, in comments on MWD's proposed Cadiz Water Project[1], estimated that the annual recharge to the groundwater in the Cadiz Groundwater Basin was approximately 5,000 afy, approximately 10 times the amount of groundwater that would be pumped under the MWD's former project and the proposed project. Sustainable use of groundwater needs to also consider the amount of near-surface water on and near the affected dry lakes necessary to minimize dust and sustain native vegetation.

The effects of groundwater pumping on wetlands, seeps and springs, and water quality within or adjacent to the Cadiz and Fenner Valleys needs to be fully studied and disclosed. Furthermore, the effect of proposed project on groundwater quantity and quality underlying federal public land needs to be analyzed.

3. Biological Resources. The effects of the proposed project, and alternatives, on sensitive biological resources need to be carefully analyzed. Such sensitive biological resources include, but are not limited to, Desert Tortoise, Mojave Fringe-toed Lizard, Golden Eagle, Prairie Falcon, Burrowing Owl and Desert Bighorn Sheep. Direct and indirect effects should be analyzed including habitat loss, disruption of movements, breeding and foraging.

4. Availability of Colorado River Water. Although the NOI indicates that the importation and storage of Colorado River water during periods when "excess" water is available is not part of the initial proposed project, we believe it must be analyzed under CEQA because it is a part of the overall intent of the project – it can't be analyzed at a later time due to prohibition against segmenting related activities. The analysis should fully analyze the projected availability of "excess" Colorado River Water for storage and subsequent pumping, and such availability must take into account the effects of climate change on Colorado River flows and demands from users who hold rights to divert such water.

---

[1] Bredehoeft, John. 2001. Revised Comments: Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California. Prepared for Western Environmental Law Center, Taos, New Mexico. 21 pp.

5. Effect on Public Lands and Resources. Private lands proposed to be used for the project are surrounded by federal public lands in the California Desert Conservation Area managed by the Bureau of Land Management. These lands support numerous species of plants and animals, some of which are federal and state listed threatened (Desert Tortoise) or designated as sensitive (Mojave Fringe-toed Lizard, Golden Eagle, Burrowing Owl, Desert Bighorn Sheep, and numerous species of plants). The effects of the proposed project on these species and their habitats need to be fully analyzed. There are also several designated federal wilderness areas near the proposed project. The effects of the proposed project on these areas, their biological resources and air quality should be analyzed as well.

I hope that these comments are helpful in preparing the Draft Environmental Impact Report for the proposed project. Please add me to the distribution list for the EIR and all notices associated with the project.

Sincerely,

Jeff Aardahl
California Representative
46600 Old State Highway, Unit 13
Gualala, CA 95445
Email: jaardahl@defenders.org

National Parks Conservation Association®
Protecting Our National Parks for Future Generations®

March 29, 2011

Cadiz Scoping Comments
c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

Dear Mr. Barnes:

The National Parks Conservation Association (NPCA) has been the leading voice of the American people in protecting our national parks since 1919. NPCA has over 325,000 members and supporters and is the largest independent membership organization dedicated to protecting the natural, cultural, and historic treasures of our National Park System. Our mission is to protect and enhance our national parks today for our children and grandchildren tomorrow.

NPCA welcomes the opportunity to provide scoping comments on the Cadiz Valley Water Conservation, Recovery, and Storage Project and is concerned about the environmental impacts of this project on the Mojave National Preserve, air quality and water resources. The draft EIR must use sound science and address the following issues:

Impacts to Mojave National Preserve

The 1.6 million acre Mojave National Preserve was created by the 1994 Desert Protection Act and the National Park Service is mandated by the 1916 Organic Act to preserve its natural and cultural resources "Unimpaired for future generations".

The Mojave National Preserve has outstanding natural features like singing sand dunes, the largest and densest Joshua tree forest in the world and alpine fir communities high atop the New York Mountains. The Preserve also has a rich history of Native American tribes that hunted and gathered along the steep bajadas and broad alluvial fans; miners who searched for the mother lode and ranchers who raised cattle on this parched land. The Preserve is loved by hikers, campers, backpackers, equestrians, four wheel drive enthusiasts, birdwatchers and hunters.

But the Mojave National Preserve is not only a refuge for outdoor recreationists, nature lovers and history buffs, but is a local and regional economic engine. In fiscal year 2009, there were almost 530,000 visitors to the Preserve who contributed over 10 million dollars to local economies and supported over 100 jobs[1].

[1] according to the Michigan State University Money Generation Model.

The Cadiz Valley Water Conservation Recovery and Storage Project must not harm or impair the natural or cultural resources of the Mojave National Preserve or the social and economic fabric of reliantdesert communities. The draft EIR must use the best and most realistic assessment of how the capture and recovery of 50,000 acre feet of groundwater from the Fenner Valley Watershed through the Fenner Gap will affect seeps, springs and groundwater in the Mojave National Preserve, **especially in areas like Clipper Springs**. Additionally, the true impacts of fugitive dust that may be created from the desiccation of the Bristol and Cadiz Dry Lakes must be accurately assessed and viewed cumulatively in combination with other concurrent efforts within 100 miles of the project.

California Climate Change and Groundwater

Phase I of the Cadiz Valley Water Conservation, Recovery, and Storage Project NOP states that this project is sustainable becausethe amount of water that will be diverted is evaporating from the Bristol and Cadiz Dry Lake beds with a recharge rate of 32,500 acre feet/ year and an additional aquifer recharge of 17,500 acre feet for a total of 50,000 acre feet/year of annual recharge during the project's 50 year life span. Phase II assumes that there will be a sufficient water to allocate and store from the Colorado River. NPCA questions both of these assumptions due to the increasing demand for water resources, the natural variability of desert hydrologic systems and climate change. The DEIR should provide detailed information relating to the projected availability of Colorado River water for diversion and a plan for acquisition.

Climate Change

The draft EIR must contain a thorough and scientifically meaningful evaluation of how climate change will affect water resources. The California Climate Adaptation Strategy says, "Generally, research indicates that California should expect overall hotter and drier conditions with a continued reduction in winter snow (with concurrent increases in winter rains), as well as increased average temperatures, and accelerating sea-level rise. In addition to changes in average temperatures, sea level, and precipitation patterns, the intensity of extreme weather events is also changing. The impacts assessment indicates that extreme weather events, such as heat waves, wildfires, droughts, and floods are likely to be some of the earliest climate impacts experienced."[2]

Additionally, it predicts temperature increases of 2-5 deg. F by 2050[3], an average annual precipitation of 12-35% decrease by 2050[4] and a sea level rise 12-18" by 2050[5]. The adaptation strategies also make the following predictions:

• Average temperature increase is expected to be more pronounced in the summer than in the winter season.[6]

---

[2] 2009 California Climate Adaptation Strategy. California Natural Resources Agency. Sacramento, CA. p.15 Available online at www.climatechange.ca.gov.adaptation/count/click/php

[3] Ibid, p.15
[4] Ibid, p.15
[5] Ibid, p.15
[6] Ibid, p.16

• Inland areas are likely to experience more pronounced warming than coastal regions.[7]

• Heat waves are expected to increase in frequency, with individual heat waves also showing a tendency toward becoming longer, and extending over a larger area, thus more likely to encompass multiple population centers in California at the same time.

The California Climate Adaptation Strategy also states that,

"While the precipitation results vary more than the temperature projections, 11 out of 12 Precipitation models run by the Scripps Institution of Oceanography suggest a small to significant (12-35 percent) overall decrease in precipitation levels by mid-century. In addition, higher temperatures increase evaporation and make for a generally drier climate, as higher temperatures hasten snowmelt and increase evaporation and make for a generally drier climate. Moreover, the 2009 Scenarios Project concludes that more precipitation will fall as rain rather than as snow, with important implications for water management in the state. California communities have largely depended on runoff from yearly established snowpack to provide the water supplies during the warmer, drier months of late spring, summer, and early autumn. With rainfall and melt water running off earlier in the year, the state will face increasing challenges of storing the water for the dry season while protecting Californians downstream from floodwaters during the wet season."[8]

Other sources indicate that the American Southwest will be one of hardest hit areas in the country[9] because it has high values of "climate responsiveness" or where climate will change the most.[10] The Southwest's climate responsiveness comes not from just higher temperatures or less precipitation, but increased variability, especially in terms of precipitation.[11]

The U.S. Global Change Research Program[12] predicts the following about climate change in the Southwest:

- Recent warming in the southwest among the most rapid in the nation[13].
- SW temperatures have already increased 1.5 deg. F compared to a 1960-1979 baseline[14]
- Late this century the average annual temp could increase 4-10 deg F above the baseline[15]
- Large reductions in spring precipitation, as much as 30-40% less under a high emissions scenario by 2080-2099[16]

---

[7] Ibid, p. 16
[8] Ibid, p.17
[9] Kerr, Richard. "Climate Change Hot Spots Mapped Across the United States." Science Magazine: August 21, 2008

[10] Ibid
[11] Ibid
[12] U.S. Global Change Research Program. "Southwest". Washington, DC. 2009.
Available online at www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/southwest

[13] Ibid
[14] Ibid
[15] Ibid

- Increased competition for water supplies[17]

The draft EIR must address the following questions about water resources and climate change:

1) What study has assessed the total recharge rate at 50,000 acre feet/year and has it undergone peer review?

2) The Project Manager mentioned during the scoping session that the recharge figure of 50,000 acre feet/ year was within a range of numbers. Where does 50,000 acre feet year fall in that range and why has this figure been selected?

3) What scientific methodologies were used to determine recharge rates and are they the same methodologies that are endorsed by the United States Geologic Survey and other scientific organizations?

4) Do the figures listed in the NOP differ from United States Geologic Survey or other agencies' or organizations' studies, surveys or estimates and why might that be?

5) Is it realistic to assume that recharge rates for a desert aquifer will remain constant over a fifty year period in light of climate change and the natural variability of desert hydrologic systems?

6) How might the increasing variability in precipitation in the Southwest, drought and increased evaporation due to higher temperatures that are predicted with climate change affect project recharge estimates over a 50 year period?

7) What data suggests there will be sufficient water available in the Colorado River for phase II based on the natural variability of hydrologic systems, climate change and the changing demographics of the American west?

Cumulative Impacts

The cumulative impacts section of the draft EIR must have a thorough, meaningful and science based examination of how current and proposed projects in the area will affect the environment. Of particular concern are developments outlined in the Bureau of land Management and Department of Energy's Solar Programmatic Environmental Impact Statement, which seeks to carry out a mandate of developing 10,000 megawatts of solar energy on BLM lands in six western states. Under one alternative, 22 million acres of BLM lands would be opened to solar development, but concentrated in Solar Energy Zones or SEZs. The second alternative would limit solar development to 676,000 acres of BLM land on proposed SEZs.

Under the first alternative, BLM lands surrounding the Cadiz Valley Water Conservation, Recovery, and Storage Project would be open to solar development, as well as the proposed 106,000 acre Iron

---

[16] Ibid
[17] Ibid

Mountain Solar Energy Zone that would be less than 15 miles away from the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project. If the second scenario prevails, up to 80% of the 106,000 acre Iron Mountain Solar Energy Zone would be developed with utility scale solar energy. It is well documented that utility scale solar development can impair air quality during construction and operations, disrupt wildlife corridors, cause light pollution and drawdown water resources.

The following questions should be thoroughly examined by the draft EIR in terms of the cumulative impact of the Cadiz water storage project in combination with other foreseeable industrial development :

1) How will the proposed solar development on lands adjacent to the Cadiz Valley Water Conservation, Recovery, and Storage Project or the nearby Iron Mountain SEZ affect water resources in the region?
2) How will the proposed solar development on lands adjacent to the Cadiz Valley Water Conservation, Recovery, and Storage Project or the nearby Iron Mountain SEZ impact visual resources, night skies and air quality on the Mojave National Preserve, wilderness and the environmental health of the region in general?
3) How will the proposed solar development on lands adjacent to the Cadiz Valley Water Conservation, Recovery, and Storage Project or the nearby Iron Mountain SEZ impact wildlife corridors and habitat for rare and endangered species in the region?

In closing, NPCA thanks you for the opportunity to provide scoping comments on the Cadiz Valley Water Conservation, Recovery and Storage Project. As the EIR process moves forward it is essential that the true impacts of this project on the Mojave National Preserve, air quality and water resources are assessed. It is also paramount that any future project honors the will of the American people who have gone to considerable effort and expense to protect the unique ecosystems and history of the Mojave National Preserve.

Sincerely,

Seth Shteir
California Desert Field Representative
National Parks Conservation Association
sshteir@npca.org
760-332-9776

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Executive Office

March 30, 2011

Via Electronic and Federal Express
cadizproject@esassoc.com

Tom Barnes, ESA
626 Wilshire Boulevard, Ste 1100
Los Angeles, CA 90017

Dear Mr. Barnes:

Cadiz Valley Water Conservation, Recovery, and Storage Project, Notice of Preparation

The Metropolitan Water District of Southern California (Metropolitan) received the Notice of Preparation (NOP) of a Draft Environmental Impact Report (DEIR) for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). The Santa Margarita Water District (SMWD) is acting as the Lead Agency under the California Environmental Quality Act (CEQA) for this proposed Project.

Metropolitan is a public agency and regional water wholesaler, comprising 26 member cities and water agencies charged with providing a reliable supply of high quality drinking water to more than 19 million people in six counties (San Diego, Orange, Riverside, Los Angeles, San Bernardino, and Ventura) in Southern California. One of Metropolitan's primary water supplies is the Colorado River. Metropolitan owns and operates the Colorado River Aqueduct (CRA) to bring water from the Colorado River to its service area.

The NOP describes the proposed Project as including use of "the CRA delivery system owned and operated by the Metropolitan Water District of Southern California (Metropolitan)." (NOP, p. 4.) The NOP notes that Metropolitan's approval is required for the construction and operation of any modifications to the CRA, and for the use of Metropolitan facilities to deliver water for the proposed Project. (NOP, p. 6.) As a public agency that must approve aspects of the Project, Metropolitan is a responsible agency for purposes of CEQA. (Public Resources Code § 21069.) This letter provides Metropolitan's comments on the scope and content of the environmental information that is germane to Metropolitan's role as a responsible agency in the CEQA process. (Public Resources Code § 21080.4.)

On the basis of the Project description in the NOP, the environmental information pertinent to Metropolitan's role in the proposed Project includes:

- Identification and description of the environmental impacts from construction and operation of any Project facilities (e.g., turn-out structure, pipeline) that would be constructed on Metropolitan property,
- Environmental effects of construction and operation of any water treatment facilities that may be required to introduce the water supply into Metropolitan's conveyance system, and
- Environmental effects of the construction and operation of any electric power generating or transmission facilities that may be required to deliver the water supply through Metropolitan's conveyance system.

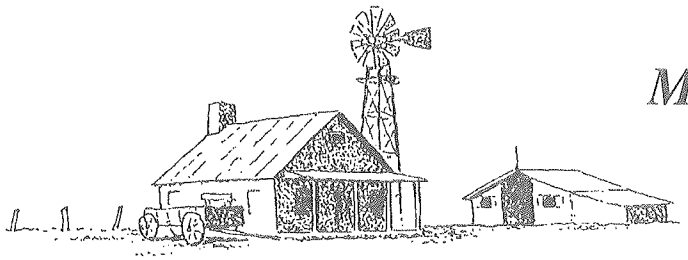
We appreciate the opportunity to provide input to your planning process and we look forward to receiving the Draft EIR for the proposed Project. Please direct all further communications related to the proposed Project to Dr. Marty Meisler at (213) 217-6364.

Very truly yours,

John Shamma

John Shamma
Manager, Environmental Planning Team

MM:rdl
(J:\Environmental-Planning&Compliance\COMPLETED JOBS\March 2011\Job No. 2011032433)



Mojave Desert Heritage and Cultural Association

30 March 2011

Tom Barnes
ESA
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017

Re: Comments regarding the Notice of Preparation of a Draft EIR (NOP) for the Cadiz Valley Water Conservation, Recovery and Storage Project

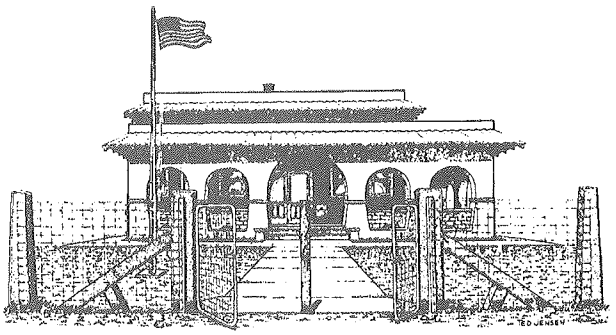
Dear Mr. Barnes:

As a follow-up to my comments made at the public scoping meeting held March 16, 2011 at the Santa Margarita Water District offices, this letter constitutes the complete comments of the Mojave Desert Heritage and Cultural Association (MDHCA). I am a member of the MDHCA Board of Directors and have been authorized to speak on behalf of our organization.

The MDHCA is a 501(c)(3) nonprofit corporation operating a 75-acre cultural center in the community of Goffs, California, located within the Fenner Watershed. Our mission is to preserve the heritage of the East Mojave Desert. We represent a membership of 700 citizens who care for the well-being and history of our desert. The grounds of the cultural center house the Goffs Schoolhouse, which is a National Register Property, the Mojave Desert Archives in the Dennis G. Casebier Library, and many significant historic structures, displays, and artifacts.

The MDHCA is not averse to the concept of recovering groundwater that naturally discharges to the atmosphere or the concept of using an aquifer to store surplus surface water supplies and extracting these stored supplies during dry years. The MDHCA is concerned that the planned draw down of 50,000 acre feet per year (AFY) from the Fenner Watershed by the Cadiz Valley project may negatively impact the quality and quantity of domestic water in its wells in Goffs as well as water for all uses permitted by the zoning regulations of San Bernardino County, such as commercial, livestock, and agricultural.

Chris Ervin
President
Telephone: 760-733-4482



Goff's Schoolhouse
37198 Lanfair Road — G-15
Essex, California 92332

The Goffs Cultural Center is solely dependent for its water upon two 900-foot water wells, drilled at great expense to the organization. The most recent well, installed in 2007, was funded by a grant from the State of California. Because our grounds are open to the public, we are required by the County of San Bernardino to regularly monitor the quality of our water supply.

The projected draw down of 50,000 AFY is characterized by Cadiz as sustainable. Yet the recoverable water model presented in the Cadiz Water Conservation Project presentation by CH2M HILL dated February 8, 2010 indicates previous estimates of recoverable water as low as 2,070 to 10,343 AFY (USGS, 2000) to a high of 15,839 to 41,539 AFY (GSSI, 1999). Two aspects of this data are of concern;

1) the planned draw down of 50,000 AFY creates an annual water deficit of ~8,500 acre feet using the highest estimate (41,539 AFY) or an annual deficit of nearly 40,000 acre feet using the lowest estimate (10,343 AFY), and,

2) the estimates from the three sources cited (GSSI, USGS, Davison and Rose) vary so widely that it calls into question the reliability of any of the estimates. It is difficult to see how the data supports characterizing the projected 50,000 AFY draw down as sustainable.

The MDHCA is resolute in the absolute need for early identification of any negative trend or the detection of any unanticipated impacts to the water our organization and the visiting public depend upon. Otherwise, it may be too late to reverse negative trends and impacts once a problem is detected. Therefore, the MDHCA strongly recommends:

1) Including within the Cadiz Valley project a water monitoring program for the Fenner Watershed to measure any impacts, negative or positive, to the quality or quantity of water used for domestic, commercial, livestock, and agricultural purposes. Monitoring stations should be located near the highest point of the watershed (Lanfair Valley) and other critical points, and operate for one year prior to any draw down of water from the Fenner Watershed. The monitoring program should continue throughout the 50-year life of the project.

2) Setting thresholds of water quality and quantity for each station of the monitoring program to determine the occurrence of negative impacts to all water use. Any measurements falling outside the set thresholds of the Cadiz Valley project monitoring program should immediately initiate mitigation actions.

3) Including predefined mitigation actions that would immediately halt the draw down of water from the Fenner Watershed to avoid any further loss of water quality or quantity for those who are dependent upon it.

4) Having a third party conduct the monitoring program, such as the U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Park Service, or Bureau of Land Management. The data from the monitoring program should be shared with both Cadiz and the affected community.

Ten years ago, during the comment period of the prior Cadiz Valley project, the MDHCA offered use of our well for the purpose of monitoring water quantity and quality. We again make that same offer to the current project.

Consideration of Residents and Wildlife within the Fenner Watershed

The Cadiz Valley project needs to recognize the vast amount of private land and the large number of residents with domestic wells within the Fenner Watershed. It's worth noting the special status of private property within the MNP. The California Desert Protection Act (CDPA) of 1994 specifically states that private property within the boundaries of the MNP are within and under the jurisdiction of the County of San Bernardino, not federally managed public lands. The planned draw down to intentionally induce more water to flow down from these high elevations seems likely to negatively impact the water quantity and quality for the residents of Fourth of July Canyon, Round Valley, Pinto Valley, Lanfair Valley, Gold Valley, Vontrigger, and Goffs. These land owners should be made aware of this project and the possible impacts on their water and the value of their land. There should be a public meeting held near the affected real estate, such as at the Goffs Schoolhouse, Hole-In-The-Wall Fire Station, or Kelso Depot. As it is, the two public meetings held were over 100 miles from the affected private property.

There is also a great diversity of wildlife dependent upon the numerous springs in the Mojave National Preserve (MNP) adjacent to Goffs. It is important that the planned draw down not upset the delicate natural balance, as it would have serious consequences to the wildlife found there.

Thank you for the opportunity to provide comments on the Cadiz Valley project NOP. Your contact at the Mojave Desert Heritage and Cultural Association will be Chris S. Ervin, MDHCA Director, at the return address on the letterhead.

Sincerely,

Chris S. Ervin
Director

LAND USE SERVICES DEPARTMENT

COUNTY OF SAN BERNARDINO

ADMINISTRATIVE OFFICE
385 North Arrowhead Avenue • San Bernardino, CA 92415-0187
(909) 387-4431 Fax (909) 387-3223
http://www.sbcounty.gov/landuseservices

CHRISTINE KELLY
Director

March 30, 2011

Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
Telephone: 213-599-4300

Re: NOTICE OF PREPARATION OF A DRAFT EIR
Cadiz Valley Water Conservation, Recovery, and Storage Project
SCH # 2011031002

Dear Mr. Barnes:

Pursuant to the Guidelines for California Environmental Policy Act, Title 14, Cal. Code Regs. ("CEQA Guidelines") § 15103, the County of San Bernardino ("County") submits the following comments on the above-referenced Notice of Preparation ("NOP") for the Cadiz Valley Water Conservation, Recovery, and Storage Project ("Project"):

1. Lead Agency Designation

The County reserves all rights with respect to the Santa Margarita Water District's (SMWD) assertion of lead agency status for the Project, including, without limitation, the right to initiate the Office of Planning and Research lead agency designation process pursuant to Public Resource Code §21165.

The County and SMWD are currently consulting regarding lead agency designation for the Project in accordance with CEQA Guidelines § 15053. In the event that County and SMWD reach agreement on the designation of SMWD as lead agency for the Project, the County will be a "Responsible Agency" for the Project within the meaning of CEQA Guidelines § 15381. In such event the County will have all of the rights and responsibilities of a Responsible Agency, including but not limited to (i) the right and duty to evaluate potential impacts of the Project; (ii) discretion whether to issue or reject discretionary approvals of the Project under the County's zoning and building laws and regulations; (iii) discretion whether to issue or reject discretionary approvals for the Project under the County's ordinances pertaining to groundwater including but not limited to the Desert Groundwater Management Ordinance (San Bernardino County Code, Title 3, Division 3, Chapter 6, Article 5, sections 33.06551 et seq.); and (iv) authority to regulate the extraction and use of groundwater resources within the County as enunciated in *Baldwin v. County of Tehama* (1994) 31 Cal.App.4th 166. Because of the limitations of the Project Description set forth in the NOP (see discussion below), the County is unable to ascertain the full scope of required permits for the Project, including the requirement for subsequent conditional use permits. Consequently, the County reserves the right to require additional zoning, building and other permits pursuant to County laws and regulations.

GREGORY C. DEVEREAUX
Chief Executive Officer

Board of Supervisors
BRAD MITZELFELT ..... First District
JANICE RUTHERFORD ..... Second District
JOSIE GONZALES ..... Fifth District
NEIL DERRY ..... Third District
GARY C. OVITT ..... Fourth District

2. Project Description

The Project Description in the NOP does not provide an adequate description of the Project. Specifically, detailed maps are needed to indicate where proposed facilities will be located and what the physical components of the facilities will be. The County is most interested in the location and physical requirements of the proposed extraction wells (well-field).

Both phases of the Project need to be clearly defined, including at a minimum, physical components, amount of water to be extracted and stored, and proposed timing and duration for each phase.

3. Desert Groundwater Management Ordinance

The Project will be subject to the Desert Groundwater Management (GM) Ordinance (San Bernardino County Code, Title 3, Division 3, Chapter 6, Article 5, sections 33.06551 et seq.) that is intended to protect groundwater resources within the un-adjudicated, unincorporated desert regions of the County, including the health of individual aquifers, and the continued ability of those aquifers to store and maintain water.

In complying with provision of the GM Ordinance, the project is subject to the County's discretionary review. The County's discretionary review of the Project will apply to: (a) the proposed well-field; (b) the sources of energy to power the well-field and pumping stations; and (c) the construction of a new pipeline and pump stations (if any). The County's evaluation will be consistent with the purposes of the GM Ordinance and consider the potential cumulative extractions from the proposed Project as well as those undertaken pursuant to the existing Cadiz CUP.

The EIR must clearly identify this groundwater management permit as a required entitlement of the Project and include the requisite analysis in the EIR for the County to assess the environmental impacts associated with issuing such a permit. The EIR must identify mitigation, as required, to reduce potentially significant impacts associated with permit issuance.

The County reserves all rights pursuant to CEQA Guidelines § 15096 to determine the adequacy of the Project EIR relative to required County permits and discretionary approvals, and to require additional CEQA review as necessary, including a subsequent or supplemental EIR as provided in CEQA Guidelines §§ 15162 and 15163.

4. Compliance with County Conditional Use Permits

The EIR must assess the Project's compliance with adopted County Conditional Use Permits and the Mitigation Monitoring Program promulgated through the 1993 Final EIR (SCH #89020203).

5. Subsidence

The pending EIR for the Project must evaluate the potential for the project to exacerbate existing subsidence issues and cumulative loss of available groundwater.

6. Growth-Inducing Impacts

Consistent with Section 15126.2, the EIR must evaluate for all phases of the Project potential growth-inducing impacts. This discussion must describe the ways in which the Project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment.

7. Project Alternatives

Consistent with Section 15126.6 (e) of the CEQA Guidelines, the "no project" analysis presented in the EIR must discuss the existing conditions at the time the notice of preparation is published. Existing conditions must include current groundwater use on the Cadiz property, which according to the *Twelfth Annual Groundwater Monitoring Report (January – December 2009) Cadiz Valley Agricultural Development, prepared by Cadiz, Inc., dated June 30, 2010* was approximately 1,882 acre feet in 2009.

A project alternative must include build-out conditions under existing County entitlements for the Cadiz property. These entitlements include: GPA/90-0017, CUP/90-0019, CUP/90-0031, CUP/90-0032 and CUP/95-0015 (as revised), Maximum entitlements permitted under GPA/90-0017, CUP/90-0019, CUP/90-0031, CUP/90-0032 are limited to the groundwater extraction assumptions evaluated under certified Final EIR SCH #89020203, and Mitigation Measure WR6 which stipulates provisions for groundwater monitoring.

The County appreciates SMWD's attention to its concerns regarding the deficiencies of the NOP. The County looks forward to working with SMWD to achieve a thorough and adequate EIR.

Please do not hesitate to contact me at (909) 387-4431 should you have any questions.

Sincerely,

Christine Kelly
Director of Land Use Services

cc: Kevin M. O'Brien
Gregory C. Devereaux
Dena Smith
Jim Squire
Wes Reeder
Joe Scalmanini
Will Halligan
Joann Lombardo

From: joe ross [rossjoe@hotmail.com]
Sent: Saturday, March 12, 2011 7:51 AM
To: Cadiz Project
Cc: joe ross
Subject: Cadiz NOP

To: Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

Hello Tom,

I briefly glanced at the SMWD Notice of Preparation of a Draft EIR (NOP) for the Cadiz Valley Water Conservation, Recovery and Storage Project.

It appears that the project and associated lands would be incompatible with lands being analyzed (under their Alternative 3) by the U.S. Marine Corps for potential expansion of the Marine Corps Air Ground Combat Center in 29 Palms. Their project Draft EIS was just recently released about 25 Feb, and comments are being solicited until 26 May:

http://www.marines.mil/unit/29palms/LAS/Pages/EIS.aspx

Public meetings for that project will be held on 12-14 April:

http://www.marines.mil/unit/29palms/LAS/Documents/EIS/29_Palms_EIS_NOA_NOPM_-_FINAL_-_2011-02-14_%20rev%2015.pdf

Within the "Environmental Consequences" section of their Draft EIS, there are many statements about the Cadiz landholdings and project made:

ON Page 4.1-11:

4.1.4 Alternative 3 Impacts

4.1.4.1 Plans and Policies
Alternative 3 would potentially be inconsistent with the CDCA Plan's multiple use objectives, including provisions for mining access and, in turn, approved plans and permits that allow for current operation of the TETRA Technologies, Inc. (TETRA) Amboy Operation and National Chloride mines in the east study area (see Figure 3.1-5 and Section 4.12, *Geological Resources*). Although the ability to continue mine operations would be considered on a case-by-case basis if Alternative 3 were implemented, it is possible that these two mines could, after such an evaluation, require closure (see Mining below). In addition, BLM has assigned a Known Sodium Leasing Area (43 Code of Federal Regulations [CFR] 2400) land classification to lands in the vicinity of these two mines, further indicating its intent to retain access to mineral resources without interference from other uses.
Alternative 3 would be inconsistent with San Bernardino County agricultural land use designation in the east study area and associated agricultural operations on 1,600 acres (648 hectares)

within the Cadiz Inc.
landholdings.
These inconsistencies with plans and policies related to mining on public lands and agriculture on private,
agriculturally designated lands are considered to be significant and unavoidable.

ON Page 4.1-12:
4.1.4.5 Agriculture
The majority of the Cadiz Inc. land holdings are undeveloped with the exception of approximately 1,600
acres (648 hectares) of existing agricultural operations which contain citrus, vineyards, and row crops.
No prime or unique soils or farmlands of state or local importance have been identified. There are seven
groundwater production wells that supply water for agricultural irrigation. Alternative 3 would be
incompatible with existing agricultural land use. Approximately 1,000 acres (405 hectares) are cultivated
in citrus and vineyards, which constitutes over 25% of San Bernardino County's fruit and nut crop
acreage. However, land use impacts associated with agricultural land use are considered to be less than
significant on a county-wide basis due to the fact that there were 1,021,585 acres (413,400 hectares) in
agricultural production in San Bernardino County (San Bernardino County 2008), of which the 1,000
acres cultivated by Cadiz Inc. represent less than 2% of the agricultural acreage in San Bernardino
County.
Note that socioeconomic effects on the agricultural sector (e.g., jobs) are addressed in Section 4.3.4. A
proposed major water recharge project on the Cadiz Inc. landholdings is addressed in Section 4.13.3,
Water Resources and Chapter 5, *Cumulative Impacts*.

ON Page 4.1-20 (in Table 4.1-3 reference impacts under Alternative 3):
Agriculture
 LSI and incompatible due to loss of 1,600 acres of cultivated agricultural lands; the 1,000
acres cultivated by Cadiz Inc. represents less than 2% of the agricultural acreage in San
Bernardino County.

On Page 4.3-17 and 4.3-18:
4.3.4 Alternative 3 Impacts
4.3.4.1 Impacts to Displaced Residents and Businesses
There are no existing residences within the boundaries of the east and south study areas that would be
displaced by the proposed land acquisition under Alternative 3. As discussed in Section 3.1, *Land Use*
and Section 3.12, *Geological Resources*, three operating businesses are located in the east study area
(Cadiz Inc. agricultural holdings and mining operations by TETRA and National Chloride Company).
Based on public records for all three companies, the analysis for Alternative 3 conservatively estimated
that a total of 150 employees (100 for Cadiz Inc. and 25 each for the two mining

companies) would be
displaced if the acquisition of the east study area were implemented. These job losses were factored into
the EIFS modeling along with the proposed increase in installation personnel.

As indicated in Section 2.6, *Disposition of Mines*, individual mine properties (e.g., TETRA and National
Chloride Company in the east study area) would be evaluated before implementation of any selected
project alternative to determine whether the properties would be acquired or if reasonable access to the
property would be afforded so that operations could continue following project implementation. In the
case of mining operations on or near dry lake beds (which are not conducive to military training
operations), providing reasonable access for business operations may be a realistic option. Although it is
not a mining operation, similar consideration would be applicable to Cadiz Inc.'s agricultural and
groundwater holdings. Should Cadiz Inc.'s plans for development of groundwater production to serve the
Los Angeles area become viable, it may be possible to provide reasonable access to the groundwater
assets, from either inside or outside the boundaries of the Alternative 3 east study area. Provided that
reasonable accommodation of Cadiz Inc.'s business plans would not interfere with achieving training
objectives under an Alternative 3 scenario, the Marine Corps would consider such accommodations
during the real estate acquisition process. According to the company's public records, the potential
realization of Cadiz Inc.'s business plans for groundwater development depend more on identifying and
implementing a means of transporting the water to the market area than on extracting the water from the
source. Potential plans for transporting the retrieved water to the market area are not sufficiently defined
to allow an evaluation of their compatibility with Alternative 3 at this time. Accordingly, an analysis of
the potential economic opportunity cost of not developing this water source would be hypothetical and
purely speculative, and is outside the scope of this EIS.
Given the considerations above, the existence of programs to assist and fairly compensate displaced
businesses, and the fact that only three such businesses occur in the acquisition study areas, Alternative 3
would have less than significant direct impacts to private property owners in the west and south study
areas.

ON Page 4.12-13:
Cadiz Inc. has agricultural operations on 1,600 acres (648 hectares) on alluvial soils in the north-central
portion of the east study area. Due to overlap of planned direct and indirect fire SDZs, the Cadiz Inc.
facilities and their personnel would present incompatible use and safety concerns for the planned military

uses of the east study area. The owners of the property would be offered fair market value for their land,
the agricultural operations would be closed, and the facilities and equipment would be removed. As
stated in Section 4.1.4.5, San Bernardino County has 1,021,585 acres (413,400 hectares) in agricultural
production. Therefore, loss of access to agricultural soil in the east study area would be a less than
significant impact to soil resources.

On Page 4.12-14:
Paleontological Resources
As described in Section 3.12.3.4, some specific locations of paleontological resources in the east study
area were documented through a survey conducted in conjunction with the Cadiz Groundwater Storage
and Dry-Year Supply Program (Metropolitan Water District [MWD] and BLM 2001). Under Alternative
3, areas known to contain significant fossil resources could be among those planned for ordnance delivery
and military vehicle travel (activities that would crush/destroy fossils). However, paleontological
resources within the east study area would be managed by the MAGTF Training Command NREA
Natural and Cultural Resources Branch, and would be addressed by a proactive management and
conservation program to minimize damage or loss. Therefore, under Alternative 3 there would be less
than significant direct impacts. There would be no indirect impacts.

On 4.13-3:
• impacts to southern California water supply by eliminating the Cadiz Project.

Within the "Cumulative Impacts" section of their Draft EIS, the following statements are made:

ON Page 5-8:
5.3.2.7 Cadiz Groundwater Storage and Dry-Year Supply Program
An EIS/Environmental Impact Report was prepared in September 2001 to evaluate the environmental
impacts associated with the Cadiz Project proposal. The Cadiz Valley Dry Year Supply Project is an
aquifer storage, recovery, and dry-year supply project designed to provide southern California with as
much as 150,000 acre-feet (AF) per year of reliable water during droughts, emergencies, or other periods
of need. The project is designed to store surplus water available during 'wet' years on the Colorado
River, or – by way of exchanges – from other sources of surplus water. Total storage capacity is greater
than 1 million AF. When needed, indigenous groundwater or previously stored water would be recovered
by wells and conveyed to the Colorado River Aqueduct for delivery to participating water agencies
throughout southern California. The Cadiz Project components include a water conveyance facility,

spreading basins, pumping plant, wellfield, power distribution facilities, and groundwater and air quality
monitoring facilities. The 390-acre (158-hectare) spreading basins would be located to the south of the
Burlington Northern and Santa Fe railroad lines, and northeast of the proposed wellfield. The project
wellfield would be constructed in the Fenner Gap in the vicinity of the spreading basins and would travel
in a generally southeasterly direction. Most of the project facilities would be constructed in the east study
area. The EIS/Environmental Impact Report concluded that after implementation of identified mitigation
measures there would be significant unavoidable adverse impacts to air quality (during construction only),
hazardous materials (related to the potential to unearth unexploded ordnance[UXO]), and paleontological
resources.

ON Page 5-50:

5.4.12 Geological Resources

5.4.12.1 Alternative 1

The majority of the projects listed above in Section 5.3 (e.g., construction projects at the Combat Center,
the wind and solar energy projects in the surrounding area, and development within the City of
Twentynine Palms) would involve ground disturbance. As such, they have the potential to disrupt soil
surfaces and cause compaction and erosion of soils in the ROI. As ground-disturbing projects, they also
have the potential to damage paleontological resources that may be present. The Environmental Impact
Report/EIS for the Cadiz Groundwater Storage and Dry-Year Supply Program found that the project
would have significant, unavoidable adverse impacts to paleontological resources that were determined to
be present within the project footprint for the water pipeline. Implementation of Alternative 1 would have
less than significant impacts to soils and paleontological resources because such resources would be
managed according to existing Natural Resources and Environmental Affairs (NREA) programs designed
to protect such resources and minimize impacts to them. In conjunction with other past, present, and
foreseeable future projects in the region, Alternative 1 would marginally increase the potential for impacts
to these resources, but such impacts are expected to be less than significant.

ON Page 5-52:

5.4.13.3 Alternative 3

The Alternative 3 acquisition study area includes approximately 35,000 acres (14,200 hectares) of Cadiz
Inc. landholdings. Cadiz Inc. is the main water user in the Cadiz Valley Area. Cadiz Inc. currently
cultivates approximately 1,500 acres (600 hectares) of their 9,000 acres (3,600 hectares) that are zoned for
agriculture. Agriculture is considered a beneficial use of water in the state of California. Alternative 3

would eliminate or curtail this agricultural operation and the Cadiz Inc. access to portions of its existing
water supply system. Therefore, Alternative 3 would have significant impacts to Cadiz Inc. groundwater
supplies.
Implementation of Alternative 3 would also interfere with or preclude the Cadiz Water Conservation and
Storage Project, a potential new water supply for southern California, because the alternative would
overlap in the east study area with the proposed footprint of the Cadiz Water Conservation and Storage
Project. The project is currently under environmental review and it is unknown if or when this project
would be implemented. While acquisition of the Cadiz Inc. land may be beneficial for the water supply
on the Combat Center, it would have a regionally significant impact because it would inhibit Cadiz from
instituting their Conservation and Storage Project.

ON Page 5-61 (in Table 5-5) in reference to their Alternative 3 a "signficiant impact" is notated:
SI
 The proposed action would inhibit Cadiz Inc. from instituting their Conservation and Storage Project. It would also reduce their agricultural operations and limit access to the existing agricultural water supply.

I hope that you will find this input to be helpful as part of your NOP scoping process.

Best wishes,
Joe Ross

p.s.
Pls feel free to add my email address to your contact list, but I wish to withhold my snailmail address from public review.

Cadiz Project
Project Manager: Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017

March 23, 2011

Dear Mr. Barnes:

I am writing to you today regarding a water project that is very disturbing for my husband and I, as we have recently purchased acreage in the East Mojave desert. I am referring to the Cadiz Project and the aquifers that will be impacted by the draining of 50,000 acre feet of water.

Mr. Barnes, we rely solely on our well water in the 4th of July Canyon. Our well is an aquifer that has been sustaining the water needs of the people in that area for at least a century now. However, we are limited to the amount of water we can pump from our aquifer on a daily basis. Ours is a community well, and we have had to set a limit of 45 minutes of pumping per day. Any pumping in excess of 45 minutes compromises the quality of the water. Our concern is, if we lose any water due to the Cadiz Project, we are in serious risk of not having enough water to live on our ranch.

Water is a precious resource and the draining of an aquifer in the middle of the desert is most certainly going to impact the area in detrimental ways. There is no positive effect from the Cadiz Project, for the flora, fauna or humans living in the East Mojave. The draining of 50,000 acre feet can't possibly be sustainable. There must be a smaller amount to start with very gradual increases only if severely needed.

Our specific concerns; first of all, we need an extension for the "Notice of Preparation of a Draft EIR (NOP)" so more comments can be thoughtfully presented. Second, there must be regular monitoring of water, quantity and quality, in place. Especially in Round Valley, 4th of July Canyon, Goffs, 7IL area, Lanfair and the Budweiser Springs area, prior to any draw down, so that a baseline may be set. Thresholds must be set that would indicate when negative impacts are occurring, and mitigation be built into the project upfront to avoid any loss of water quality or quantity for those of us who are dependent upon it. Springs, wells and wildlife must be monitored prior to the pumping, as well as during drawdown. Lastly, most all of the water used to fight the wildfire here came from wells in Round Valley and Gold Valley, when drawn down by Cadiz, what happens to us and our homes?

Mr. Barnes, a copy of this letter has also been sent to both Senator Feinstein and Congressman Lewis, so that they may bring these concerns to the table for those of us living in the East Mojave Desert Region.

Sincerely,

Russell Woodruff Marilyn E Woodruff

Russell and Marilyn Woodruff
Parcel #0567101420000
San Bernardino Co.

2234 EAGLE DR
LA VERNE CA. 91750

From: Brendan Hughes [jesusthedude@hotmail.com]
Sent: Friday, March 25, 2011 9:39 PM
To: Cadiz Project
Subject: Comment

Hello. My name is Brendan Hughes and I would like to be kept informed via email regarding this project.

Also, I would like the environmental documents to do a thorough analysis of the impacts to springs and seeps, desert tortoises, rare plant assemblages, wilderness characteristics, and burrowing owls.

Thank you.

Note: Please do not send me paper mail regarding this issue. Please use email.

Brendan Hughes
jesusthedude@hotmail.com

March 25, 2011

Mr. Tom Barnes, ESA
Cadiz Project Manager
626 Wilshire Blvd, St e 1100
Los Angeles, CA 90017

Valerie Finstad
8965 10th Ave
Hesperia, CA 92345

Dear Mr. Barnes:

Per our telephone conversation today regarding the Cadiz Project, my concerns and comments are as follows:

The East Mojave Property Owners have just become aware of the Cadiz Project and need additional time to make comments and voice our deep concerns before the NOP is finalized.

We certainly feel that human and animal habitat must be included. All of our survival in the area depends on natural springs (many of which dry up in the summer) and well water.

The amount of water suggested for draw down is a vast concern. With the little rain we get in the area, the 50,000 acre-feet cannot possibly be replenished. What took millions of years to accumulate will be gone. Owens Dry Lake keeps recurring in my thoughts. We certainly do not need a repeat of that travesty.

I would hope that a baseline at several monitoring stations would be established prior to any drawdowns occurring. Progress would be tracked and procedures put in place in case quality or quantity changes.

Fire protection must be considered. Lightning strikes burned 70,000 acres 6 years ago. Water was scare then! Since that fire, nothing has grown back. There isn't enough moisture. The pinions and cedars grew during a wetter period. Pulling water from the Cadiz watershed only adds insult to injury.

I can only relate to you what I have observed during the 40 years I have had the property in the New York Mtns. There are two mine shafts I periodically visit. In 1971 both were full to the brim. It was that way pretty consistently for about 10 years. They have since continually dropped. The first shaft is 12' lower and the lower shaft is 5' lower. There is a hand dug well just above my property. It varied with rains and snows, but always about 8 to 15 feet down during the dry periods. In the last 15 years no water was visible at all

during the dry period. The Park Service has recently filled it full of concrete to protect the ground water. The concrete truck driver told us they hit water at 40 feet.

These are my concerns and the concerns of others in the area. Please keep me advised of any meetings. If you would like to visit the area, please let me know and I will arrange a tour.

Sincerely,

Valerie Finstad

Valerie Finstad

From: Chris Brown [CBrown@pbewarehouse.com]
Sent: Monday, March 28, 2011 6:37 PM
To: Cadiz Project
Subject: Regarding East Mojave Preserve
Attachments: Newsletter 3.21.11.docx

My name is Chris Brown. I am a representing the East Mojave Landowners Association. I, nor any of the property owners in the East Mojave Preserve have been notified of your intent to exploit ground water resources in the Cadiz area. The property owners in the Preserve rely solely on water wells which feed your aquifer. I watched your video which described where the basin gets its water resources from and I can assure you allot comes from our area due to our elevation. I have attached a letter that has been e-mailed from our Chairman that should give you some understanding of our concerns. I have a good understanding of ground water tables in the East Mojave and have been a witness to many wells that have been drilled. Most property owners own the water rights to their properties. A significant pumping of your aquifer could result in a draw down of the water table in the East Mojave Preserve especially at the higher elevations. Many wells are close to the surface, some having static water at twenty feet. Others can be much deeper.

I know your project requires you make a profit! I would hope you consider the water rights of your neighbors up stream by allowing our input. I also hope your company might make the investment to monitor static water levels in the Preserve while your project gets underway. Any significant water table draw down could and should be a direct result of your project getting underway.

Thank you,
Chris Brown
19508 N. 78' Ave.
Glendale, Az. 85308
602 328-0978

Regarding property address:
52202 New York Mountain Rd.
Cima, Ca. 92323
760 928-0978

From: Eldenhughes@aol.com
Sent: Monday, March 28, 2011 9:09 PM
To: Cadiz Project
Subject: (no subject)
Attachments: CBD'sScopingcommentsCWCRSPfinal3-28-11.zip

Elden Hughes
7544 Sunny Vista Road
Joshua Tree, CA 92252
760 592-1212

By electronic and US mail

March 28, 2011

C/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
Telephone: 213-599-4300
FAX: 213-599-4301
cadizproject@esassoc.com

RE: Scoping Comments on Cadiz Valley Water Conservation, Recovery, and Storage Project

Dear Mr. Barnes,

I am Elden Hughes, Honorary Vice President of the Sierra Club and past chair of the Sierra Club's Desert Committee. These scoping comments are made in behalf of me and the Sierra Club, a California corporation.

I have read and studied the scoping comments of the Center for Biological Diversity and I defer to their greater experience in developing scoping comments. With the permission of the Center and by reference I include their comments as part of these comments. Beyond that, I will add some personal observations.

IMPORTED WATER STORAGE COMPONENT Water can now be stored for free in Lake Mead. The economic viability of water storage in the Cadiz aquifer depends on government decisions which are out of the control of the project proponents and decisions which are extremely unlikely. This should not be a part of this EIR.

NATIVE VALUES In the next valley to the east, Ward Valley, an entire project for the disposal of low level nuclear waste that was fully approved by the State of California has been abandoned because the proponents did not trouble themselves to study and learn the spiritual importance to Native Americans of the trail system and native sites. I have been told of trails in the Cadiz Valley and I have personally observed portions of trails in the vicinity as well as spiritual sites. These must be fully inventoried and protected.

WILDLIFE The second largest herd of bighorn sheep in the California Desert is in the Marble Mountains which forms the immediate northern and eastern boundary of the Cadiz Valley. This herd depends on springs and seeps which may well be put at risk by any lowering of the aquifer in the Cadiz Valley.

I have observed eagle's nests east of Fenner. The project area is certainly part of their foraging area.

PLANT LIFE Two new species of plants have just been found in the area adjacent to the project site. The project site has not been adequately surveyed and requires at minimum of a fall and a spring survey each following rains.

AIR QUALITY If the project is able to achieve its goal of intercepting the water presently evaporating from Bristol and Cadiz dry lakes, it may well create an "Owens Lake" dust source that could be devastating to air quality in San Bernardino County and the Mojave National Preserve. Presently the Los Angeles Department of Water and Power is spending one-half billion dollars seeking to control the dust they created.

NEPA Federal lands will be affected by this project although NEPA is not being considered. If a reservoir near Danby and/or Freda becomes necessary then even more certainly NEPA should be part of process.

I hope that my comments and the comments of the Center for Biological Diversity are helpful in guiding the preparation of an EIR that will adequately protect the beautiful resource that is the Cadiz Valley. Please add me to the distribution list for the EIR and all notices associated with the project.

Sincerely,

Elden Hughes

Attachment:

Arizona • California • Nevada • New Mexico • Alaska • Oregon •Washington • Illinois • Minnesota • Vermont • Washington, DC
Ileene Anderson, Biologist/Desert Program Director
8033 Sunset Blvd., #447 • Los Angeles, CA 90046-2401
tel: (323) 654.5943 *fax:* (323) 650.4620 *email*: ianderson@biologicaldiversity.org
www.BiologicalDiversity.org
protecting and restoring natural ecosystems and imperiled species through science, education, policy, and environmental law
via electronic and US mail

March 28, 2011
Santa Margarita Water District
c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste. 1100
Los Angeles, CA 90017
Telephone: 213-599-4300
FAX: 213-599-4301
cadizproject@esassoc.com
RE: Scoping Comments on the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project

Dear Santa Margarita Water District,

The Center for Biological Diversity ("the Center") submits the following comments on the Notice of Preparation ("NOP") for an Environmental Impact Report ("EIR") for the proposed the Santa Margarita Water District, Cadiz Valley Water Conservation, Recovery, and Storage Project on behalf of our board, staff, and members of the public with an interest in protecting the native species and habitats in and around the Cadiz Valley.. The Center is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 255,000 members and activists throughout California and the United States, with a number of them living within California and visit and enjoy the Mojave desert in the vicinity of the proposed project.
The remote desert of Cadiz Valley is surrounded by federally designated wilderness near the Mojave National Preserve. The general area is habitat for rare and endangered species, including the federally and state threatened desert tortoise (*Gopherus agassizii*), the very rare white margined beardstongue (*Penstemon albomarginatus*), the California leaf-nosed bat (*Microtus californicus*), desert bighorn sheep (*Ovis canadensis nelsonii*) and other rare species (CNDDB 2011). The proposed project also could affect rare desert riparian areas, springs and seeps – the lifeblood of the desert - outside of the physical boundaries of the project area. The proposed project area is also rich in cultural and historical significance.
The Center offers these comments regarding the scope of issues that need to be addressed in the Draft Environmental Impact Report (EIR). Most importantly, the EIR should clearly identify the purpose and need for groundwater pumping of the aquifer. The purported hydrology that the NOP describes as "The groundwater naturally flows to the Bristol and Cadiz Dry Lakes (Dry Lakes) and is lost to evaporation" need to be scientifically corroborated and the implication

that any natural evaporation is somehow a "problem" to be "solved" needs to be fully examined. In addition, the Draft EIR should adequately demonstrate if and how each project element will fulfill the project's purpose and need, and adequately describe a range of alternatives that could avoid the significant impacts of the project, including a no action alternative. The EIR must also fully identify and analyze how the proposed project and alternatives would impact biological resources and provide minimization and mitigation measures for any impacts that cannot be feasibly avoided. Following are specific issues the Center believes must be addressed in the EIR under the California Environmental Quality Act, Public Resources Code §§ 2100 et seq. ("CEQA"). Up-to-date natural and cultural resource surveys and inventories of the area need to be completed and included in the DEIR. Complete documentation of the hydrology of the area must also be included.

The EIR Must Consider a Range of Alternatives

In general, the EIR should include "a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives," as required by Section 15126.6 (a) of the CEQA Guidelines. The alternatives should include those that would avoid or substantially lessen any of the significant environmentally negative effects of the project and ongoing management [CEQA Guidelines, section 15126.6(1)]. For each alternative, the EIR should provide a discussion on how each alternative would avoid or minimize significant impacts on biological resources. The EIR should provide a very clear and detailed description of the purpose, goals, and objectives for the project, as this will be critical in determining the most appropriate alternative and to allow for comprehensive analysis of the avoidance and minimization opportunities and if impacts can not be avoided, mitigation for specific issues.

The EIR Must Consider Direct, Indirect and Cumulative Impacts to Biological Resources

The EIR must be prepared to address the direct, indirect and cumulative impacts of the proposed project to threatened, endangered, and sensitive species as well as unique plant communities not only within the boundaries of the proposed project, but also outside of the project area, including the seeps and springs in the adjacent areas upon which desert wildlife species depend.

Not only must the EIR fully disclose and analyze impacts to any listed, candidate, sensitive, or locally rare species, but it also must discuss alternatives that will avoid those impacts. Even if alternatives that completely avoid such impacts may be later found infeasible, the EIR must explore alternatives that minimize impacts to species and any remaining impacts to the species must be mitigated though enforceable mitigation measures. The EIR must also fully disclose and analyze impacts to sensitive vegetation types.

The EIR must include a *quantitative, data-based* analysis of the direct impacts of the proposed Park management from the loss of habitat, as well as the indirect impacts resulting

from pollution, noise, increase in fire, disturbance, invasion of non-native species, growth inducing effects, green house gas analysis and other effects on biological resources.
The analyses must not be comprised only of general, qualitative descriptions of potential impacts, but contain quantitative analyses of effects based on population data obtained from field surveys and local conditions. In addition, the EIR must include a detailed analysis of the cumulative impacts of this project together with other completed, current, and reasonably foreseeable projects in the area.

Wildlife and Plant Species

During the course of the surveys, if other rare or regionally unique species are identified during the data gathering phase for the DEIR, these species also need to be included and analyzed for impacts. The EIR must consider the impacts on each of these species and as well as the cumulative impacts.

Listed Species

The state and federally listed threatened desert tortoise (*Gopherus agassizi*), which is also the state reptile, also occurs within the vicinity of the proposed project, and the area provides an important linkage for this species between northern and southern populations.
Where "take" of a species listed under the federal or California Endangered Species Act is anticipated, the EIR must document *and quantify* past and reasonably foreseeable future take authorizations for that species issued by the U.S. Fish and Wildlife Service ("FWS") and California Department of Fish and Game ("DFG") in order to evaluate the project's direct and cumulative impact on the species. The EIR also must consider the project's impacts on the *recovery* of listed endangered and threatened species that may occur on the site. Any potential impairment of species recovery associated with the project must be considered a potentially significant impact.

Sensitive Species

The EIR should also thoroughly evaluate the impacts of the proposed permitted activities on sensitive and locally rare species (not merely federally and state-listed threatened and endangered species). The preservation of regional and local genetic diversity is very important to the long-term persistence of species. Therefore, we request that all species found at the edge of their ranges or that occur as disjunct locations be evaluated for impacts by the proposed permitted activities.
Raptor species such as golden eagles (*Aquila chrysaetos*), a "fully protected" species under California law and protected under the Migratory Bird Treaty Act, the Bald and Golden Eagle Act and the Lacey Act, likely use the proposed project area as foraging habitat and may nest in adjacent habitat. FWS recently issued a final rule on acquiring permits to "take" golden eagles[1] that maybe required for this project. Guidance is also provided for evaluating impacts to golden eagles which should be used in the EIR. The burrowing owl (*Athene cunicularia*), a state

1 http://www.fws.gov/migratorybirds/baldeagle.htm

during surveys (ex. annual and herbaceous perennial plants). The proposed project areas can receive monsoonal rains which trigger a suite of late summer/early fall blooming annual plants, some of which are quite rare. Late season surveys should be implemented and the results should be included in the EIR.

Additionally the surveys need to be done to assess cryptobiotic soil crusts – where they exist and how to protect them. Cryptobiotic soils are an essential component of healthy desert soils, providing a protective layer that absorbs the scant precipitation events, provides "safe sites" for seed germination and prevents soil erosion. Because this and essential desert soil component is fragile and not easily restored, a full discussion of the impacts needs to be included, including alternation of the hydrology and the effects on the soil crusts.

Impact Analysis

The EIS must quantitatively evaluate all direct, indirect, and cumulative impacts to sensitive habitats/species, including impacts associated with the drawdown of ground water and its effects on adjacent spring, seeps and phreatophytic vegetation.

The EIR Must Consider Direct and Cumulative Impacts to Water Resources, Soils, and Air Quality

The pumping proposed under the project may impact water resources and water quality. These issues must be fully considered. The project components and water pumping may also affect soils by disrupting soil structure and drying.

The Mojave Desert Air Quality Management District (MDAQMD) is currently exceeding the federal standards for the criteria pollutants PM_{10} and ozone. Off-road vehicle use, military activities and other issues contribute to existing air quality problems. The EIR must fully disclose and analyze the direct, indirect and cumulative impacts of groundwater pumping on soils and the already compromised air quality in the region, and discuss effective alternatives and mitigation measures to avoid, reduce, and mitigate these impacts.

The EIR Must Adequately Describe the Environmental Baseline

Because the proposed project intends to pump groundwater from a desert basin, obviously baseline conditions in water quantity and quality need to be identified. As suggested above, hydrological studies must unequivocally prove that groundwater naturally flows to the Bristol and Cadiz Dry Lakes (Dry Lakes) and is lost to evaporation. Secondly, the proposed project must show the actual amount of recharge that is lost to evaporation. Our sense is that 50,000 afy is well above the annual recharge to the aquifer that is lost to evaporation. If additional water pumping above and beyond the evaporation rate is proposed, it will result in over-drafting of the groundwater basin and will cause significant environmental impacts. Groundwater monitoring must be put in place prior to the draft EIR so that a baseline groundwater scenario can be used to evaluate potential impacts from the proposed project.

Helena Bongartz
PO Box 695
Twentynine Palms, CA 92277

T 760 3613035

helenabongartz@mac.com

March 28, 2011

c/o Tom Barnes, ESA
626 Wilshire Boulevard, Ste.1100
Los Angeles, CA 90017

Dear Mr. Barnes:

Before commenting on the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project, I would like to request an extension of the comment period beyond the March 30, 2011 deadline. Adequate notice was not given, particularly to those in the Eastern Mojave and the public meetings held too recently and for many at too great a distance to allow a considered and informed response.

My comments on the project are as follows:

1. This project threatens the groundwater resources essential to sustaining habitat and wildlife in the Mojave National Preserve and surrounding areas It poses a serious threat to the desert and Preserve by potentially depleting water supplies upon which humans, animals and plants rely for their survival. USGS studies estimate the groundwater recharge rate for the underlying aquifer to be 5 to 25 times less than the study used for the earlier project shows. Other studies also show a substantially lower recharge rate. This discrepancy needs to be addressed, and the actual rate of recharge determined. This should be throughly analyzed prior to any pumping in excess of the amount of water currently pumped by Cadiz for their agricultural use, approximately 5,000 as-ft/yr. Pumping in excess of this amount threatens the integrity of the Eastern Mojave desert as well as the economic activities of those companies who mine Bristol Lake.

2. While monitoring is essential if the project is implemented, a system must be implemented that can detect between the effects of the pumping and the effects of natural fluctuations. In fact the latter ought to be studied first. What threshold level would constitute a signal of adverse impacts on the groundwater and what remedial measures would be taken to stop the adverse consequences.

3. How is this project a "conservation" project? While it proposes to prevent loss of water to evaporation, it also would lower the groundwater table thus depriving current users of its benefit. It is also possible that the highly saline waters under Bristol Lake would be drawn into the aquifer. What measures would be implemented to monitor and prevent this?

4. If groundwater is pumped beyond the recharge rate, it is understood that the negative effects of this on the desert ecosystem would persist significantly beyond the date that pumping was suspended.

5. What is the connection between springs in the area and pumping operations? The springs are the water source for many mammals including the Desert Bighorn Sheep, a large population of which lives in the Marble Mountains. Also, a lowering of the groundwater would cause the death of the vegetation upon which animals rely. How could the vegetation ever be replaced?m

6. What about DUST? If the groundwater level drops, the ground will dry up causing a dust problem similar to that in Owens Valley.

7. Can this project be considered economically viable if only 5,000 ac-ft/yr of water is pumped?

8. Is the construction of an underground water pipeline to the Colorado River Aqueduct under an existing railroad right of way consistent with the granting of the right of way across BLM property (for railway use)?

9. If monitoring wells were to be installed, does Cadiz have the permits for these wells, and if not is the project viable without them?

10. What organization would oversee extraction/injection of water from/into the aquifer?

11. What is the federal need for water in the Eastern Mojave, the National Preserve and the wilderness areas? How can adverse effects be mitigated?

12. What private uses of water might be affected by this project? How can adverse effects be mitigated?

13. What are the Cadiz water rights to the aquifer? How does it exercising it's rights conflict with the rights of others (11 and 12 above).

14. I am also concerned about the visual and sound impacts of this project, not only during the construction phase but also during operation. What would these be and what measures could be taken to mitigate adverse impacts. The dark skies and silence are part of the beauty of this desert and a vanishing resource.

Thank you for your consideration of the above comments. I would appreciate your informing me of developments in the EIS process as they occur.

Because of the severe time constraint imposed by the March 30, 2011 deadline, I am also sending an email with an attachment of this letter to cadizproject@esassoc.com.

Sincerely yours,

Helena Bongartz

From: Helena Bongartz [helenabongartz@mac.com]
Sent: Tuesday, March 29, 2011 9:25 AM
To: Cadiz Project
Subject: Cadiz Project additional comments for EIR
Attachments: Cadiz Project

Dear Mr. Barnes:

I would like to add one further question to my comments which I sent to you yesterday by both mail and email (email attached includes letter). What might the potential impact be on the water of the Dale Basin located to the south of the project area. How would this potential to drain water from this basin be assessed and what controls or monitoring system could be put in place to monitor this?

Thank you for including this email with my previous comments.

Sincerely,
Helena Bongartz

30 March 2011

Tom Barnes
ESA
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017

Re: Comments regarding the Notice of Preparation of a Draft EIR (NOP) for the Cadiz Valley Water Conservation, Recovery and Storage Project

Dear Mr. Barnes:

The comments that follow may seem familiar in some respects. The reason is that I have sent comments on the Cadiz Valley project under a separate cover on behalf of the Mojave Desert Heritage and Cultural Association (MDHCA) in my role as Board Director and contact. In this letter I am providing you with comments in my role as an owner of private property and a private water well within the Fenner Watershed.

My wife Leslie and I own nine parcels totaling 156 acres in the East Mojave desert across Round Valley, Pinto Mountain, and Lanfair Valley. We are stakeholders in the Cadiz Valley project, as our property near Pinto Mountain has a well and other improvements within the boundaries of the Fenner Watershed. The property sits at about 5,000 feet elevation.

My wife and I are not averse to the concept of recovering groundwater that naturally discharges to the atmosphere or the concept of using an aquifer to store surplus surface water supplies and extracting these stored supplies during dry years. But we are concerned that the planned draw down of 50,000 acre feet per year (AFY) from the Fenner Watershed by the Cadiz Valley project may negatively impact the quality or quantity of the water in our well at our Pinto Mountain property. We're also concerned about how the Cadiz Valley project may impact our neighbors' water wells.

The projected draw down of 50,000 AFY is characterized by Cadiz as sustainable. Yet the recoverable water model presented in the Cadiz Water Conservation Project presentation by CH2M HILL dated February 8, 2010 indicates previous estimates of recoverable water as low as 2,070 to 10,343 AFY (USGS, 2000) to a high of 15,839 to 41,539 AFY (GSSI, 1999). Two aspects of this data are of concern;

1) the planned draw down of 50,000 AFY creates an annual water deficit of ~8,500 acre feet using the highest estimate (41,539 AFY) or an annual deficit of nearly 40,000 acre feet using the lowest estimate (10,343 AFY), and,

2) the estimates from the three sources cited (GSSI, USGS, Davison and Rose) vary so widely that it calls into question the reliability of any of the estimates.

It is difficult to see how the data supports characterizing the projected 50,000 AFY draw down as sustainable.

My wife and I are resolute in the absolute need for early identification of any negative trend or the detection of any unanticipated impacts to the water at our Pinto Mountain property and the wells of our many neighbors. Otherwise, it may be too late to reverse negative trends and impacts once a problem is detected. Therefore, we strongly recommend:

1) Including within the Cadiz Valley project a water monitoring program for the Fenner Watershed to measure any impacts, negative or positive, to the quality or quantity of water used for domestic, commercial, livestock, and agricultural purposes. Monitoring stations should be located near the highest point of the watershed (Round Valley, Fourth of July Canyon, Pinto Valley, or Lanfair Valley) and other critical points, and operate for one year prior to any draw down of water from the Fenner Watershed. The monitoring program should continue throughout the 50-year life of the project.

2) Setting thresholds of water quality and quantity for each station of the monitoring program to determine the occurrence of negative impacts to all water use. Any measurements falling outside the set thresholds of the Cadiz Valley project monitoring program should immediately initiate mitigation actions.

3) Including predefined mitigation actions that would immediately halt the draw down of water from the Fenner Watershed to avoid any further loss of water quality or quantity for those who are dependent upon it.

4) Having a third party conduct the monitoring program, such as the U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Park Service, or Bureau of Land Management. The data from the monitoring program should be shared with both Cadiz and the affected community.

The Ervins' Pinto Mountain property is solely dependent for its water upon a 100-foot well. Water stands at a depth of 66 feet. When you take into consideration the necessary depth of our solar pump, we have only about 30 feet of usable water column. Our well will quickly become dry and our property useless should the Cadiz Valley project lower the water column in our well. I am sure my neighbors are in similar situations with the potential impact the project poses to their wells.

The Ervins offer use of our well at Pinto Mountain to the Cadiz Valley project for the purpose of monitoring water quantity and quality in the area.

Insufficient Notification to Stakeholders within the Fenner Watershed

The Cadiz Valley project needs to recognize the vast amount of private land and the large number of residents with domestic wells within the Fenner Watershed. It's worth noting the special status of private property within the MNP. The California Desert Protection Act (CDPA) of 1994 specifically states that private property within the

boundaries of the MNP are within and under the jurisdiction of the County of San Bernardino, not federally managed public lands.

I became aware of the Cadiz Valley project NOP not because I received a stakeholder package in the mail, but in my capacity as a director with the MDHCA, which did receive notification. A quick survey of my neighbors confirmed that residents and property owners in the affected area were not notified by Cadiz, Inc. of the potential impact of the Cadiz Valley project to their water and their property.

A check of the San Bernardino County property records would have alerted Cadiz to the presence of many private property holdings and water well improvements within the Fenner Watershed. A study of the San Bernardino County Assessor's records I conducted in 2006 revealed 3,264 private properties in the East Mojave, owned by 2,023 unique individuals. That is quite a large constituency for the Cadiz Valley project to exclude from receiving the NOP stakeholder package. I believe you'll agree this is a significant omission by your project team and amounts to insufficient notification of stakeholders with regard to the Cadiz Valley project.

The planned draw down to intentionally induce more water to flow down from the high elevations where many property owners are dependent upon wells seems likely to negatively impact the water quantity and/or quality for the residents of Fourth of July Canyon, Round Valley, Pinto Valley, Lanfair Valley, Gold Valley, Vontrigger, and Goffs. It is incumbent upon the Cadiz Valley project to make property owners aware of this project and the possible impacts on our water and the value of our land. There should be a public meeting held near our affected real estate, such as at the Goffs Schoolhouse, Hole-In-The-Wall Fire Station, or Kelso Depot. As it is, the two public meetings held were over 100 miles from our properties.

Thank you for the opportunity to provide comments on the Cadiz Valley project NOP. Please feel free to contact me using the contact information below.

Sincerely,

Chris S. Ervin
25 Via Gatillo
Rancho Santa Margarita CA 92688-3185

949-888-9745 (home)
714-428-1288 (work)
714-824-9978 (mobile)

Attachment 6
Scoping Meeting Comments

Santa Margarita Water District
Cadiz Valley Water Conservation, Recovery, and Storage Project
NOP Scoping Meeting
March 16, 2011

Public Comments

- Are there any existing roadblocks?
- What is the quality of water at the surplus zone? Does it change as it is pumped out?
- Fenner Watershed: Mojave Desert Cultural Center
- Concerns about preservation of the history of the Mojave Desert
    - Depends on existing wells
- Offer existing wells for monitoring
    - Quantity concern
- Set thresholds
    - Trigger remediation
- Is there groundwater modeling and/or simulations?
    - What is the extent of it?

Joshua Tree Community Center – March 24, 2011 - 6:00pm
Cadiz Scoping Meeting Notes

Whiteboard Notes

- What would have to change to make the storage component worthwhile?
- Does the estimated recharge amount take into account variability within the desert?
- Climate change could change recharge amount over time?
- Please refer to climate change report by Governor of California reference in EIR (Climate Adaptation Strategies 2009)
- Impacts to the Mojave National Preserve need to be understood
- Parks are an important aspect of an economy. What are the impacts to parks?
- Indicate type of water will be collected.
- Will the project impact mining operations?
- Will there be dust since the project would be removing water from the dry lake?
- Surface water sinks down into mineral deposits. Will the project affect surface water?
- If project assumes that water is evaporating now, but it is actually being used by mine.
- Recharge was estimated at 6,000 acre-feet/year under Cadiz property in a study 10 years ago.
- Does your current study of 32,000 afy differ from USGS estimates?
- Address impacts to private property and wells in area
- 10 years ago monitoring wells were proposed. Are they proposed now?
- Visual impacts: what type of facility will be constructed? Will there be lights?
- Feasibility of Phase II assumes water is available from Colorado River
- Will project affect plants and animals on dry lake if evaporation is eliminated?
- What are the impacts on towns and homes along 66?
- Does hydraulic control impact the flow of water towards it?
- How far does the project proposed to draw down the water table?
- Wells along route 66 are a concern
- Ability of desert land and plants to store carbon – deep root system
- Bighorn sheep dependent on springs. What will happen to the springs?
- Where is Mitchell Cavern?
- How much excavation will occur?
- Will there be disturbance in mountains?
- Where is the power coming from for the wells?
- Will there be noise? When construction is finished will there be noise?
- How will new service roads affect the area?
- Is railroad right of way leased from BLM still BLM land?
- If there is a problem with groundwater levels, who takes Cadiz to court? How are project limits enforced?
- Would there be any impacts to Mojave Wilderness Areas or other lands outside Preserve?
- Air quality and water quality can affect those distant areas.
- Are GIS files available of pipeline route?
- Who approves this project? Why Santa margarita Water District?.

Attachment 7
Matrix of Comments

NOP Comments
Summary Table

Agency/ Organization	Mitigation measures	Insufficient notification to stakeholders / Extension of comment period	Water draw down/ withdrawal / recharge rate too high	Use of Railroad Right of Way	Private land water rights	Need for monitoring system of water resources	Need to consider cumulative impacts	Climate change / GHG	Fire protection	Human/ animal and plant habitat needs attn	Wilderness and Public Lands	US Marine Corps	Dust concerns	Solar Dev. concerns	Cadiz	Impacts to Mojave National Preserve	Impact to Dale Basin (south)	Air Quality	Toxic Materials
Federal Agencies																			
US Department of Interior – National Park Service	X		X	X		X										X			
United States Marine Corps												X – expansion in Alternative 3 would include portion of land owned by Cadiz							
State Agencies																			
Governor's office of Planning and Research (State Clearinghouse)																			
Department of Toxic Substances Control																			X
Native American Heritage Commission																			
California Department of Fish and Game	X		X – specifically the elimination of the dry lake ecosystem; creation of giant fissures in the dry lake beds		X		X			X – specifically Borrego milkvetch, desert tortoise, bighorn sheep		X – Bristol Lake water	X			X – also, need to amend the Desert Conservation Plan			
Organizations																			

NOP Comments
Summary Table

Agency/ Organization	Mitigation measures	Insufficient notification to stakeholders / Extension of comment period	Water draw down/ withdrawal / recharge rate too high	Use of Railroad Right of Way	Private land water rights	Need for monitoring system of water resources	Need to consider cumulative impacts	Climate change / GHG	Fire protection	Human/ animal and plant habitat needs attn	Wilderness and Public Lands	US Marine Corps	Dust concerns	Solar Dev. concerns	Cadiz	Impacts to Mojave National Preserve	Impact to Dale Basin (south)	Air Quality	Toxic Materials
Mojave Desert Air Quality Management District													X						
East Mojave Land Owners Association	X	X	X		X	X			X	X									
San Bernardino County Public Works Department																			
Center for Biological Diversity			X – establish baseline					X		X						X		X	
Mojave Preserve Land Owners Association		X	X		X	X			X	X						X			
Defenders of Wildlife			X							X	X								
National Parks Conservation Association			X				X	X					X	X		X			
Metropolitan Water District			X																
Mojave Desert Heritage and Cultural Association	X	X – Public meeting should be held near affected real estate	X		X	X – include monitoring for Fenner Watershed; third party conduct monitoring program										X			
San Bernardino County Land Use Services Department	X		X – project will be subject to Desert Groundwater Management Ordinance				X – Growth inducing impacts												
Individuals																			

NOP Comments
Summary Table

Agency/ Organization	Mitigation measures	Insufficient notification to stakeholders / Extension of comment period	Water draw down/ withdrawal / recharge rate too high	Use of Railroad Right of Way	Private land water rights	Need for monitoring system of water resources	Need to consider cumulative impacts	Climate change / GHG	Fire protection	Human/ animal and plant habitat needs attn	Wilderness and Public Lands	US Marine Corps	Dust concerns	Solar Dev. concerns	Cadiz	Impacts to Mojave National Preserve	Impact to Dale Basin (south)	Air Quality	Toxic Materials
Joe Ross												X - Inconsistencies between project and Marine Base expantion							
Russel and Marilyn Woodruff	X		X			X			X	X									
Brenden Hughes										X									
Valerie Finstad			X			X			X	X									
Chris Brown		X	X		X	X				X	X					X			
Elden Hughes			X							X – Cultural resources; bighorn sheep	X – Concern that NEPA should be involved, esp. concerning Danby or Freda		X						
Helena Bongartz	X	X	X	X	X	X – specifically between pumping effects and natural fluctuations	X – water, visual, sound			X			X		X – Does Cadiz have water rights? Does Cadiz have permits for monitoring wells?	X				

NOP Comments
Summary Table

Agency/ Organization	Mitigation measures	Insufficient notification to stakeholders / Extension of comment period	Water draw down/ withdrawal / recharge rate too high	Use of Railroad Right of Way	Private land water rights	Need for monitoring system of water resources	Need to consider cumulative impacts	Climate change / GHG	Fire protection	Human/ animal and plant habitat needs attn	Wilderness and Public Lands	US Marine Corps	Dust concerns	Solar Dev. concerns	Cadiz	Impacts to Mojave National Preserve	Impact to Dale Basin (south)	Air Quality	Toxic Materials
Helena Bongartz (2)						X											X		

Attachment 8

Matrix of Alternative Suggestions

NOP Comments
Summary of Proposed Alternatives

Organization/ Agency	Commenter	Proposed Alternative Summary
Federal Agencies		
US Department of Interior – National Park Service	Christine Lehnertz	1. DEIR needs to demonstrate that the proposed path of the water conveyance infrastructure is entirely on privately owned land and not on a right-of way-that includes portions of public land (NOP describes the AZ and CA Railroad right-of-way as privately owned, but also identifies US Fish and Wildlife Service and US Army Corps of Engineers as involved, which would activate NEPA). An alternative would be to prove acquisition of needed rights from the legal holder of the right-of-way. 2. Project needs to adhere to a hydrologic sustainable yield concept. 3. Lead/responsible agencies should be guided by peer-reviewed science in the development and preparation of DEIR; estimate of annual groundwater discharge should be supported by several independent lines of analysis. 4. the DEIR should recognize that most of the groundwater recharge studies conducted in the study area indicate that natural recharge to the Fenner and Bristol Valleys ranges from 2,000 to 11,000 acre-feet per year and that the Project's recharge estimate is 3 to 120 times too high. 5. Provide a thorough discussion of all previous hydrologic investigations relating to quantifying the amount of water entering, moving through and discharging from the groundwater systems beneath the study area or in other proximal valleys. 6. The current estimate of annual groundwater recharge for the Project should be supported by several independent lines of analysis. 7. If a watershed model is used in the DEIR to calculate the recoverable water in the basin, the model should account for bedrock permeability when estimating the amount of recharge to the groundwater system. The model should also incorporate routines to route water through the surface drainage network and estimate downstream flow and subsequent populations. 8. If a chloride mass balance approach is used in the DEIR to support groundwater recharge estimates it should be properly applied to the study area. 9. If isotopic data are used in the DEIR to support groundwater recharge estimates, proper data should be collected so that reliable groundwater age determinations can be made or estimated. 10. The Lead Agency should consider seeking an impartial technical review of the EIR's water resource impact analysis from the US Geological Survey. 11. The DEIR should clearly demonstrate the Project's need for the groundwater stored in the Bristol and Fenner Valleys. 12. Project should strive to maintain its total groundwater pumping within the sustainable yield of the watersheds. 13. Project needs to demonstrate that soil evaporation is actively occurring from the dry lakes and that their pumping will lower groundwater beneath the dry lake discharge areas to a level that prevents the natural evaporation from occurring during the life of the Project. 14. The meaning of "hydraulic control" must be addressed in presenting Phase I of the proposed Project; does this relate

		only to the establishment of a sufficient drawdown area or does it also apply to the lowering of groundwater levels enough to cause natural evaporation to cease from the dry lake areas? 15. The DEIR should address in detail whether California statues allow for the banking of unused groundwater rights for use in future years, and if so, how the banking of carry-over water will be managed Phase I and 2 of the Project. 16. DEIR should provide a thorough evaluation and discussion of reasonable alternatives to the Proposed Action. 17. The DEIR should utilize groundwater flow modeling to simulate the potential impacts to water resources. 18. The EIR should thoroughly discuss the potential impacts associated with the various programmatic elements of the Imported Water Storage Component of the project (Colorado River surplus, preliminary modeling of potential impacts to the groundwater flow system resulting from artificial recharge and subsequent pumping, expected evaporative losses, etc.). 19. If potential adverse impacts to water resources are determined to be significant enough to warrant implementation of mitigation measures, the EIR should first consider the relevancy of the mitigation measure that were developed and proposed under the former Cadiz Project. 20. The DEIR should provide a thorough discussion on closure plans associated with the Project.
United States Marine Corps	B.R. Norquist	Proposed Marine Corps expansion designates land to the west of the existing base, although Alternative 3 does include a large portion of the Cadiz Inc. held lands. Even though this land does not appear to include the Cadiz Valley Water Project's proposed well fields or spreading basins, it does include large amounts of adjacent lands. Marine Corps encourages the DEIR to fully consider the land use and other impacts of the Twentynine Palms Land Acquisition and Airspace Establishment project on the Cadiz Valley Water project.
State Agencies		
Office of Planning and Research (State Clearinghouse)	Scott Morgan	N/A
Department of Toxic Substances Control	.Leonard Robinson	1. DEIR needs to evaluate whether conditions at site will pose a threat to human health or the environment. 2. Hazardous soils need to be appropriately removed from the site, as well as hazardous structures and chemicals in compliance with CA codes.
Native American Heritage Commission	Dave Singleton	N/A

California Department of Fish and Game	Michael Flores	1. An analysis and graphics showing depth to groundwater of the existing water table and the water table if the project is implemented. 2. An analysis of the flow of water to the dry lakes during the rainy and dry seasons and the amount of water necessary to maintain the ecosystem. 3. Basic biological survey needs to be conducted, preferably within a year of the distribution of the CEQA document. 4. A CECA permit must be obtained. 5. Incorporate all information regarding impacts to lakes, streams and associated habitat within the DEIR, which should include an analysis of impacts to habitat caused by a change in the flow of water across the site.

Organizations		
Mojave Desert Air Quality Management District	Alan De Salvio	Recommends that the project comply with the requirements of MDAQMD Rule 403 – Fugitive Dust. If the proposed project includes a pump which is not grid powered, or if there is a back-up generator, District permits may be required.
East Mojave Land Owners Association	Richard MacPherson	1. Regular monitoring of water quantity and quality be put in place in several places (ie Round Valley, 4th of July Canyon, Goffs, 7IL area, Lanfair, Budweiser Springs area, etc) prior to any drawdown to set a baseline. 2. Thresholds set would indicate whether or not negative impacts are occurring. 3. Mitigation should be built into the project upfront to avoid any loss of water quantity or quality for those who are dependent upon it. Springs, wells, and wildlife must be monitored prior to as well as during drawdown.
San Bernardino County Public Works Department	Annesley Ignatius	N/A
Center for Biological Diversity	Ileene Anderson	1. DEIR needs to clearly identify the purpose and need for groundwater pumping of the aquifer. 2. Alternatives should include those that would avoid or substantially lessen any significant environmental negative effects o the project. 3. EIR must consider direct, indirect and cumulative impacts to Biological Resources. All species found at the edge of their ranges need to be evaluated for impacts. 4. Surveys need to be done for cryptobiotic soil crusts, and late season surveys should be implemented and the results included in the DEIR. 5. The DEIR needs to include the Water Storage Component as a fully developed part of the whole project – this component cannot be segmented from the environmental review of the project as a whole. 6. The DEIR must adequately describe the environmental baseline.

NOP Comments
Summary of Proposed Alternatives

Mojave Preserve Land Owners Association	Richard MacPherson	1. All monitoring to verify draw down levels needs to be completed by a neutral organization. 2. Following places must be monitored prior to draw down: Granite Mountains on north and south sides; springs or wells in Van Winkle, Horse Hills, lower Providence Mountains; Springs and wells on both sides of Providence Mountains, Mid Hills, Gold Valley, Round Valley, Pinto Valley, Fourth of July Canyon, Caruthers Canyon, New York Range, Lanfair Valley; Hackberry Mountain springs; wells in Goffs and Essex; springs in Clipper Mountains and Old Woman Mountains; Joshua Tree National Park and Mojave National Preserve. 3. Contingency plan must be set up to deal with water loss for residents with wells.
Defenders of Wildlife	Jeff Aardahl	1. Purpose and need for the project needs to be clearly defined. 2. The need to augment the water supply for the four water purveyors needs to be justified and alternative means to provide additional desired water need to be justified and analyzed. Alternatives should include conservation of existing supplies through reduced consumption and recycling, and alternative sources. 3. Independent study and assessment of the groundwater hydrology of Cadiz and Fenner Valley's needs to be completed, including long-term effects of climate change.4. The project must analyze the projected availability of "excess" Colorado River Water for storage and subsequent pumping. 5. Direct and indirect effects on sensitive biological species need to be analyzed. 6. Project effects on surrounding public land and wilderness needs to be addressed.
National Parks Conservation Association	Seth Shteir	1. DEIR should provide detailed information relating to the projected availability of Colorado River water for diversion and a plan for acquisition. 2. DEIR must contain a thorough and scientifically meaningful evaluation of how climate change will affect water resources. 3. DEIR must assess how the capture and recovery of 50,000 acre feet of groundwater from the Fenner Watershed will affect seeps, springs and groundwater in the Mojave National Preserve. 4. Included in the DEIR must be a cumulative discussion of solar projects in the area and how they will affect the environment, specifically: How will the proposed solar development on lands adjacent to the project or nearby Iron Mountain SEZ affect water resources in the region, visual resources, night skies and air quality on the Mojave Preserve, wilderness and the environmental health of the region, wildlife corridors and habitat for rare species in the region?
Metropolitan Water District	John Shamma	N/A
Mojave Desert Heritage and Cultural Association	Chris Ervin	1. Include a water monitoring program for the Fenner Watershed to measure any impacts, negative or positive, to the quality or quantity of water used for domestic, commercial, livestock, and agricultural purposes. Monitoring stations should be located near the highest point of the watershed (Round Valley, Fourth of July Canyon, Pinto Valley, Lanfair Valley).

		Monitoring should continue through the 50 year life cycle of project. 2. Setting thresholds of water quality and quantity at each water monitoring station to determine negative impacts. 3. Include predefined mitigation actions that would immediately halt water draw down. 4. Third party needs to conduct monitoring program (US Geological Survey, US Army Corps of Engineers, US Fish and Wildlife Service, NPS, BLM).
San Bernardino County Land Use Services Department	Christine Kelly	1. Both phases of the project need to be clearly defined, including physical components, amount of water to be extracted and stored, and proposed timing and duration for each phase. Specifically, detailed maps are needed to indicate where proposed facilities will be located and what the physical components of the facilities will be. 2. The project will be subject to the Desert Groundwater Management Ordinance that intends to protect groundwater in the unincorporated desert regions of the County. The DEIR must clearly identify this groundwater management permit as a required entitlement of the Project. 3. Project must address cumulative loss of available water and evaluate all phases of the project for potential growth-inducing impacts.
Individuals		
Public commenter	Joe Ross	N/A
Public commenter	Russel and Marilyn Woodruff	1. Thresholds must be set that would indicate when negative impacts are occurring, and mitigation be built into the project upfront to avoid any loss of water quality or quantity. 2. Springs, well, and wildlife must be monitored prior to the pumping, as well as during the drawdown.
Public commenter	Brenden Hughes	N/A
Public commenter	Valerie Finstad	1. Baseline at several monitoring stations be established prior to any drawdown occurring.
Public commenter	Chris Brown	Monitor static water levels in the Mojave Preserve while the project gets underway.
Public commenter	Elden Hughes	1. Imported water storage component should not be part of the DEIR. Cultural resources need to be inventoried and protected. 2. Project site requires a minimum of two surveys per year to detect flora and fauna. 3. NEPA needs to be part of the process.
Public commenter	Helena Bongartz	1. Discrepancy between various studies assessing recharge rates needs to be addressed in DEIR. 2. Monitoring system must be addressed that can detect the difference between the effects of pumping and the effects of natural fluctuations.

Public commenter	Helena Bongartz (2)	N/A
Public commenter	Chris Ervin	1. Include a water monitoring program for the Fenner Watershed to measure any impacts, negative or positive, to the quality or quantity of water used for domestic, commercial, livestock, and agricultural purposes. Monitoring stations should be located near the highest point of the watershed (Round Valley, Fourth of July Canyon, Pinto Valley, Lanfair Valley). Monitoring should continue through the 50 year life cycle of project. 2. Setting thresholds of water quality and quantity at each water monitoring station to determine negative impacts. 3. Include predefined mitigation actions that would immediately halt water drawdown. 4. Third party needs to conduct monitoring program (US Geological Survey, US Army Corps of Engineers, US Fish and Wildlife Service, NPS, BLM).

Groundwater Management, Monitoring, and Mitigation Plan

For

The Cadiz Groundwater Conservation, Recovery and Storage Project

November 29, 2011

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY 1
CHAPTER 1 INTRODUCTION AND BACKGROUND 5
1.1 The Cadiz Valley Water Conservation, Recovery, and Storage Project 5
1.2 Overview of the Management Plan 8
1.3 The Project Area 11
1.4 The Parties 14
1.4.1 Cadiz, Inc 14
1.4.2 Santa Margarita Water District 15
1.4.3 County of San Bernardino 15
1.4.4 Fenner Valley Mutual Water Company 16
1.4.5 Other Anticipated Project Participants 16
1.5 Project Description 17
1.5.1 Phase I 17
1.5.2 Phase II 18
1.6 Project Objectives 18
1.7 Existing Groundwater Management 19
1.8 Purpose and Scope of Management Plan 20
CHAPTER 2 DESCRIPTION AND CHARACTERISTICS OF GROUNDWATER BASINS AND PRESENT USES 21
2.1 Geologic Setting 21
2.2 Surface Water Resources 22
2.3 Natural Recharge 23
2.4 Hydrogeology 24
2.5 Groundwater Storage 25
2.6 Groundwater Quality 28
TABLE 2-2: GROUNDWATER CHEMISTRY AT CADIZ ALLUVIAL AQUIFER 28

TABLE OF CONTENTS
(continued)

Page

2.7 Present Groundwater Production and Uses 32

CHAPTER 3 PROJECT OPERATION, GROUNDWATER CONSERVATION, AND CONSISTENCY WITH APPLICABLE LEGAL AUTHORITY 32

CHAPTER 4 ASSESSMENTS OF POTENTIAL ADVERSE IMPACTS TO CRITICAL RESOURCES IN OR ADJACENT TO THE PROJECT AREA 35

4.1 Potential Project Impacts to Basin Aquifers 36

4.1.1 Water Resources Modeling 36

4.1.1.1 INFIL3.0 37

4.1.1.2 MODFLOW-2000/MT3D - Groundwater Flow And Transport Model 37

4.1.1.3 Density-Dependent Groundwater Flow And Transport Model, Including Subsidence 38

4.1.2 Application of Water Resources Models 39

TABLE 4-1: GEOSCIENCE GROUNDWATER MODEL ASSUMPTIONS 42

4.1.2.2 Project Impact Findings from Groundwater Flow Model 42

4.1.2.3 Groundwater Elevations 43

TABLE 4-2: GROUNDWATER DRAWDOWN IMPACTS 43

4.1.2.4 Depth to Groundwater 51

TABLE 4-3: GROUNDWATER MODEL DEPTH IMPACTS 52

4.1.2.5 Saline/Freshwater Interface 52

TABLE 4-4: SALINE/FRESHWATER BOUNDARY MIGRATION 53

4.1.2.6 Groundwater in Storage 53

TABLE 4-5: REDUCTION IN ALLUVIAL GROUNDWATER IN STORAGE 55

4.1.2.7 Potential Land Subsidence 55

TABLE 4-6: MAXIMUM POTENTIAL LAND SUBSIDENCE 56

4.2 Potential Impacts to Springs Within the Fenner Watershed 57

TABLE OF CONTENTS
(continued)

Page

4.3 Potential Impacts to Brine Resources Brine Resources at Bristol and Cadiz Dry Lakes 59

4.4 Potential Impacts to Air Quality 59

4.5 Potential Impacts to Project Area Vegetation 61

4.6 Potential Impacts to the Colorado River and its Tributary Sources of Water 63

CHAPTER 5 MONITORING NETWORK 64

5.2 Springs (Feature 1) 66

5.3 Observation Wells (Features 2) 69

5.4 Proposed Observation Well Clusters (Feature 3) 70

5.5 Project Production Wells (Feature 4) 70

5.5.1 Existing Cadiz Agricultural Wells 70

5.5.2 New Production Wells 71

5.6 Land Surface Monitoring (Feature 5) 73

5.7 Extensometers (Feature 6) 73

5.8 Flowmeter Surveys (Feature 7) 73

5.9 Proposed Observation Well Clusters At Bristol Dry Lake (Feature 8) 74

5.10 Proposed Observation Well Clusters At Cadiz Dry Lake (Feature 9) 76

5.11 Gamma-Ray/Dual Induction Downhole Geophysical Logs (Feature 10) 76

5.12 Weather Stations (Feature 11) 76

5.13 Air Quality Monitoring (Feature 12) 77

5.13.1 Monitoring at Bristol and Cadiz Dry Lakes 77

CHAPTER 6 MONITORING AND MITIGATION OF PROJECT IMPACTS TO CRITICAL RESOURCES (ACTION CRITERIA, DECISION-MAKING PROCESS AND CORRECTIVE MEASURES) 78

6.2 Third-Party Wells 81

TABLE OF CONTENTS
(continued)

Page

6.2.1 Action Criteria 81
6.2.2 Decision-Making Process 82
6.2.3 Corrective Measures 82
6.3 Land Subsidence 83
6.3.1 Action Criteria 83
6.3.2 Decision-Making Process 83
6.3.3 Corrective Measures 84
6.4 Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes 85
6.4.1 Action Criteria 85
6.4.2 Decision-Making Process 85
6.4.3 Corrective Measures 86
6.5 Brine Resources Underlying Bristol and Cadiz Dry Lakes 87
6.5.1 Action Criteria 87
6.5.2 Decision-Making Process 87
6.5.3 Corrective Measures 88
6.6 Adjacent Basins, Including The Colorado River and its Tributary Sources of Water 89
6.6.1 No Action Criteria; Verification Monitoring 89
6.7 Springs 90
6.7.1 No Action Criteria; Verification Monitoring 90
6.8 Air Quality 90
6.8.1 Verification Monitoring 91
6.8.2 Action Criteria 91
6.8.3 Decision-Making Process 91
6.8.4 Corrective Measures 92

TABLE OF CONTENTS
(continued)

Page

CHAPTER 7 CLOSURE PLAN AND POST-OPERATIONAL REPORTING 92
CHAPTER 8 TECHNICAL REVIEW PANEL 93
8.1 Members 94
8.2 Responsibilities 94
8.3 TRP Convening, Determinations, and Reporting 95
CHAPTER 9 MONITORING AND REPORTING 95
9.1 Project Data Monitoring 95
9.2 Project Reports 97
9.2.1 Annual Reports 97
9.2.2 Five-Year Reports 97
9.2.3 Report Preparation and Approval Process 99

FIGURES

Figure 1.1 6

Figure 1.2 8

Figure 1.3 13

Figure 1.4 14

Figure 2.1 24

Figure 2.2 27

Figure 2.3 31

Figure 4.1 40

Figure 4.2 41

Figure 4.3 43

Figure 4.4 46

Figure 4.5 47

Figure 4.6 48

Figure 4.7 49

Figure 4.8 50

Figure 5.1 65

Figure 5.2 66

Figure 5.3 68

Figure 5.4 72

Figure 5.5 75

Figure 6.1 79

TABLES

Table 2.1 25

Table 2.2 28

Table 2.3 30

Table 3.1 34

Table 4.1 42

Table 4.2 43

Table 4.3 52

Table 4.4 53

Table 4.5 55

Table 4.6 57

Table 5.1 100

Table 5.2 103

Table 6.1 109

Groundwater Management, Monitoring, and Mitigation Plan For the Cadiz Groundwater Conservation, Recovery and Storage Project

EXECUTIVE SUMMARY

The fundamental purpose of the Cadiz Valley Groundwater Conservation, Recovery and Storage Project (Project) is to conserve and recover substantial quantities of groundwater that in absence of the Project would otherwise evaporate. This Groundwater Management, Monitoring and Mitigation Plan (Management Plan) sets forth the plan of action to optimally manage groundwater resources, monitor and mitigate physical effects of the Project, and ensures that Project operations will be conducted without significant adverse impacts to critical resources. It is prepared to comply with the County of San Bernardino's Desert Groundwater Ordinance either as a permitted or exempted Project. The Project is a 50-year groundwater recovery, conservation and conjunctive use storage project located within the collective Fenner, Orange Blossom Wash, Bristol and Cadiz Watersheds in the Eastern Mojave Desert. It will provide reliable water supply to the Santa Margarita Water District (SMWD) and other participating water agencies. The first phase of the Project will provide for the extraction of groundwater in amounts not to exceed an annual average of 50,000 acre-feet per year (afy) from a wellfield in the area within and south/southwest of the Fenner Gap. The second phase of the Project will use available aquifer capacity to operate a one million acre-feet groundwater storage bank to facilitate the storage and recovery of imported water over the Project's 50-year term. The full term of the Project's operation, including the first and second phases, shall be limited to 50-years.

In order to assess impacts that might occur post-project operations, modeling of impact assessments associated with groundwater extraction cover at least 100 years: 50 years of Project operations and 50 years after completion of Project operations. During the first phase, the average extraction of 50,000 afy will capture annual native recharge plus groundwater in storage that is migrating toward the Bristol and Cadiz Dry Lakes. Additional extractions above annual native recharge are planned for the purpose of strategically lowering groundwater levels in the vicinity of the Project wellfield in a managed manner to realize two essential Project benefits that are not available under existing conditions. First, the lowering of groundwater levels will cause existing groundwater gradients to reverse so that the Project will retrieve substantial quantities of potable groundwater located to the south and east of the wellfield that would otherwise flow into the saline groundwater underlying the dry lakes and ultimately be lost to evaporation. Lowered groundwater levels at the end of pumping will further slow the loss of groundwater to evaporation at the dry lakes until these lowered

groundwater levels recover as a result of natural recharge and restore the hydraulic gradient such that losses to evaporation return to pre-project levels. The cumulative reduction in evaporative losses of groundwater from the dry-lakes over 100 years could be as much as 2,210,000 acre-feet for the higher recharge rate. Second, the managed lowering of groundwater levels will also establish dewatered space within the aquifer to facilitate the storage and recovery of imported water during the second phase of the Project.

The Management Plan is designed to avoid significant adverse impacts to the critical resources within the region, including the following:

- Groundwater aquifers tapped by the Project, including chronic decline in groundwater levels, potential impacts to groundwater quality, land subsidence, and existing groundwater uses;
- Local springs within the Fenner Watershed;
- Brine resources of Bristol and Cadiz Dry Lakes
- Air quality in the Mojave Desert region; and
- Adjacent areas, including the Colorado River and its tributary sources of water.

By definition, the Project intends to implement a managed drawdown in water levels to achieve specific conservation objectives. This Management Plan is designed to prevent adverse Project impacts traditionally associated with groundwater pumping by collecting data and determining if observed changes in groundwater levels, groundwater quality, and land subsidence are consistent with projected changes from groundwater modeling as described in this Management Plan and references cited herein. If there are deviations from the groundwater modeling projections, those deviations will prompt further investigation and assessment under this Management Plan, and if necessary, implementation of corrective measures so as to avoid potential adverse impacts to critical resources. As discussed in this Management Plan, significant technical research has been undertaken to determine the likely impacts of the Project, if any, to these critical resources. The Project approval is limited to a defined period of operations (50 years). The existing research demonstrates that it is unlikely the Project will cause any significant adverse impacts to the identified critical resources, including area springs, vegetation, regional air quality, and the Colorado River and its tributary sources of water. Existing research and groundwater modeling also demonstrates that

the drawdown of groundwater caused by the Project will not cause any long-term material impacts to the aquifer system or surface uses within the Project area.

The Management Plan nonetheless incorporates a comprehensive network of monitoring features and data collection facilities combined with procedures for comprehensive scientific review of all actions and decisions to avoid potential significant adverse impacts by the Project to the critical resources. The monitoring features and data collection facilities include:

- Local springs;
- Observation wells at various locations, several of which will be clustered wells with depth-discrete screened intervals;
- Project production wells;
- Land survey benchmarks;
- Downhole flowmeter surveys;
- Gamma-ray and dual induction electric logs;
- Nephelometers for dust monitoring; and
- Weather stations.

The Management Plan establishes a process for scientific review of the observations and data obtained from monitoring features and facilities, and sets forth action criteria, and if appropriate, corrective measures to be taken if an action criterion is exceeded. The Management Plan has taken a conservative approach in its action criteria and potential corrective measures for the following potential Project impacts so that even where technical memoranda indicate that no impacts are expected to occur, some action still may be contemplated:

- Local springs;
- Third-party wells;
- Land subsidence;
- Induced flow of lower-quality water from Bristol and Cadiz Dry Lakes;

- Brine resources underlying Bristol and Cadiz Dry Lakes;
- Air quality; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.

This Management Plan requires FVMWC to operate the Project while using Cadiz land and resources in compliance with the plan's provisions. These provisions incorporate those required by the California Environmental Quality Act (CEQA) as mitigation for potential project impacts and also include additional project design features to monitor and verify project operations and predicted effects and confirm protection of critical resources. These additional project design features are not required under CEQA but, for the avoidance of doubt, they have been included to provide a comprehensive monitoring program for the groundwater basin and all critical resources within the watershed. In particular, some of the additional project design measures have been included in the plan for select resource areas even though the technical information (as reflected in the EIR analysis) indicates that the Project would have no adverse effect on these resources. These resource areas include springs, air quality/dust, and groundwater resources within adjacent basins. Although the Project would not result in adverse effects on these specific resources, verification monitoring will be conducted on these resource areas under this Plan.

A Technical Review Panel (TRP) is created to review data, technical analyses compiled by the Fenner Valley Mutual Water Company (FVMWC) as well as FVMWC's assessment of technical data and responsive actions, proposed refinements to the Management Plan, and corrective measures regarding compliance with the provisions of the Management Plan. The TRP will be constituted by technical appointees of the County of San Bernardino, the FVMWC and/or its joint powers agency affiliate, and a third technical appointee chosen and appointed by the technical appointees of the County and the FVMWC. Determinations and recommendations from the TRP are to be provided to SMWD for final decision as the Project's Lead Agency with responsibility for mitigation of Project impacts pursuant to the Project's Environmental Impact Report and Public Resources Code section 21081.6.

The Management Plan requires that all technical data be made available to the public in the form of annual reports approved and maintained by SMWD, and also calls for periodic water resources model refinements and incremental five-year projections of the physical impacts of Project operations to be set forth in periodic reports, together with any recommendations for Project improvements.

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 The Cadiz Valley Water Conservation, Recovery, and Storage Project

This Groundwater Management, Monitoring and Mitigation Plan (Management Plan) is an integral part of the Cadiz Groundwater Conservation, Recovery and Storage Project (Project). The Project is a water conservation supply and conjunctive use storage project that would make optimal use of the groundwater resources within the collective Fenner, Orange Blossom Wash, Bristol and Cadiz Watersheds in the Eastern Mojave Desert, without displacing other beneficial uses (See Figure 1-1). The Project will develop a new water supply from the surplus waters of the Watersheds and enable the use of groundwater storage for banking with participating water agencies as described herein.

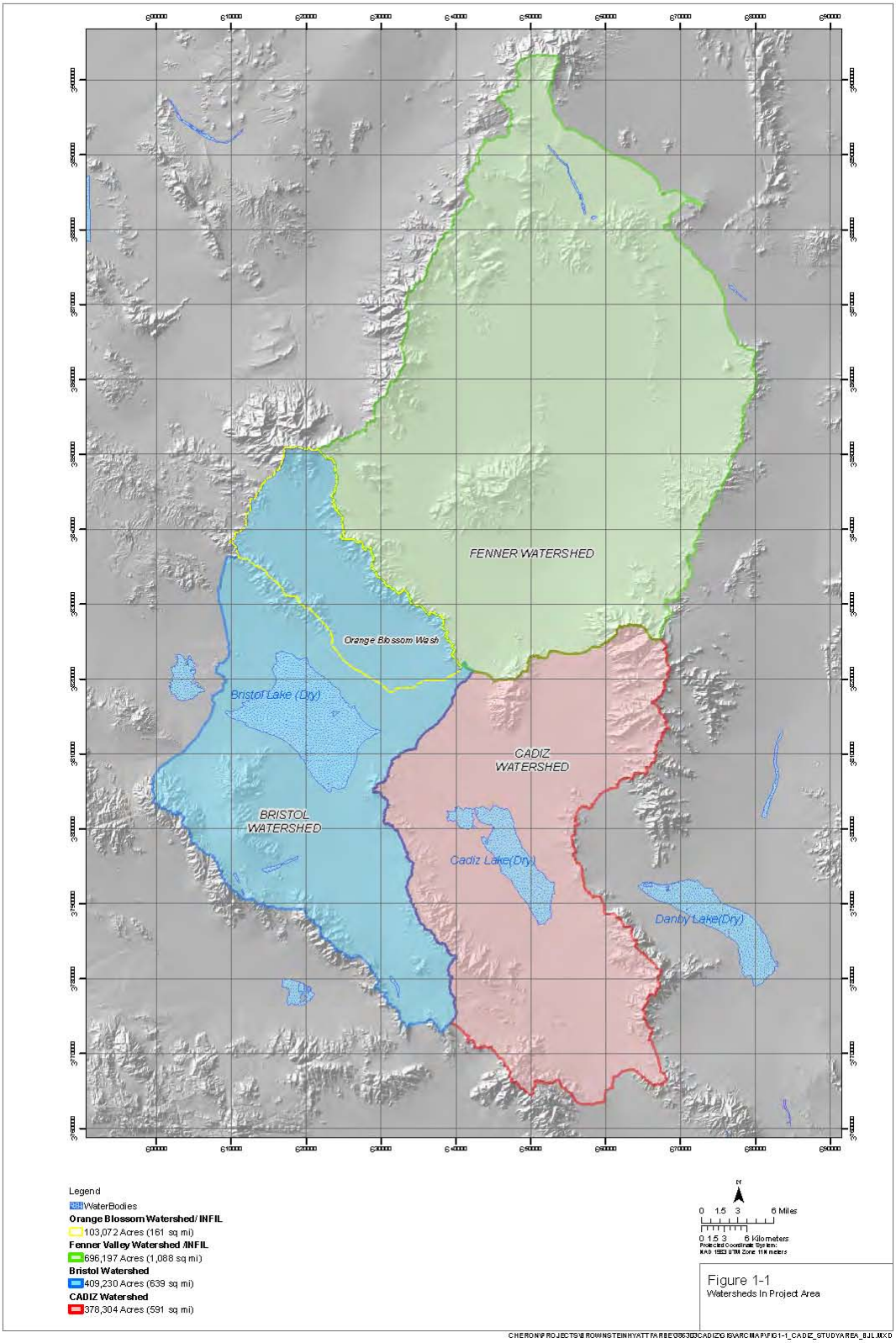


Figure 1-1
Watersheds In Project Area

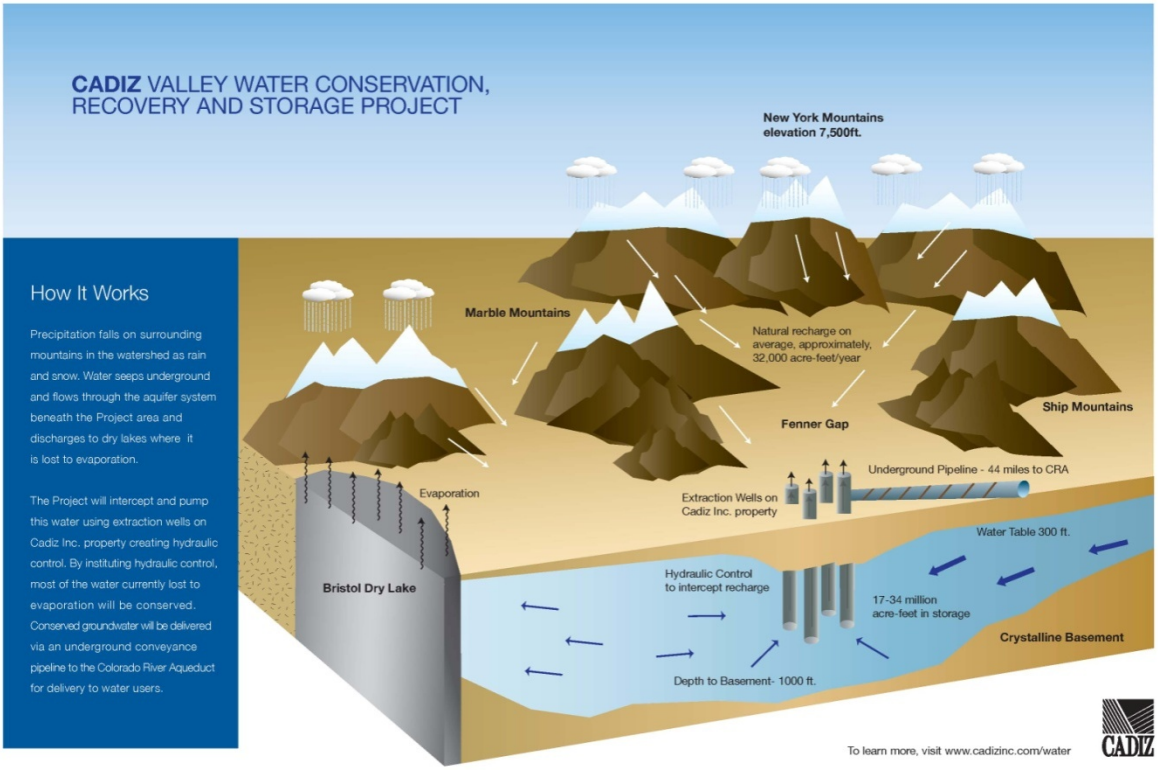
C:\HERON\PROJECTS\BROWNSTEINHYATTFARBER\3563\03CADIZGIS\ARCMAP\FIG1-1_CADIZ_STUDYAREA_BJL.MXD

The first phase of the Project, which is referred to herein as the "Conservation Component," would extract and convey an average of approximately 50,000 acre-feet per year (afy) from a wellfield in the area within and south/southwest of Fenner Gap via pipeline to the Colorado River Aqueduct (CRA). The 50,000 afy of extraction will make use of the long-term average annual natural recharge from the Fenner and Orange Blossom Wash Watersheds. Groundwater extraction will strategically lower groundwater levels within the immediate vicinity of the Project wellfield to intercept natural recharge and retrieve groundwater already held in storage beneath and downgradient of the wellfield before it can evaporate from the dry lakes as discussed below.

The second phase of the Project, the Storage Project, would involve managing the groundwater basin conjunctively, by importing water during times of surplus, storing it in the basin, and recovering the stored water to meet drought, emergency, or other demands. The dewatered storage created by extracting more than the annual natural recharge in Phase I will create supplemental storage space within the aquifer system, which can support a conjunctive use project to store surplus imported surface water when available to be recovered when needed. Imported water for storage would be conveyed to the Fenner Gap area by pipeline from the CRA, and potentially an interconnection of the California Aqueduct to the Project through a converted natural gas pipeline. The water would be recharged into the groundwater basin via spreading basins constructed within or just north of the Fenner Gap.

Under the Storage Component of the Project, up to 1 million acre-feet of dewatered capacity would be managed and made available for groundwater banking.

A conceptual model of the Project is shown in Figure 1-2.



Proposed monitoring in this Management Plan only addresses Phase I of the Cadiz Groundwater Conservation, Recovery and Storage Project. The potential storage and recovery of up to a million acre-feet of imported water was previously analyzed in 2000-2002 by the United States Bureau of Land Management in connection with its grant of a right-of-way for a project then proposed by the Metropolitan Water District of Southern California. This Management Plan will be updated and revised prior to implementation of Phase II in order to integrate additional monitoring and mitigation requirements that may result from additional CEQA analysis and review associated with the proposed conjunctive use operations taking into account variables such as the identify of the project participants, the source of supply, volumes and timing.

1.2 Overview of the Management Plan

This Management Plan governs water use, storage and extraction for the Project, and ensures that Project operations and future irrigation under the Cadiz Valley agricultural development will be conducted without significant adverse impacts to critical resources. Agricultural irrigation will also remain subject to the Cadiz Valley Agricultural Development Ground Water Monitoring Plan required by the County of San Bernardino until the agricultural operations are phased out, when this Project produces 50,000 afy. Regardless, the total quantity of groundwater extracted will not exceed 50,000 afy annual average over the 50-year operational term. This Management

Plan is designed to prevent adverse Project impacts by collecting data and determining if observed changes in groundwater levels, groundwater quality, and land subsidence are consistent with projected changes from groundwater modeling as described in this Management Plan and references cited herein. If there are deviations from the groundwater modeling projections, those deviations will prompt further investigation and assessment under this Management Plan, and if necessary, implementation of corrective measures, so as to avoid potential adverse impacts to critical resources. Critical resources identified in this Management Plan are as follows:

- The basin aquifers tapped by the Project, including chronic decline of groundwater levels, potential impacts to groundwater quality, land subsidence, and existing groundwater uses;
- Springs within the Fenner Watershed, including springs of the Mojave National Preserve and BLM-managed lands;
- Brine resources of Bristol and Cadiz Dry Lakes
- Air quality in the Mojave Desert region;
- Project area vegetation; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.[1]

This Management Plan establishes a comprehensive network of monitoring and data collection facilities combined with procedures for comprehensive scientific review of all actions and decisions. The groundwater modeling analysis completed for impacts assessments provide the baseline for future observations and actions. For example, if changes in groundwater levels, groundwater quality, and land subsidence exceed that projected by the model, then these observations will trigger a reassessment of those impacts, including recalibration of the groundwater models and updated projections of potential impacts. For several critical resources, including local springs, air quality, and

[1] As explained in Chapter 2 of this Management Plan, technical analysis to date concludes that there is no hydrogeologic connection between groundwater that would be extracted by the Project, and groundwater supplies to the northeast within watersheds that are tributary to the Colorado River. Nonetheless, to confirm that no such hydraulic connection exists, this Management Plan proposes the monitoring of groundwater levels in the adjacent Piute Watershed, which is tributary to the Colorado River. This confirmation will demonstrate that the Project will not pose adverse impacts to the Colorado River, and will enable Colorado River water users to qualify for Intentionally Created Surplus (discussed below) in relation to their Project participation,

the groundwater resources of neighboring basins, the Management Plan provides for monitoring of such critical resources even though technical research and available scientific data demonstrate that the Project will not impact these critical resources. The monitoring is done as a cautionary measure for the avoidance of any doubt as to the potential to cause environmental harm and to comport with the recommendations of the Groundwater Stewardship Committee, a multi-disciplinary panel of earth science and water professionals assembled to provide advice and comment on the Project. (See Appendix A - Groundwater Stewardship Committee, Current Summary of Findings and Recommendations Cadiz Groundwater Conservation, Recovery and Storage Project.)

This Management Plan also mandates specific action criteria (trigger levels) for impacts to critical resources, and specified responses if an action criterion is reached. It establishes a defined process for scientific review of groundwater management, climate information, a decision-making process to protect critical resources, and allows for refinements to this Management Plan. Management Plan reports will be of public record.

This Management Plan has been prepared by Cadiz and FVMWC to comply with the County of San Bernardino's Guidelines for Preparation of a Groundwater Monitoring Plan and Desert Groundwater Ordinance, which provides that a groundwater extraction project may be exempted from the Ordinance if the project will be managed consistent with a County-approved management, monitoring and mitigation plan. FVMWC will operate the Project in compliance with the provisions of this Management Plan and by definition it will avoid chronic overdraft. The Project's fundamental objective is conserving groundwater already in storage that would otherwise evaporate in the absence of the Project. The Project is intended to pump groundwater in excess of the recharge rate so as to enable the retrieval of more than 2 million af of groundwater and the beneficial use of 2.5 million af of groundwater over a defined 50-year period. A TRP will be established to review data, technical analyses, and FVMWC's assessment, proposed refinements to this Management Plan, and corrective measures regarding compliance with the provisions of this Management Plan. The TRP will be comprised of technical appointees of the County of San Bernardino, the FVMWC and/or its joint powers agency affiliate, and an at large representative selected by the representative from the County and FVMWC. The composition, duties and responsibilities of the TRP, and its decision-making process are described in Chapter 8.

The term "feature" refers to any fixed object, either natural or man-made, from which data will be collected. Man-made features include wells from which water level measurements and water quality samples could be retrieved, weather stations, bench

marks, etc. A detailed list of monitoring features is given in Chapter 5 of this plan. As new data become available during Project operations, these monitoring features, monitored parameters, and monitoring frequency may be refined to protect critical resources in and adjacent to the Project area. Refinements to monitoring features will be made in accordance with the decision-making process described in Chapters 6 and 8.

The Project will be comprised of three time periods: a pre-operational period, an operational period of 50 years, and a post-operational monitoring period that will span a minimum of 10 years, subject to review and a potential extension by the TRP and SMWD. The pre-operational phase will commence upon start of construction. The pre-operational phase will last a minimum of 12 months. Cadiz will use its best efforts to complete and deliver all needed permits for monitoring facilities, as soon as practicable within the pre-operational phase. Cadiz will construct all facilities that are agreed to in this Management Plan and for which permits have been received. Construction of these facilities will be completed within one year of receipt of permits.

The Project may be extended pursuant to the exercise of discretion of the Project participants for an additional forty-year period. In the event the project participants elect to extend the Project for an additional term, new agreements and a new management plan will be required for such an extension. In addition, new environmental review would be required prior to the Project being extended. Moreover, an extension of the Project would not entitle any participant to a specific quantity of water. No quantity of recoverable groundwater for an extension is estimated at this time. A new management plan would be required for an extension.

1.3 The Project Area

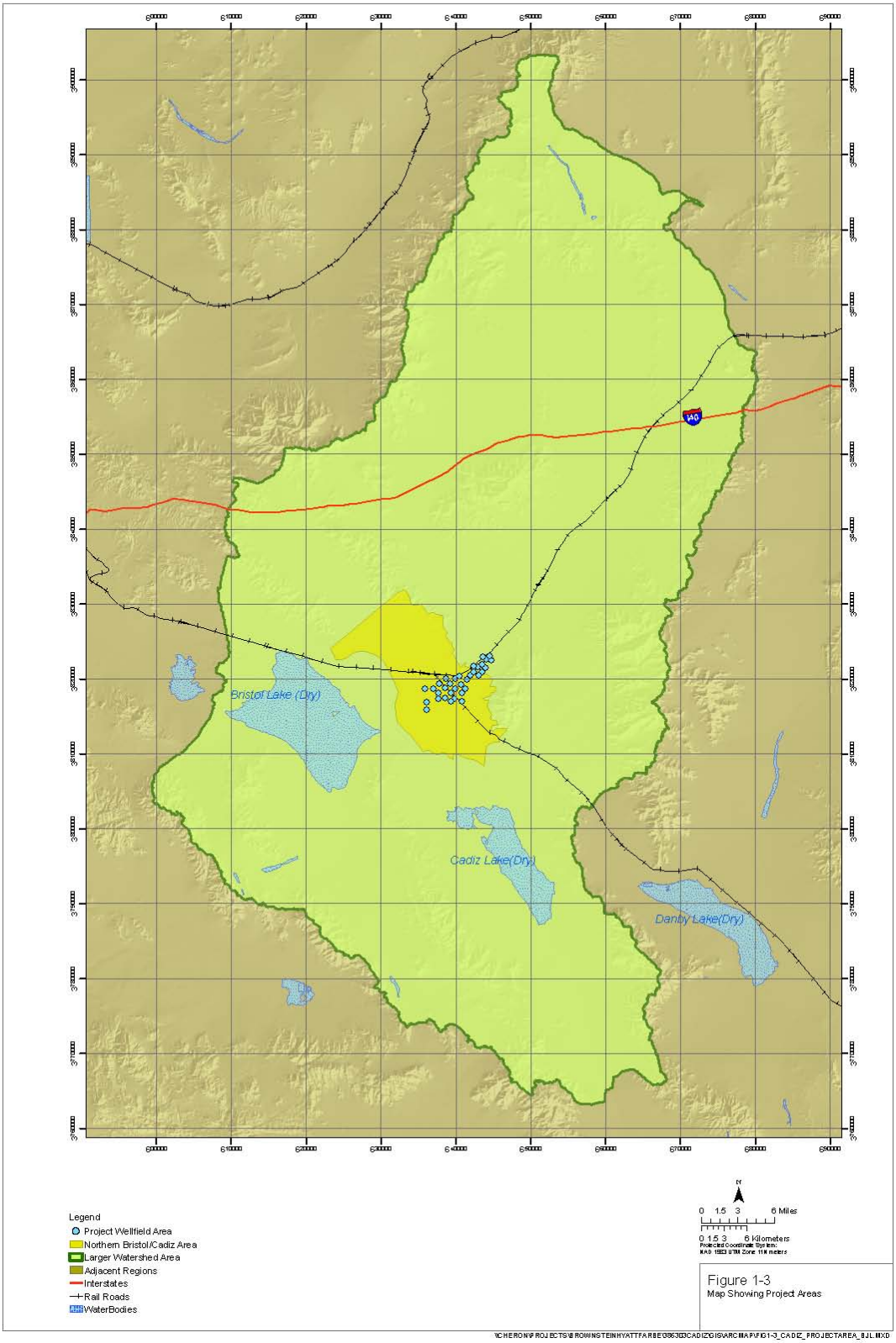
The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms. The Project wellfield is located within and south/southwest of the Fenner Gap which is centered between the Marble and Ship Mountains east of Cadiz.

The Project area can be divided into four areas for discussion purposes. The first and largest area is the area encompassed by the totality of Bristol, Cadiz and Fenner Watersheds as shown in Figure 1-3, which is referred to herein as the "larger watershed area." Orange Blossom Wash is within the Bristol Watershed. The second area is the region beyond the larger watershed area, which includes adjacent areas that are tributary to the Colorado River, such as the Piute Watershed. This second area is referred to herein as "adjacent regions." All precipitation within the larger watershed

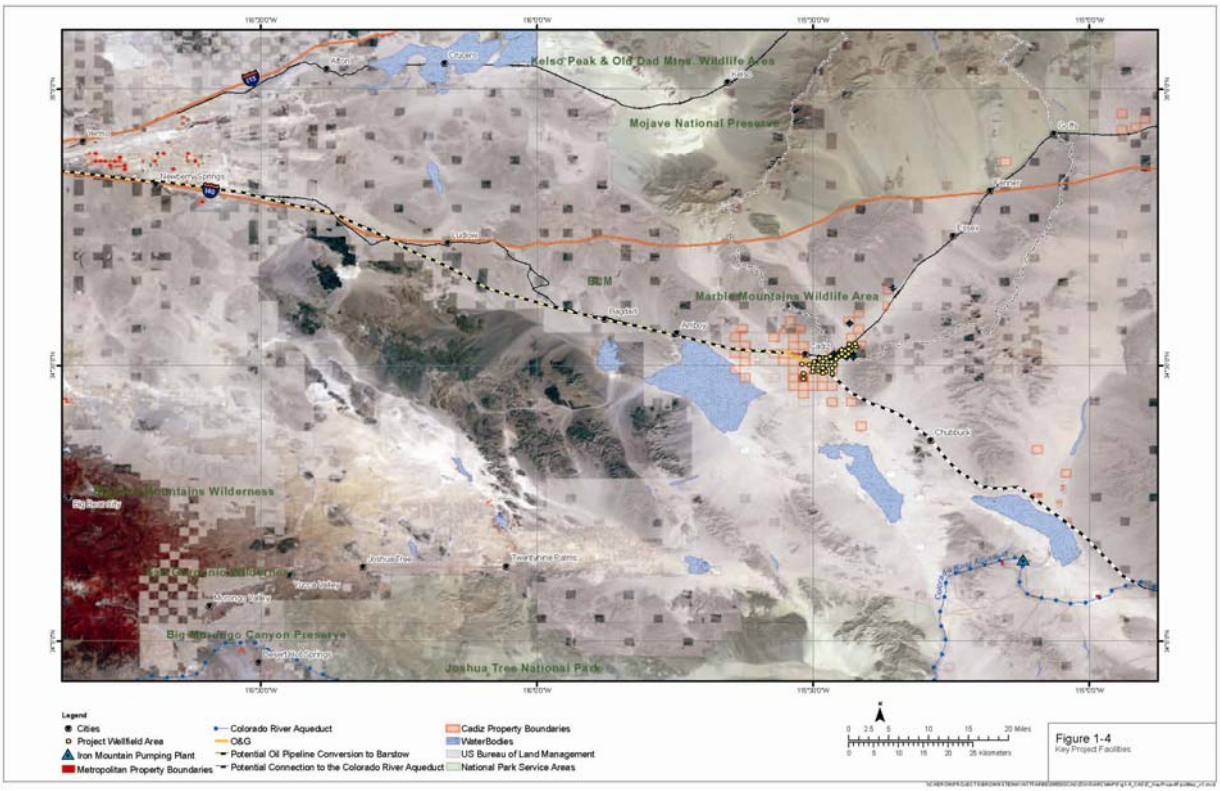
area that infiltrates to the groundwater table or runs off as surface flow, ultimately discharges to the Bristol or Cadiz Dry Lakes. Groundwater flow from the Fenner Watershed converges on and discharges through the Fenner Gap and ultimately makes its way to the Bristol and Cadiz Dry Lakes. Similarly, groundwater flow in the Orange Blossom Wash area moves downgradient to Bristol dry lake. The proposed Project wellfield would be located downgradient of the Fenner Gap, within the third area, the freshwater zone between Fenner Gap and Bristol dry lake as mapped by Shafer (1964), which is referred herein as the northern Bristol/Cadiz sub-basin (Figure 1-3). The fourth area is the area of the proposed wellfield, which is referred to herein as the wellfield area (Figure 1-3).

The total area of the Bristol (which includes Orange Blossom Wash), Cadiz and Fenner watersheds is approximately 2,320 square miles. The Bristol Watershed is approximately 640 square miles, the Cadiz Watershed is 590 square miles, and the Fenner Watershed is approximately 1,090 square miles.

These watersheds are considered to be a single closed drainage system because all surface and groundwater drains to central lowland areas of the Bristol and Cadiz Dry Lakes. The Bristol, Cadiz, and Fenner watersheds are separated from the surrounding watersheds within the adjacent regions by topographic divides (generally mountain ranges).


Bristol Lake (Dry)
Cadiz Lake(Dry)
Danby Lake(Dry)
40
Legend
Project Wellfield Area
Northern Bristol/Cadiz Area
Larger Watershed Area
Adjacent Regions
Interstates
Rail Roads
WaterBodies
N
0 1.5 3 6 Miles
0 1.5 3 6 Kilometers
Projected Coordinate System:
NAD 1983 UTM Zone 11N meters
Figure 1-3
Map Showing Project Areas
\\CHERON\PROJECTS\BROWNSTEINHYATTFARBER\0363\03CADIZGIS\ARCMAPFILES\1-3_CADIZ_PROJECTAREA_BJL.MXD

A map of key current and future Project facilities is shown in Figure 1-4.



1.4 The Parties

The Project and the Groundwater Management Plan are the joint efforts of Cadiz Inc., the SMWD, and in coordination with the County of San Bernardino Guidelines for Preparation of a Groundwater Monitoring Plan.

1.4.1 *Cadiz, Inc.*

Founded in 1983, Cadiz Inc. (Cadiz) is a renewable resources company based in Los Angeles. Using integrated satellite imagery and geological, geophysical, and geochemical survey methods, the company has identified and acquired 34,000 acres of land in Cadiz Valley situated over a large, naturally recharging basin. Cadiz's goal is for this basin to provide a high-quality, reliable water supply to southern Californians, as well as much-needed underground storage for surplus water, all without causing material adverse impacts to the local environment.

1.4.2 *Santa Margarita Water District*

SMWD was initially formed in 1964 by ranchers seeking a reliable water supply for their cattle, and it has grown into the second largest retail water agency in Orange

County. It supplies clean, affordable, reliable water and wastewater services to over 155,000 residents and businesses in Mission Viejo, Rancho Santa Margarita and the unincorporated areas of Coto de Caza, Las Flores, Ladera Ranch and Talega. When implemented, the Project will diversify SMWD's water portfolio and help drought-proof the District to ensure its water demands are met regardless of the State's supply. The District is the Lead Agency for the Project's California Environmental Quality Act (CEQA, Cal. Pub. Res. Code §§ 21000 *et seq*.) review process, and is responsible for evaluating the Project's alternatives, environmental impacts, and potential mitigation measures. This Groundwater Management Plan shall serve as an exhibit to, and be incorporated within, the Environmental Impact Report certified by SMWD for purposes of its compliance with CEQA in conjunction with its approval of the Project.

1.4.3 *County of San Bernardino*

The County of San Bernardino (County) exercises its management authority over County groundwater resources through the Desert Groundwater Management Ordinance (Ordinance). The proposed Project lies within the unincorporated desert area of eastern San Bernardino County, where water groundwater production is regulated under the County's Desert Groundwater Management Ordinance (Ordinance). (San Bernardino Code §§ 33.06551 *et seq*.). The Ordinance does not apply to the operation of groundwater wells where the operator has developed a groundwater management, monitoring and mitigation plan approved by the County and the County and the operator have executed a memorandum of understanding (MOU) that complies with the provisions of the Ordinance. (San Bernardino Code §33.06552(b)(1).) This Groundwater Management Plan shall serve as an exhibit to, and be incorporated within, a MOU amongst the County, FVMWC, SMWD and Cadiz to establish the exemption of the Project from the Ordinance pursuant to section 33.06552(b)(1) of the Ordinance, and to otherwise ensure that the Project is optimally operated to realize the Project's objectives of making the fullest beneficial use of the area's groundwater resources while avoiding significant adverse impacts to the environment. Because the County's execution of such an MOU to qualify the Project for exclusion from the Ordinance is a discretionary action by the County, it is anticipated that Santa Bernardino County's decision is discretionary and subject to CEQA with the County acting as a responsible agency.

1.4.4 *Fenner Valley Mutual Water Company*

FVMWC is a California mutual water company formed in accordance with California Water Code Section 2700 et seq. for the purpose of owning and operating a water company for the delivery of water to its shareholders at cost. Outstanding shares

are available for issuance to all project participants, and it has the power to contract with public agencies for the purposes of forming a joint powers agency. FVMWC will operate the Water Project. It may elect to contract with an affiliated joint powers agency (See California Government Code Section 6525.) Pursuant to this Management Plan, FVMWC shall assess technical data and responsive actions, proposed refinements to the Management Plan, and corrective measures regarding compliance with the provisions of the Management Plan, and prepare and submit various annual and periodic technical reports, all in consultation with the TRP and subject to the oversight and final decision of SMWD, as specified further in Chapters 6, 7, 8 and 9.

1.4.5 *Other Anticipated Project Participants*

In addition to the three Project parties listed above, other water service providers and additional users are expected to participate in the Project. These participants include:

- Three Valleys Municipal Water District, which serves 133 square miles in Los Angeles County, California, and includes Azusa, City of Industry, Covina, Claremont, Diamond Bar, Glendora, Hacienda Heights, La Puente, La Verne, Pomona, Rowland Heights, San Dimas, Walnut, and West Covina.

- Golden State Water Company, which provides service to three water service regions across 10 California counties. Region I consists of 7 customer service areas in northern and central California, and Ventura County; Region II consists of 4 customer service areas located in Los Angeles and Orange County; and Region III consists of 10 customer service areas in eastern Los Angeles County and in Orange, San Bernardino, and Imperial counties.

- Suburban Water Systems Service Area, which serves an area covering approximately 42 square miles, including all or portions of Glendora, Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, Buena Park and unincorporated portions of California's Los Angeles and Orange counties.

- Jurupa Community Services District (JCSD), which provides potable water, sewer and street lights to over 101,000 people located throughout 48 square miles in the Jurupa area of Riverside County. JCSD serves unincorporated areas of Riverside County as well as the communities of Jurupa Valley and Eastvale.

- California Water Service Company (Cal Water) distributes and sells water to 1.7 million Californians through 435,000 connections. Its 24 separate water systems serve 63 communities from Chico in Southern California to the Palos Verdes Peninsula in Southern California.

- Arizona California Railroad (ARCZ) owns and operates a railway line in a right-of-way that runs between the Cadiz Property and the Colorado River. Its parent company is RailAmerica.

1.5 Project Description

The Project will include two phases:

1.5.1 *Phase I*

Phase I will provide for extraction and delivery to the CRA of up to an annual average of 50,000 afy for delivery to Project participants in compliance with this Management Plan, to avoid adverse impacts to critical resources. Extraction in any given year may range from 25,000 to 75,000 afy, but over the 50-year operating period of the Project, shall not exceed more than an annual average of 50,000 afy, inclusive of agricultural production by Cadiz. Project participants will also be authorized to carryover their annual allocations by storing their water in the basin for later extraction and delivery during drought or emergency conditions within the 50-year operation period.

The Project involves construction and operation of the facilities shown on Figures 1-3 and 1-4 and as described below:

- A wellfield of up to approximately 34 extraction wells and appurtenant facilities;

- An approximately 43-mile long conveyance pipeline and appurtenant facilities from CRA to the wellfield, including power, generally parallel to the conveyance;

- Instrumentation and control systems to monitor all Project operations; and

- Observation wells, cluster wells, land survey benchmarks, extensometers, weather stations and other appurtenant facilities necessary for this Management Plan.

The conveyance and power distribution facilities, observation wells, land survey benchmarks, and other monitoring features, along with all Project facilities, will be located on land owned or easements obtained by Cadiz.

1.5.2 *Phase II*

Phase II will provide conjunctive-use storage, up to a total storage at any given time of one million acre-feet, in compliance with an updated version of the Management Plan and without significantly adversely impacting critical resources. Conceptually, imported water to be stored will be conveyed from either the CRA to spreading basins in the Project area during periods of surplus supply, or from the California Aqueduct via potential conversion of an existing pipeline previously used for oil and recently made ready for the delivery of natural gas. A maximum of 75,000 to 105,000 afy of water will be stored in the basin annually. This stored water will subsequently be extracted by the Project wellfield and conveyed back to the CRA and/or through a converted natural gas pipeline for conveyance of water to and from the Barstow area as needed. A maximum of 75,000 to 105,000 afy of water will be extracted annually and conveyed through the 43-mile pipeline to the CRA and/or through the converted natural gas pipeline to the State Water Project facilities in San Bernardino County. Phase I and Phase II operations will be coordinated and in lieu storage may be used for Phase II. Phase II will require additional CEQA review and updates to this Management Plan prior to implementation.

1.6 Project Objectives

The Project objectives are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation;
- Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought;
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;
- Enhance dry-year water supply reliability within SMWD and other Southern California water provider Project Participants;

- Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of carry-over storage and, for Phase II, imported water storage;
- Support operational water needs of the ARZC in the Project area;
- Create additional water storage capacity in Southern California to enhance water supply reliability;
- Locate and design the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

1.7 Existing Groundwater Management

Cadiz owns 35,000 acres of largely contiguous land in the Cadiz and Fenner Valleys of eastern San Bernardino County, where they have farmed successfully for more than 15 years, as shown in Figure 1-3. Approximately 1,600 acres of this land has been developed for citrus and stone fruit orchards, vineyards, and specialty row crops.

In 1993, San Bernardino County certified a Final Environmental Impact Report (FEIR), and granted various land use approvals for expansion of agricultural operations up to 9,600 acres on this property. As a component of this approval, the County identified specific groundwater monitoring activities to be undertaken by Cadiz. To comply with these monitoring requirements, the Cadiz Valley Agricultural Development Ground Water Monitoring Plan (GWMP) was developed in cooperation with San Bernardino County to monitor all potential environmental impacts that could result from the agricultural irrigation. This Management Plan governs water use, storage, and extraction for the agricultural operations, and ensures that Project operations and future irrigation under the Cadiz Valley agricultural development will be conducted without adverse impacts to critical resources. Agricultural irrigation will also remain subject to the GWMP required by the County, but will be phased out as the Project comes on line and produces an annual average of 50,000 afy. Regardless of any phasing, the average annual extraction over the 50 years of Project operations will be no greater than 50,000 afy from all Cadiz pumping.

1.8 Purpose and Scope of Management Plan

The purpose of this Management Plan is to facilitate the optimal management of groundwater and ensure protection of the critical resources in or near the larger watershed area and adjacent regions, and to serve as a supporting document to be incorporated within (a) the Environmental Impact Report certified by SMWD for

purposes of its compliance with CEQA in conjunction with its approval of the Project, and (b) a MOU between the County, FVMWC, SMWD and Cadiz to establish the exemption of the Project from the County's Desert Groundwater Management Ordinance. For purposes of this Management Plan, Project operations would be evaluated to also include the agricultural operations as outlined in the GWMP.

This Management Plan includes the following:

1) Description of the Project location and objectives;

2) Description of physical characteristics of the groundwater basin;

3) Identification of the critical resources and assessment of potential impacts in and surrounding the Project area due to Project groundwater extraction;

4) Description of the modeling tools that will be used to refine the monitoring network, and, will be used, in the future, to refine impact assessments and action criteria;

5) Description of the monitoring network and identification of the locations of the features of the monitoring network;

6) Description of the monitoring, testing, and reporting procedures that will be used to collect and analyze data;

7) Description of the action criteria established to avoid potential significant adverse impacts;

8) Description of the decision-making process to be used once the action criteria are met or when SMWD considers refinements to this Management Plan;

9) Description of corrective measures that may be implemented to minimize potential significant adverse impacts;

10) Description of objectives and requirements for a Closure Plan; and

11) Description of the TRP and its responsibilities and procedures.

CHAPTER 2
DESCRIPTION AND CHARACTERISTICS OF GROUNDWATER BASINS AND PRESENT USES

2.1 Geologic Setting

As shown above in Figure 1-3, the study area includes the Fenner, Bristol, and Cadiz watersheds. These watersheds are located in the Eastern Mojave Desert, which is a part of the Basin and Range Province of the western United States. The Basin and Range Province is characterized by a series of northwest/southeast trending mountain and valleys formed largely by faulting. One of the prominent features of the area is the Bristol Trough, a major structural depression caused by faulting. The Bristol Trough encompasses the Bristol and Cadiz watersheds that together form a relatively low land area that extends from just south of Ludlow, California on the northwest to a topographic and surface drainage divide between the Coxcomb and Iron mountains on the southwest. The Bristol and Cadiz Valleys are bounded on the southwest by the Bullion, Sheep Hole, Calumet, and Coxcomb mountains and on the northeast by the Bristol, Marble, Ship, Old Woman, and Iron mountains. The Cadiz and Bristol Dry Lakes are separated by a low topographic and surface drainage divide. The Fenner Watershed is located north of the Bristol Trough. This watershed encompasses approximately 1,100 square miles (mi2). It is bounded by the Granite, Providence, and New York mountains on the west and north and the Piute, Ship, and Marble mountains on the east and south. Fenner Gap occurs between the Marble and Ship mountains, where the surface drainage exits Fenner Watershed and enters the Bristol and Cadiz watersheds. The Clipper Mountains rise from the southern portion of the watershed, just northwest of Fenner Gap. (CH2M Hill, July 2010.)

The Orange Blossom Wash Watershed is a subarea of the Bristol Watershed, which is located in the western portion of the Project area between the Marble and Bristol mountains. The Orange Blossom Wash Watershed is bounded on the west by the Granite Mountains, and drains to the southeast into the Bristol Dry Lake. The Bristol and Cadiz Watersheds are located in the southern portion of the Project area. The proposed Project wellfield is located in the northern Bristol and Cadiz valleys, within and south/southwest of the Fenner Gap.

The total area of the Bristol, Cadiz and Fenner watersheds is approximately 2,330 square miles and consists of the Fenner Watershed (1,100 square miles), Bristol Watershed (640 square miles), and Cadiz Watershed (590 square miles). The surface water drainage and groundwater flow from all four of the watersheds in this Project

area drain into the Bristol and Cadiz Dry Lakes, where it joins the brine water underlying the dry lakes and evaporates. (*Id.*)

The alluvial sediments of the Fenner Valley are underlain by carbonate, granitic and metamorphic rocks, forming a rock-bounded basin overlain with sands and gravels hundreds of feet thick. Groundwater ranges from approximately 270 to 400 feet bgs in the northeastern portion of the Project area to 140 feet bgs in the southwest, becoming shallower with increasing proximity to the dry lakes. Groundwater in storage has been estimated at between 17 to 34 million acre feet. Of this amount 4 to 10 million acre-feet is thought to exist in the fresh water zone south of the Fenner Gap. (CH2M HILL, July 2010)

2.2 Surface Water Resources

Native springs and localized wet areas associated with these springs are present in the mountain ranges in the Project vicinity, as shown in Figure 2-15 of CH2M Hill's July 2010 Report. The closest native springs to the Project site are located to the north, in the Granite, Clipper, and Old Woman Mountains. The nearest spring is Bonanza Spring (Spring 007N015E22DS01S), which is located in the Clipper Mountains, approximately 11 miles north of the center of Fenner Gap. These springs are located in hard rock (volcanic, granitic and metamorphic rocks) formations substantially higher in elevation than the carbonate and alluvial aquifers of the groundwater basin, such that they are not in hydraulic communication with the proposed wellfield and spreading basin areas. Therefore, pumping in the carbonate aquifer and alluvial aquifer in the Project well field should not affect groundwater levels in the hard rock formations that supply water to the vicinity springs. Nonetheless, this Management Plan provides for monitoring of the springs to confirm that Project operations have no impact on the spring flow from these springs consistent with recommendations of the Groundwater Stewardship Committee.

The Bristol and Cadiz dry lake playas are the lowest points in the Project area and are separated by a low topographic and surface drainage divide. Since the four Watersheds are part of a closed drainage system, the only natural outlet for surface water and groundwater is through evaporation at the dry lake surfaces.

2.3 Natural Recharge

The natural recharge in the Project area watersheds has been the subject of several studies since 1970. (See Appendix D to Geoscience, September 1, 2011.) The most recent study, based on data obtained from field investigations in the Fenner Gap, use of

INFIL3.0 watershed soil-moisture budget model released in 2008, and three-dimensional groundwater flow model simulations for the Fenner Gap, estimated the long-term average annual natural recharge of 32,000 afy. (CH2M Hill, July 2010). Notwithstanding the results of the most recent study, for purpose of evaluating potential impacts attributable to the Phase I (Conservation Component) of the Project, a modeling effort was undertaken using a range of recharge rate assumptions: 32,000 afy; 16,000 afy; and 5,000 afy. See discussion in Chapter 4.

The primary sources of replenishment to the groundwater system within the larger watershed area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the larger watershed area occurs in the higher elevations, including Bristol Mountains, Granite Mountains, Providence Mountains, Marble Mountains, New York Mountains, Piute Mountains, Old Woman Mountains, Ship Mountains, Clipper Mountains, Wood Mountains, and Hackberry Mountains (CH2M Hill, July 2010).

Most of the precipitation in the Eastern Mojave Desert accumulates during the winter months from November through March. Early summer and late fall are typically periods of little rainfall. The amount of precipitation in the Bristol, Cadiz, and Fenner Watersheds vary with differences in altitude. Average annual precipitation ranges from approximately 3 inches on the Cadiz and Bristol Dry Lakes (elevations of 545 to 595 ft amsl) to over 12 inches in the Providence and New York mountains (elevations over 7,000 ft amsl). However, most of the larger watershed area receives, on the average, 4 to 6 inches of rain annually. (Geoscience, September 2011). A conceptualized model of groundwater recharge in the area is shown in Figure 2-1.

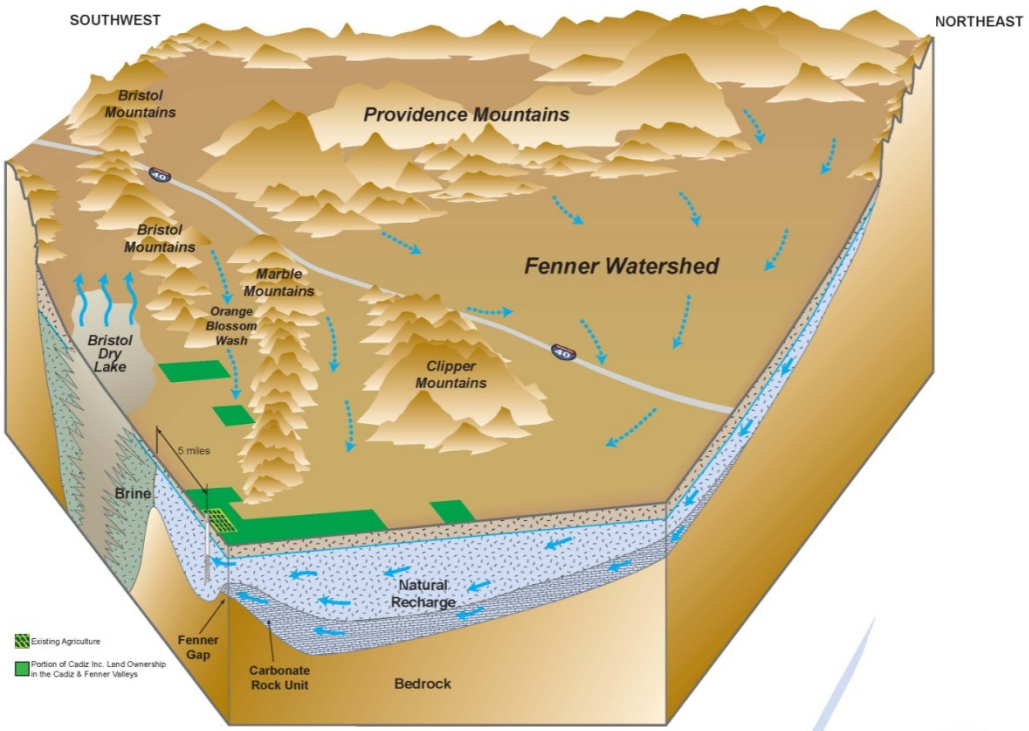


FIGURE 2-13
Conceptualization of Groundwater Occurrence and Movement In the Area of Study

2.4 Hydrogeology

Based on available geologic and geophysical data, the principal geologic deposits in the Project area that can store and transmit groundwater (i.e., aquifers) can be divided into three units: an upper alluvial aquifer, a lower alluvial aquifer, and a bedrock aquifer consisting of Tertiary fanglomerate, Paleozoic carbonates and fractured and faulted granitic rock. In general, these three units are in hydraulic continuity with each other and the separation is primarily due to stratigraphic differences. (Geoscience, September 2011).

The alluvial aquifer system consists mainly of Quaternary alluvial sediments which consist of stream-deposited sand and gravel with lesser amounts of silt. The thickness of the alluvial aquifer varies between 200 and 800 feet. To the west of Fenner Gap, the upper aquifer is separated from the lower aquifer system by discontinuous layers of silt and clay. The average thickness of the upper aquifer in Fenner Gap is approximately 500 feet. The upper aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more to wells with less than 20 feet of drawdown. (Geoscience, September 2011).

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay. The maximum thickness of the lower aquifer is unknown but may

reach over 6,000 feet in the vicinity of Bristol dry lake. Where these materials extend below the water table, they yield water freely to wells but are generally less permeable than the upper aquifer sediments. The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm. (Geoscience, September 2011).

Based on findings from recent drilling in the Fenner Gap area, Tertiary fanglomerate, fractured and faulted granitic rock, and Paleozoic carbonates, located beneath the lower alluvial aquifer, contain groundwater and are considered a third aquifer unit. Groundwater movement and storage within the carbonate bedrock aquifer primarily occurs within secondary porosity features (i.e., fracture zones associated with faulting and cracks and cavities developed within the rocks over time). (Geoscience, September 2011).

2.5 Groundwater Storage

The volume of groundwater in storage was estimated to be about 17 million to 34 million acre-feet in the alluvium of the Fenner Valley, Orange Blossom Wash, and northern Bristol/Cadiz area, where the conservation and storage Project will be sited. Four to ten million acre-feet of groundwater lie to the west and southwest of the proposed wellfield location. (Geoscience Tech Memo September 20, 2011.) Estimates of groundwater in storage in various zones within the general Project area are listed in Table 2-1, which also includes estimates of the following variables: volume of aquifer, determined as the volume between the groundwater table and the base of the alluvium (saturated thickness), percent of aquifer saturated thickness that is expected to be an aquifer (to exclude clay and silt intervals that do not yield water readily), and estimated specific yield. Low and high ranges are provided for each of these variables based on previous estimates. (CH2M Hill, July 2010.)

Table 2.1

Cadiz Study Area Groundwater Storage Calculations

Low Estimate					High Estimate				
Zones	Saturated Thickness Volume (ac-ft)	% of Saturated Thickness which is Aquifer	Specific Yield	Groundwater in Storage (ac-ft)	Zones	Saturated Thickness Volume (ac-ft)	% of Saturated Thickness which is Aquifer	Specific Yield	Groundwater in Storage (ac-ft)
Zone 1	11,251,515	75%	0.15	1,265,795	Zone 1	11,251,515	85%	0.20	1,912,758
Zone 2a	63,758,585	50%	0.10	3,187,929	Zone 2a	63,758,585	60%	0.15	5,738,273
Zone 2	93,083,800	50%	0.10	4,654,190	Zone 2	93,083,800	60%	0.15	8,377,542
Zone 3	13,052,800	20%	0.10	261,056	Zone 3	13,052,800	40%	0.15	783,168
Zone 4	489,237	50%	0.10	24,462	Zone 4	489,237	75%	0.15	55,039
Zone 5	88,466,500	50%	0.10	4,423,325	Zone 5	88,466,500	75%	0.15	9,952,481
Fenner	93,676,400	50%	0.05	2,341,910	Fenner	93,676,400	60%	0.10	5,620,584
Goffs	32,917,900	50%	0.05	822,948	Goffs	32,917,000	60%	0.10	1,975,074
				16,981,615					**34,414,919**

This storage estimate does not include water contained within the carbonate and fractured portion of the bedrock beneath the alluvial units. Recent drilling has revealed that these units also store groundwater. As such, the estimated volume of groundwater in storage is a conservative underestimate; the actual volume of groundwater in storage is larger by some unknown amount. (Geoscience, September 2011). Figure 2-2 shows the storage zones used in the calculations of groundwater in storage.

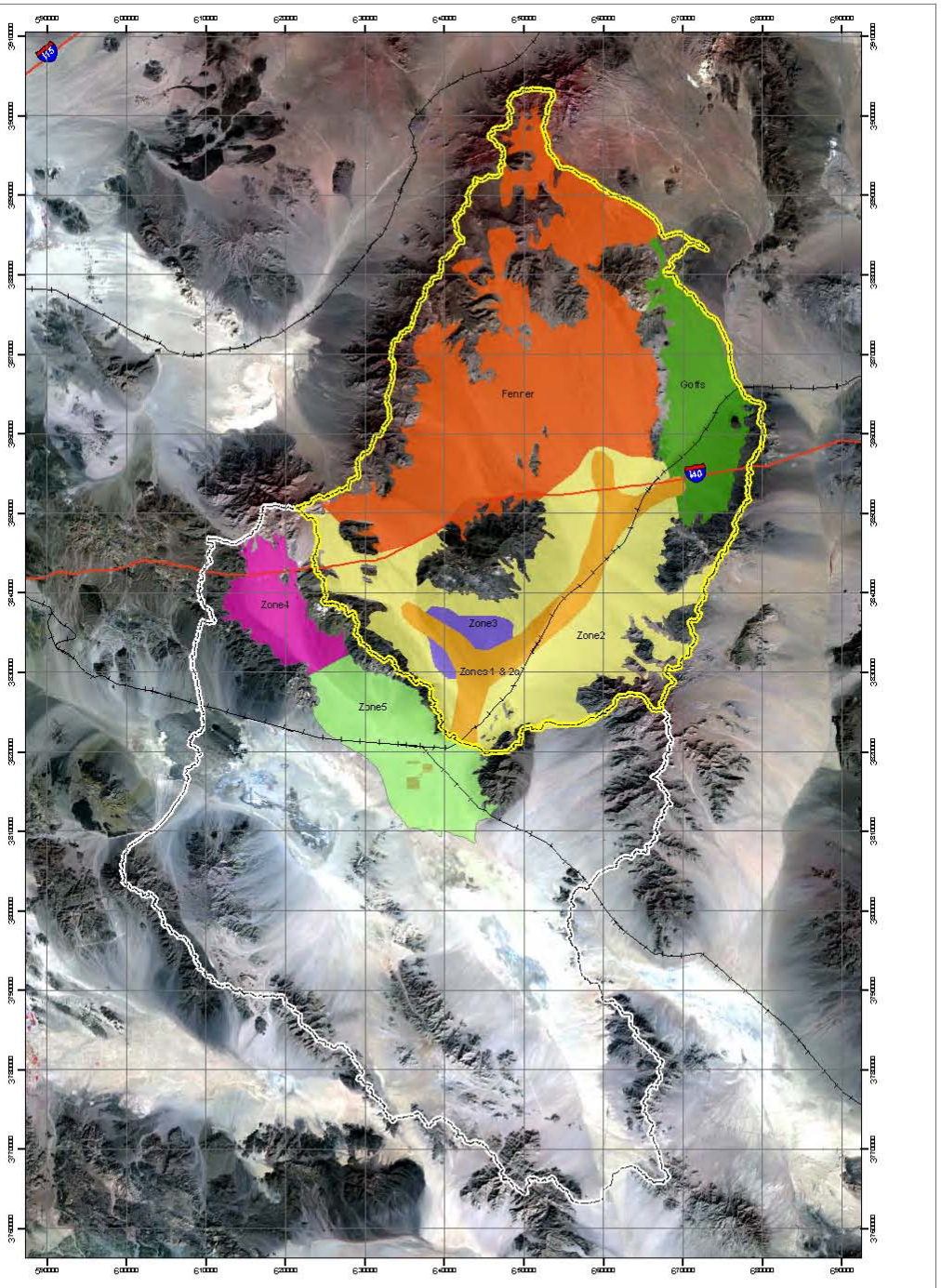


Figure 2-2
Storage Zones

2.6 Groundwater Quality

With the exception of the areas underlying and immediately adjacent to the Bristol and Cadiz Dry Lakes, the quality of the groundwater in the northern Bristol/Cadiz and Fenner Gap area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L). Table 2-2 summarizes water quality data collected from an existing well on the Cadiz agricultural operations property, south/southwest of the Fenner Gap. The State of California guideline for drinking water is a maximum TDS of 1,000 mg/L. However, all groundwater having a TDS below 3,000 mg/L is considered by the State to be a potential domestic or municipal source of water supply.

TABLE 2-2: GROUNDWATER CHEMISTRY AT CADIZ ALLUVIAL AQUIFER

	CA MCL	CA SMCL	CADIZ GROUNDWATER
TDS		500-1000 mg/L	260 mg/L
Arsenic	10 μg/L		3.1 μg/L
Chloride		250-500 mg/L	34 mg/L
Total Chromium	50 μg/L		16 μg/L
Fluoride	2.0 mg/L		1.6 mg/L
Manganese		50 μg/L	Not Detected (< 20 μg/L)
Nitrate as NO3	45 mg/L		12 mg/L
Sulfate		250-500 mg/L	11 mg/L

CA MCL: California primary maximum contaminant levels for drinking water (chemicals affecting health and safety)

CA SMCL: California secondary maximum contaminant level for drinking water (chemicals affecting taste and odor)

mg/L = milligrams per liter

µg/L = micrograms per liter

Not Detected = not detected at or above the reportable detection limit

Source: 22 CCR §§ 64431, 64449

Table 2-3 shows water quality data obtained from recent hydrogeologic investigations in the Fenner Gap area. Overall, groundwater quality in the alluvial and carbonate aquifers are of very high quality, with low total dissolved solids. Chromium, and in particular hexavalent chromium, is a constituent of potential concern given the recently adopted California Public Health Goal for hexavalent chromium of 0.02 ug/l. Groundwater containing hexavalent chromium could require treatment depending on the water quality standard developed by the State. Groundwater in the deeper section of the bedrock shows elevated concentrations of iron and manganese; however, the relative contribution of groundwater from these deeper bedrock units is expected to be small, such that the quality of groundwater in productions is expected to be representative of the water quality of the alluvial and carbonate aquifers.

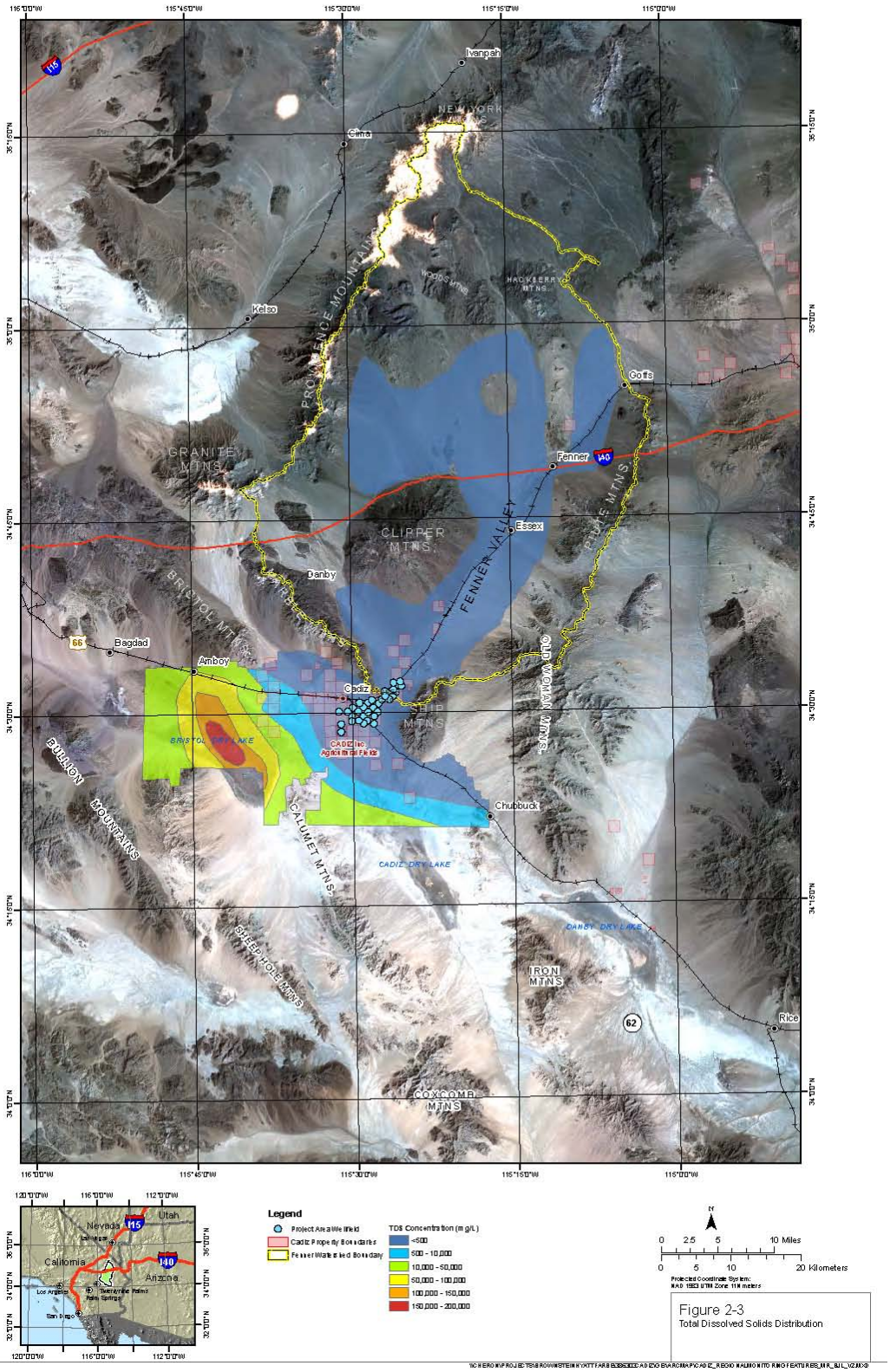
Table 2.3

Summary of Water Quality Results

Parameter	Regulatory Action Levels				Analytical Results[1]			
	CA Primary MCL	USEPA Primary MCL	CA Secondary MCL	USEPA Secondary MCL	TW-1 Carbonate 11/10/2009	TW-1 Alluvium 12/04/2009	TW-2 Alluvium 11/24/2009	DT-1 Bedrock 02/24/2011
Anions :								
Chloride (mg/L)			250 to 500	250	38	34	35	110
Fluoride (mg/L)	2	4		2	1.5	1.6	1.6	3.6
Nitrate as NO_3 (mg/L)	45				13	12	12	ND < 1.0
Sulfate (mg/L)			250 to 500	250	32	11	30	110
Total Anions (me/L)					4.23	3.46	4.09	-
Alkalinity :								
Total Alkalinity (mg/L)					110	100	110	130
Bicarbonate Alkalinity (mg/L)					130	130	130	160
Carbonate Alkalinity (mg/L)					ND < 3.0	ND < 3.0	ND < 3.0	ND < 3.0
Hydroxide Alkalinity (mg/L)					ND < 3.0	ND < 3.0	ND < 3.0	ND < 3.0
Cations :								
Calcium (µg/L)					24	27	26	13
Magnesium (µg/L)					5.7	5.2	5.7	5.0
Potassium (µg/L)					5.0	4.9	5.2	4.9
Sodium (µg/L)					60	48	53	170
Total Hardness (mg/L)					84	89	88	54
Total Cations (me/L)					4.4	4	4.2	-
General Parameters :								
pH				6.5 to 8.5	8.0	8.0	7.9	8.6
Langlier Index at 25 C					0.01	-0.01	-0.11	-
Total Dissolved Solids (mg/L)			500 to 1,000	500	220	260	300	530
Metals and Metalloids :								
Arsenic (µg/L)	10	10			7.5	3.1	6.5	11
Total Chromium (µg/L)	50	100			14	16	18	2.9
Hexavalent Chromium (µg/L)	[2]				16	14	14	-
Iron (µg/L)			300	300	ND < 100	ND < 100	ND < 100	11,000
Manganese (µg/L)			50	50	ND < 20	ND < 20	ND < 20	210

Notes:
(1) TW-1 and TW-2 samples were collected at the end of constant rate pumping tests.
DT-1 sample airlifted through the drill string after achieving total depth (1,500 feet).
(2) Hexavalent chromium is currently regulated under the MCL for total chromium.
CA = California
USEPA = United States Environmental Protection Agency
MCL = maximum contaminant level

At the Bristol and Cadiz Dry Lakes, surface water and shallow groundwater evaporation has concentrated dissolved salts resulting in TDS concentrations as high as 298,000 mg/L. (Shafer, R. A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, California* (1964); Engineering Department Southern California Edison Company, Unpublished Report at 172, pp 12 plates; *cited in* Metropolitan and Cadiz Inc., *Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Cadiz Groundwater Storage and Dry-Year Supply Program (Cadiz Project)*, pages 5-72, 5-80, and 5-81 (September 2001)). The location of the interface between the low-TDS "fresh" groundwater (i.e., TDS concentrations less than 1,000 mg/L) and high-TDS "saline" groundwater underlying the dry lakes has been mapped on the basis of data from observation wells in the area, and is shown in Figure 2-3.


Ivanpah
Cima
Kelso
Goffs
Fenner
Essex
Danby
Bagdad
Amboy
Cadiz
Chubbuck
Rice
NEW YORK MTNS.
PROVIDENCE MOUNTAINS
WOODS MTNS.
HACKBERRY MTNS.
GRANITE MTNS.
CLIPPER MTNS.
FENNER VALLEY
PISGAH MTNS.
BRISTOL MTNS.
MARBLE MTNS.
OLD WOMAN MTNS.
CADIZ Inc. Agricultural Fields
BRISTOL DRY LAKE
BULLION MOUNTAINS
CALUMET MTNS.
CADIZ DRY LAKE
SHEEP HOLE MTNS.
DANBY DRY LAKE
IRON MTNS.
COXCOMB MTNS.
Utah
Nevada
California
Arizona
Legend
Project Area Well Field
Cadiz Property Boundaries
Fenner Watershed Boundary
TDS Concentration (mg/L)
<500
500 - 10,000
10,000 - 50,000
50,000 - 100,000
100,000 - 150,000
150,000 - 200,000
0 2.5 5 10 Miles
0 5 10 20 Kilometers
Figure 2-3
Total Dissolved Solids Distribution

2.7 Present Groundwater Production and Uses

Land use in the area consists primarily of desert conservation open space and agriculture, with limited chloride mining of the brine from the dry lakes and other mining, military uses, recreation, railroad, and electrical, gas, and oil utility corridors. Cadiz used, on average, 5,000 to 6,000 afy of groundwater between 1994 and 2007 for its agricultural operations. This annual usage was reduced beginning in 2007 in connection with the removal of approximately 500 acres of vineyard that had reached the end of its commercial life. Based on the current crop mix (lemons on 370 acres and grapes on 160 acres and seasonal row crops), the agricultural operations are using approximately 1800-1900 acre-feet of water per year. Another 1,070 acres are fallow and currently not irrigated.

There are also two existing salt mining operations at the Bristol and Cadiz Dry Lakes. These operations involve evaporation of the hyper-saline groundwater from the dry lakes to obtain remaining salts. One operation uses approximately 500 afy of the hyper-saline groundwater based upon recorded water extractions pursuant to California Water Code Section 4999 et seq., while it is estimated that the other operation, being approximately one-half of the size, uses approximately 250 afy for a total of 750 afy.

CHAPTER 3
PROJECT OPERATION, GROUNDWATER CONSERVATION, AND CONSISTENCY WITH APPLICABLE LEGAL AUTHORITY

The Project is designed to operate consistent with California's constitutional requirement that all waters of the state not be wasted, but rather put to fullest beneficial use. In relevant part, article X, section 2 of the California Constitution declares:

> "[B]ecause of the conditions prevailing in this State the general welfare requires that the *water resources of the State be put to beneficial use to the fullest extent of which they are capable*, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. . ." (California Constitution Article X, Section 2 [emphasis added].)

For decades, California has emphasized the importance of using its groundwater supplies responsibly and to manage surface and groundwater supplies conjunctively. According to the California Supreme Court, each groundwater basin has a safe or perennial yield which is "the maximum quantity of water which can be withdrawn annually from a ground water supply under a given set of conditions without causing an undesirable result." (*City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 278).

By applying modern groundwater management strategies, groundwater levels can be adjusted to achieve conservation objectives, to enhance the a basin's recoverable yield, promote conservation, and conjunctively manage surface water and groundwater. As articulated by the California Supreme Court, "if a ground basin's lack of storage space will cause a limitation of extractions to safe yield to result in a probable waste of water, the amount of water which if withdrawn would create the storage space necessary to avoid the waste and not adversely affect the basin's safe yield is a temporary surplus available for appropriation to beneficial use." (*City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 280).

Consistent with the groundwater management principles articulated by the California Supreme Court, a temporary surplus exists in the northern Bristol/Cadiz sub-basin. The Project's withdrawal of groundwater is intended to exceed the natural recharge for the intentional and strategic purpose of lowering the water table in the well-field to change the hydraulic gradient. The specific effects of the Project in terms of changes in aquifer water levels and associated impacts are discussed in detail in Chapter 4 below.

By strategically lowering water levels in the northern Bristol/Cadiz sub-basin, the Project will not only intercept natural recharge flowing through the Fenner Gap and from Orange Blossom Wash, but reverse existing groundwater gradients and retrieve water stored in alluvial aquifers to the immediate southwest and southeast of the Fenner Gap back to the Project wellfield. (Geoscience, September, 20 2011.) Existing groundwater gradients cause water within these alluvial aquifers to flow towards the Bristol and Cadiz Dry Lakes, where it blends with brine beneath the dry lakes and ultimately evaporates (and therefore is wasted). Thus, the Project's goal of lowering the water table will facilitate the recovery and conservation of this water before it is lost to the dry lakes where it evaporates.

This premise was studied and reported on in a technical memorandum issued by Project consultant Geoscience Support Service Inc. (Geoscience), titled Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation, Storage and Recovery Project, dated September 20, 2011. Geoscience used a variable density

groundwater flow and transport model that it developed for the Project (see discussion of groundwater flow models in Chapter 4) to evaluate the savings of fresh groundwater as a result of the Project that would otherwise be loss to evaporation in the dry lakes absent the Project. It determined that assuming 32,000 and 16,000 afy natural recharge scenarios (see discussion of recharge assumptions in Chapter 4), an average pumping of 50,000 afy, would create a net savings of 1,990,000 and 674,000 acre-feet, respectively over a 100-year period. (Geoscience, September 20, 2011). The volumes of groundwater impacted by the migration of saline water from the dry lakes into presently fresh water supplies to northeast towards the Project wellfield were 173,000 and 215,000 acre-feet for the 32,000 and 16,000 natural recharge scenarios, respectively. However, even considering these volumes, Geosciences modeling concluded there would still be a significant net savings of fresh groundwater by implementing the Project versus not implementing it. (*Id.*) The only modeled scenario in which the production of an average pumping of 50,000 afy would create a net loss of freshwater (i.e., the volume of groundwater impacted by the migration of saline water exceeds savings of water from evaporation) is where recharge is assumed to only be 5,000 afy. A summary of the results of Geoscience's modeling of net water savings as a result of the Project's proposed production quantities is set forth in Table 3-1. It should be noted that Geoscience found that savings from evaporation would be even higher if Project groundwater production were accelerated into the first half of the Project operation period pumping at the higher rates early (i.e., 75,000 afy were produced in the first 25 years of the alternative pumping schedule). (*Id.*) In all cases, the recovered groundwater would be beneficially used by Project Participants.

Table 3-1: Summary of Net Savings from Proposed Project Production (Average 50,000 afy/50 Years)

Natural Recharge	Time	Cumulative Reduction of Evaporative Losses [acre-ft]	Cumulative Depletion of Storage [acre-ft]	Cumulative Net Water Saving from Project [acre-ft]
32,000 acre-ft/yr	At the End of 100 Years	2,210,000	220,000	1,990,000
16,000 acre-ft/yr	At the End of 100 Years	1,544,000	870,000	674,000
5,000 acre-ft/yr	At the End of 100 Years	470,000	1,870,000	-1,400,000

By lowering groundwater levels in the alluvial aquifers, the Project will also create space in the sub-basin to store imported water as part of the conjunctive use planned for the second phase of the Project. In sum, the Project will capture natural recharge, optimize conservation by retrieving groundwater presently in storage before it can evaporate, allow for the carry-over of native water in storage and set the stage of a new conjunctive use storage opportunity that does not presently exist. As explained below in Chapter 4, this Management Plan provides for comprehensive monitoring of potential Project impacts to critical resources, together with a series of action criteria and potential corrective measures, to ensure that the Project does not cause material adverse environmental impacts. For these reasons, the Project is entirely consistent with the state policy of fullest beneficial use of water resources for municipal uses as set forth in Article X, Section 2 of the California Constitution and the other legal principles discussed above.

CHAPTER 4
ASSESSMENTS OF POTENTIAL ADVERSE IMPACTS TO CRITICAL RESOURCES IN OR ADJACENT TO THE PROJECT AREA

As discussed above, the objectives of this Management Plan are to ensure that the groundwater supplies within the Project area are put to beneficial use to the fullest extent possible, and the present waste of groundwater to salinity and evaporation is significantly reduced, all while avoiding any material adverse impact to critical resources. This Management Plan addresses the following critical resources:

- The basin aquifers tapped by the Project, including avoiding the chronic decline of groundwater levels, potential impacts to groundwater quality, land subsidence, and existing groundwater uses;
- Brine resources of Bristol and Cadiz Dry Lakes;
- Springs within the Fenner Watershed including springs of the Mojave National Preserve and BLM-managed lands;
- Air quality in the Mojave Desert region;
- Project area vegetation; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.

This Chapter 4 takes a conservative approach in its technical analysis of the potential adverse impacts to these critical resources as a result of the Project operations.

4.1 Potential Project Impacts to Basin Aquifers

For the purposes of this Management Plan, the basin aquifers include aquifers of the Fenner, Bristol, and Cadiz watersheds as described in Chapter subsection 2.4. However, emphasis is placed on the aquifers in the vicinity of the northern Bristol/Cadiz area. Emphasis is placed on Fenner and the northern Bristol/Cadiz sub-basin areas, which encompasses the proposed extraction wellfield and potential artificial recharge facilities proposed for implementation in Phase II in and around the Fenner Gap area and existing Cadiz agricultural wellfield. Potential Project impacts to the Fenner and northern Bristol/Cadiz project sub-basin include:

- Potential for chronic decline of groundwater levels
- Potential for impacts to wells owned by neighboring landowners (including wells operated in the larger watershed area) due to Project operations;
- Potential for land subsidence and loss of groundwater storage capacity due to groundwater withdrawal; and
- Potential for induced flow of lower quality water from Bristol and Cadiz Dry Lakes; and

Water resources models were developed and applied to assess these potential impacts. The specific models and their application are described below in Sections 4.1.1 and 4.1.2.

4.1.1 *Water Resources Modeling*

Water resources models developed during the pre-operational phase of the Project have been, and are planned to be, used to simulate the impacts of planned Project operations. These models include the INFIL3.0 soil-moisture budget model, MODFLOW-2000/MT3D groundwater flow and solute transport model, and SEAWAT-2000 model (note that selection of models may change based on either updates to these models or availability of comparable models). The results of simulations using these models have been used to assess potential impacts during Project operations. Results of these simulations are used to identify monitoring features and conditions to be monitored and locations and frequency of monitoring during Project operations in order to verify these model projections. During Project operations, the results of monitoring will be

used to evaluate whether any action criteria are triggered. Evaluation of monitoring results could result in refinements to action criteria as well as identifying areas where collection of additional data may be needed to improve the monitoring network. Any refinements to models that monitoring data indicate may be needed will be made in accordance with the decision-making process described in Chapters 6 and 8.

4.1.1.1 INFIL3.0

INFIL3.0 is a grid-based, distributed–parameter, deterministic water-balance watershed model, released for public use by the USGS in 2008, which is used to estimate the areal and temporal net infiltration of precipitation below the root zone (USGS, 2008). This model was used to estimate potential recoverable water for the Project. The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone, and is no longer affected by evapotranspiration and is capable of percolating to and recharging groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water run-on (runoff and streamflow). Application of INFIL3.0 to the Fenner and Orange Blossom Wash watersheds produced long-term average annual natural recharge estimates of approximately 32,000 afy.

If necessary, this model will be updated and refined during Project operations based on data obtained from the monitoring features.

4.1.1.2 MODFLOW-2000/MT3D - Groundwater Flow And Transport Model

Geoscience Support Services, Inc. (Geoscience) developed a numerical groundwater flow and solute transport model of a large portion of the larger watershed area, based on MODFLOW2000 and MT3D. This model provides the basis for developing the density-dependent model described in the next section. If necessary, this model along with other models, will be updated and refined during Project operations based on monitoring data, and the monitoring network and action criteria refined during the Project if needed.

The numerical groundwater flow and solute transport model was developed based on a conceptual model developed during the pre-operations stage incorporating the area of interest, aquifer systems and boundary conditions. This conceptual model of hydrogeology and groundwater flow conditions in the larger watershed area will be

further refined based upon a thorough analysis of the available hydrogeologic data for the modeled area as additional information is collected from installation of the monitoring wells and extraction wells, and as monitoring data are compiled during the operations stage. The groundwater flow model will integrate quantities and distribution of recharge and discharge estimated from updates to INFIL3.0 and Project extractions.

4.1.1.3 Density-Dependent Groundwater Flow And Transport Model, Including Subsidence

A density-dependent flow and transport model based on SEAWAT-2000 was also developed by Geoscience. This model simulates the transport of solute mass through numerical solution of a mass balance equation involving fluid density, and was specifically designed to estimate the likely effects of Project operations on the projected saline/freshwater interface (northerly of the margins of the dry lakes). The single solute species, total dissolved solids (TDS) is transported conservatively (i.e., there is no absorption or any other losses of TDS) in the model. Sources and boundary conditions of solutes are specified as sources of salts, such as the dry lakes.

The model domain extends over the same area as the flow and solute transport model domain. The height, and horizontal and vertical grid spacing was selected based on available data and the intended use of the model. These models include hydraulic conductivity, specific storage, effective porosity, and dispersion coefficients for each model element. Specified flux and chloride mass fraction was provided by the regional groundwater flow and solute transport model described previously.

In addition, in order to simulate subsidence potential, the density-dependent flow and transport model was augmented by incorporating the Subsidence and Aquifer-System Compaction (SUB) Package (Hoffmann, et. al, 2003). The SUB package is used in conjunction with SEAWAT-2000 to simulate the elastic (recoverable) compaction and expansion and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The deformation of interbeds is caused by changes in effective stress as a result of groundwater level changes. If the stress is less than the preconsolidation stress of the sediments, the deformation is elastic (i.e., recoverable). If the stress is greater than the preconsolidation stress, the deformation is inelastic (i.e., permanent).

If necessary, this model will be updated and refined during Project operations based on data obtained from the monitoring features.

4.1.2 *Application of Water Resources Models*

To obtain a comprehensive understanding of the likely effects of the Project's proposed groundwater extraction and storage activities, Cadiz Inc. retained the firm Geoscience to assess the Project's potential impacts associated with environmental concerns, including lowering of groundwater levels, movement of the saline water/freshwater interface and potential land subsidence.

Building on prior technical investigations of area groundwater resources, geologic mapping, and recent exploratory drilling and testing, Geoscience developed a three-dimensional density-dependent groundwater flow and solute transport model of a larger portion of the larger watershed area to simulate the operation of the proposed wellfield and its effects on groundwater levels, groundwater in storage, the freshwater/saltwater interface near the dry lakes, and potential land subsidence. The results of Geoscience's investigation and modeling are set forth in its report titled Cadiz Groundwater Modeling and Impact Analysis, dated September, 1, 2011.

Geosciences's groundwater model consists of a six-layer density-dependent flow and solute transport model constructed to simulate the groundwater conditions that underlie Fenner Valley, Fenner Gap, and a portion of the Bristol and Cadiz Dry Lakes. Recent geologic mapping, interpretive geologic cross-sections, and lithologic logs from exploratory borings and water wells, along with geologic and hydrologic data available in the literature, are used to develop the six model layers. The model layers consist of the following:

- Layer 1 - Upper Alluvium
- Layer 2 - Alluvium beneath the Upper Alluvium to a depth of approximately 1,200 ft
- Layer 3 - Alluvium beneath a depth of 1,200 ft
- Layer 4 - Fanglomerate, carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 5 - Carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 6 - A Detachment Fault Zone (approximately 200 ft thick) in the Fenner Gap area, and weathered granitic rocks.

(Geoscience, September 1, 2011).

Geoscience simulated two wellfield configurations as shown in Figures 4-1 and 4-2. The first simulation (Configuration A) modeled a wellfield configuration of two large-capacity wells in the carbonate units encountered in the Fenner Gap area, which results in a more tightly clustered wellfield in the Fenner Gap area. The second simulation (Configuration B) assumed a more dispersed wellfield with pumping more evenly distributed among the wells.

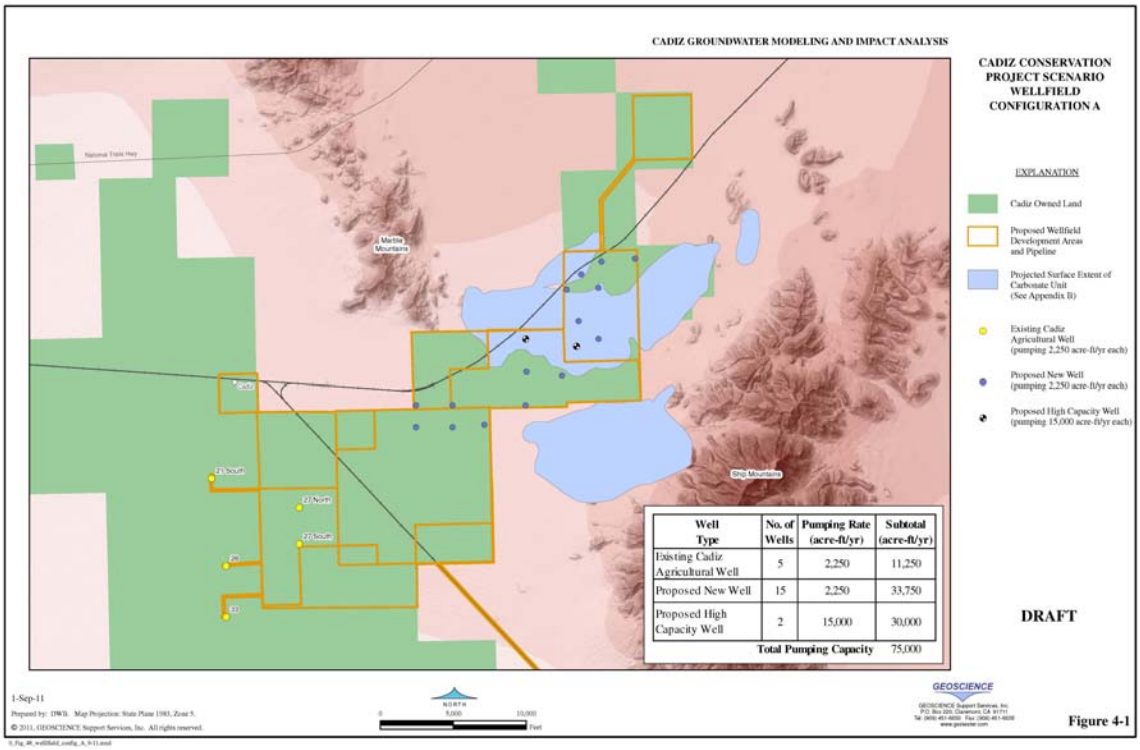
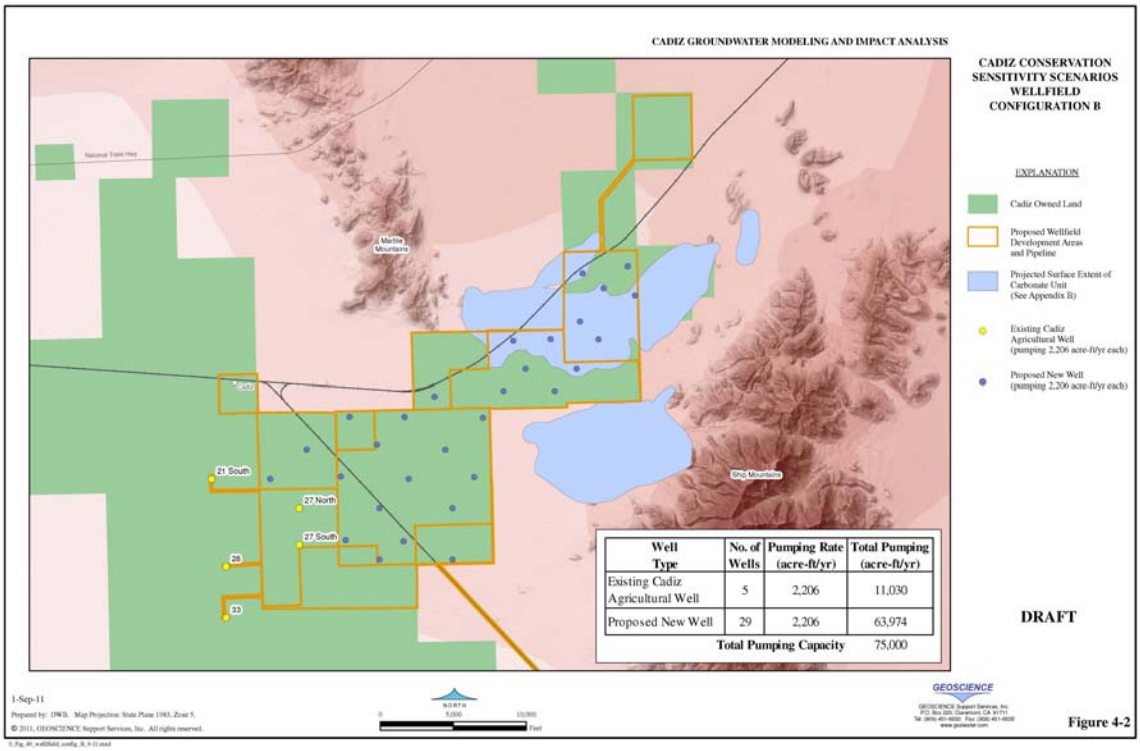


Figure 4-1



The groundwater model developed by Geoscience assumed horizontal groundwater flow through each model layer, with vertical leakage providing hydraulic connection between the layers. The model accounted for both natural and artificial recharge, as well as discharge via evaporation at the dry lakes and agricultural pumping. Geoscience applied the industry standard "history matching" technique to both steady state and transient calibration. For each calibration run, the relative error was 0.15% for the steady state model and 1.7% for the transient model, both well below the recommended relative error of 10%.

Geoscience simulated three recharge scenarios, including 5,000 afy, 16,000 afy, and 32,000 afy to assess effects on groundwater levels, the movement of the freshwater/saltwater interface near the dry lakes, and land subsidence. The 32,000 afy recharge scenario is based on INFIL3.0 modeling of the soil-moisture water budget for the Fenner and Orange Blossom Wash watershed areas. Geoscience simulated this large range in long-term average annual recharge by reducing the projected recharge by 50 percent (16,000 afy) and then to an amount that is generally equivalent to Cadiz historical agricultural pumping (5,000 afy) in order to increase the conservatism of the analysis (identify potential worst-case impacts).

After the model was calibrated, Geoscience simulated 100-year predictive runs for each of the three ranges of recharge scenarios, including 32,000 afy, 16,000 afy, and 5,000 afy.

The Project Scenario assumed 32,000 afy of natural recharge, and a Project wellfield clustered around Fenner Gap (Configuration A). The 32,000 afy recharge scenario was based on INFIL3.0 modeling of the soil-moisture water budget for the Fenner and Orange Blossom Wash watershed. The two Sensitivity Scenarios, which assumed less natural recharge and a Project wellfield spread out from Fenner Gap (Configuration B), allowed Geoscience to evaluate the potential range of worst-case impacts on groundwater levels, migration of the saline/freshwater interface, and subsidence. The model scenarios and assumptions used in each are summarized in Table 4-1.

TABLE 4-1: GEOSCIENCE GROUNDWATER MODEL ASSUMPTIONS

Model Scenario	Model Assumptions			
	Natural Recharge (afy)	Wellfield Configuration	Groundwater Pumping Years 1 to 50 (afy)	Groundwater Pumping Years 50 to 100 (afy)
Project Scenario	32,000	Configuration A	50,000	0
Sensitivity Scenario 1	16,000	Configuration B	50,000	0
Sensitivity Scenario 2	5,000	Configuration B	50,000	0

4.1.2.2 Project Impact Findings from Groundwater Flow Model

Based on the results of its groundwater model, Geoscience made the determinations about the impact of the Project discussed in this section below. As the Project is implemented, data will be obtained from drilling and testing of Project production and monitoring wells and monitoring data will be obtained as a part of the monitoring plan described in Chapter 5. The monitoring plan will serve to verify the model projections. As data are obtained, these water resources models will be periodically updated to continuously assess the validity of the model projections and if necessary, to revise the

monitoring program, action triggers, and mitigation responses as described in Chapter 6.

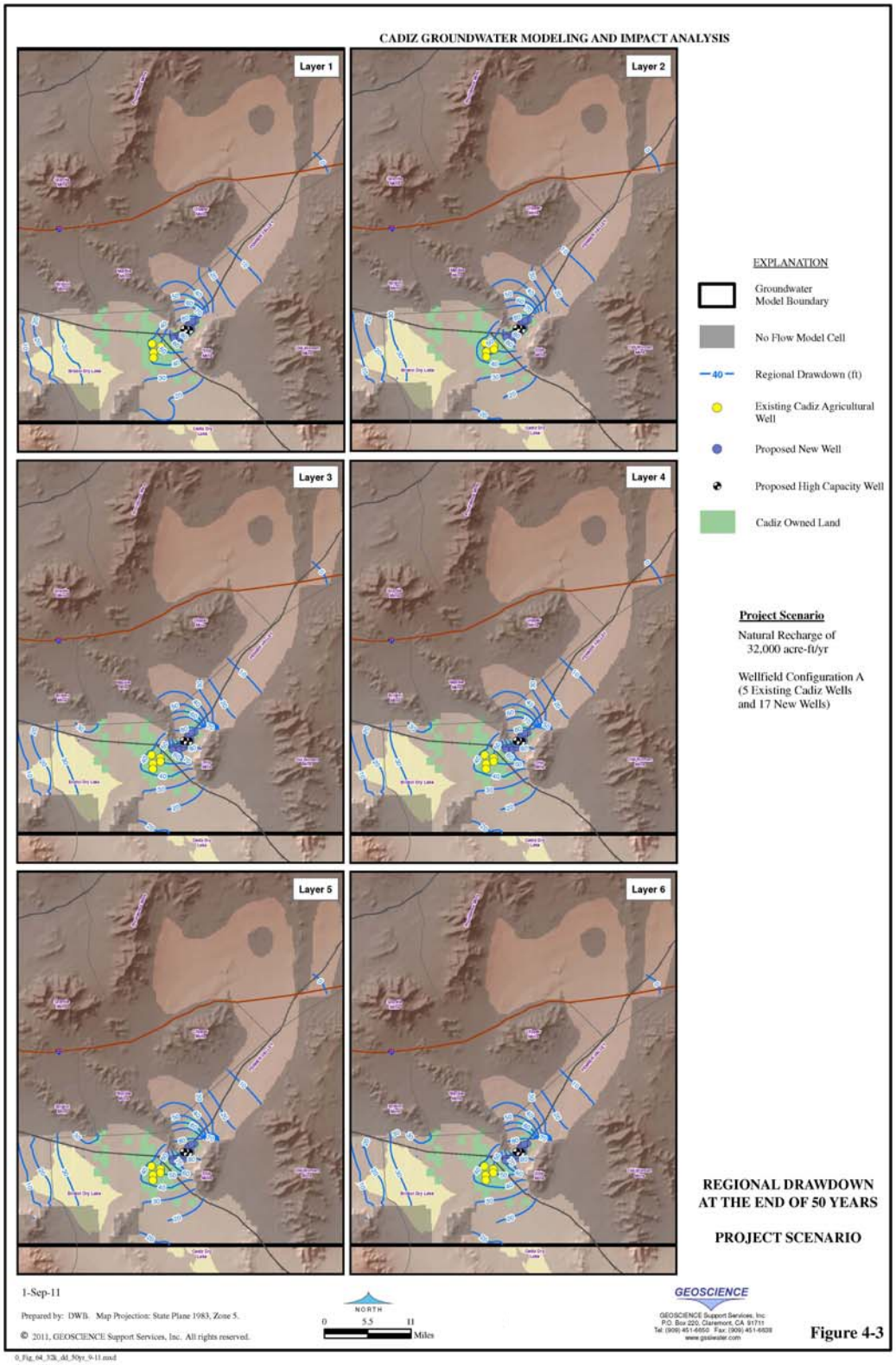
4.1.2.3 Groundwater Elevations

Table 4-2 below shows the change in groundwater elevations at the end of year 50 under each model-calculated scenario. The lowest groundwater levels (i.e., greatest impact) would occur at the center of the Project wellfield. The pumping would create a cone of depression and groundwater would flow toward the proposed wellfield from Fenner, Bristol and Cadiz valleys. At the end of 100 years, groundwater levels in the wellfield approach pre-Project levels for the Project scenario (full recovery in Year 117) (Geoscience, September 1, 2011). For the two scenarios simulating lower recharge values, recovery to pre-Project levels is estimated to occur approximately 100 to almost 400 years after pumping stops. The groundwater flow model simulations show that there is no chronic decline of groundwater levels: groundwater levels are drawn down to effect capture of water that would otherwise evaporate to the dry lakes, then groundwater levels recover upon cessation of pumping.

TABLE 4-2: GROUNDWATER DRAWDOWN IMPACTS

Model Scenario	End of 50 Years (End of Project Pumping)		End of 100 Years (End of Model Simulation or 50 Years After Pumping Stops)	
	Drawdown at Wellfield (feet)	**Drawdown at Bristol Dry Lake (feet)**	**Drawdown at Wellfield (feet)**	**Drawdown at Bristol Dry Lake (feet)**
Project Scenario	70 – 80	10 – 30	0 – 10	10 – 20
Sensitivity Scenario 1	120 – 130	10 – 60	10 – 20	30 – 40
Sensitivity Scenario 2	260 – 270	0 – 80	50 – 60	10 – 70

Figures 4-3 through 4-8 show groundwater-level drawdown for those various recharge scenarios simulated, both at the end of 50 years of pumping and then for 50 years since cessation of pumping (for a total of simulated period of 100 years). Groundwater level drawdown decreases northward into Fenner Valley, such that drawdown effects near Danby decrease to about 15 feet and at Interstate 40 (and certainly at Goffs) are negligible. The following observations are made from these simulations:


CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Proposed High Capacity Well
Cadiz Owned Land
Project Scenario
Natural Recharge of 32,000 acre-ft/yr
Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)
REGIONAL DRAWDOWN AT THE END OF 50 YEARS
PROJECT SCENARIO
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0
5.5
11
Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.geoinwater.com
Figure 4-3

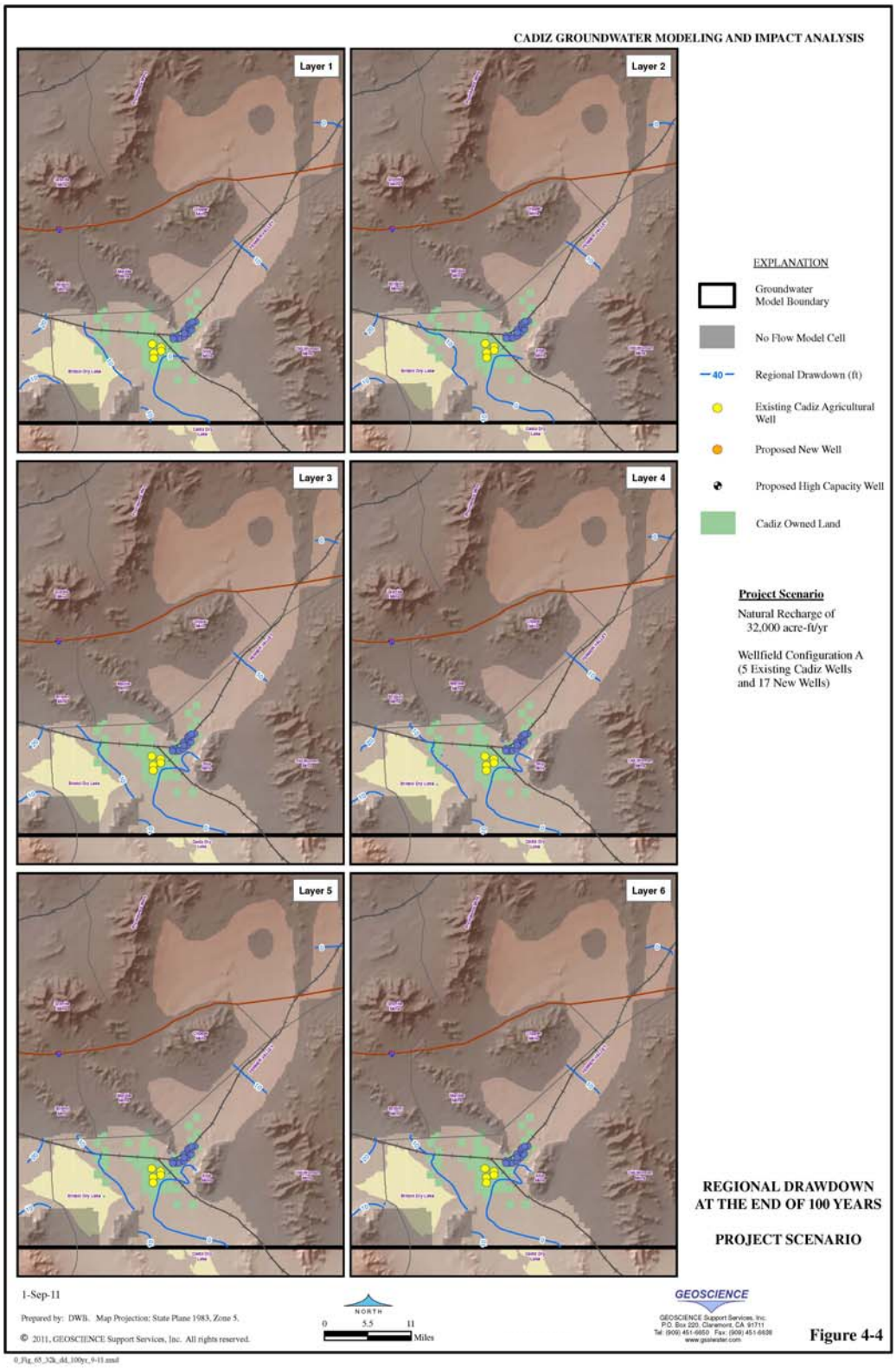

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Proposed High Capacity Well
Cadiz Owned Land
Project Scenario
Natural Recharge of 32,000 acre-ft/yr
Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)
REGIONAL DRAWDOWN AT THE END OF 100 YEARS
PROJECT SCENARIO
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0 5.5 11 Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.geoinstar.com

Figure 4-4

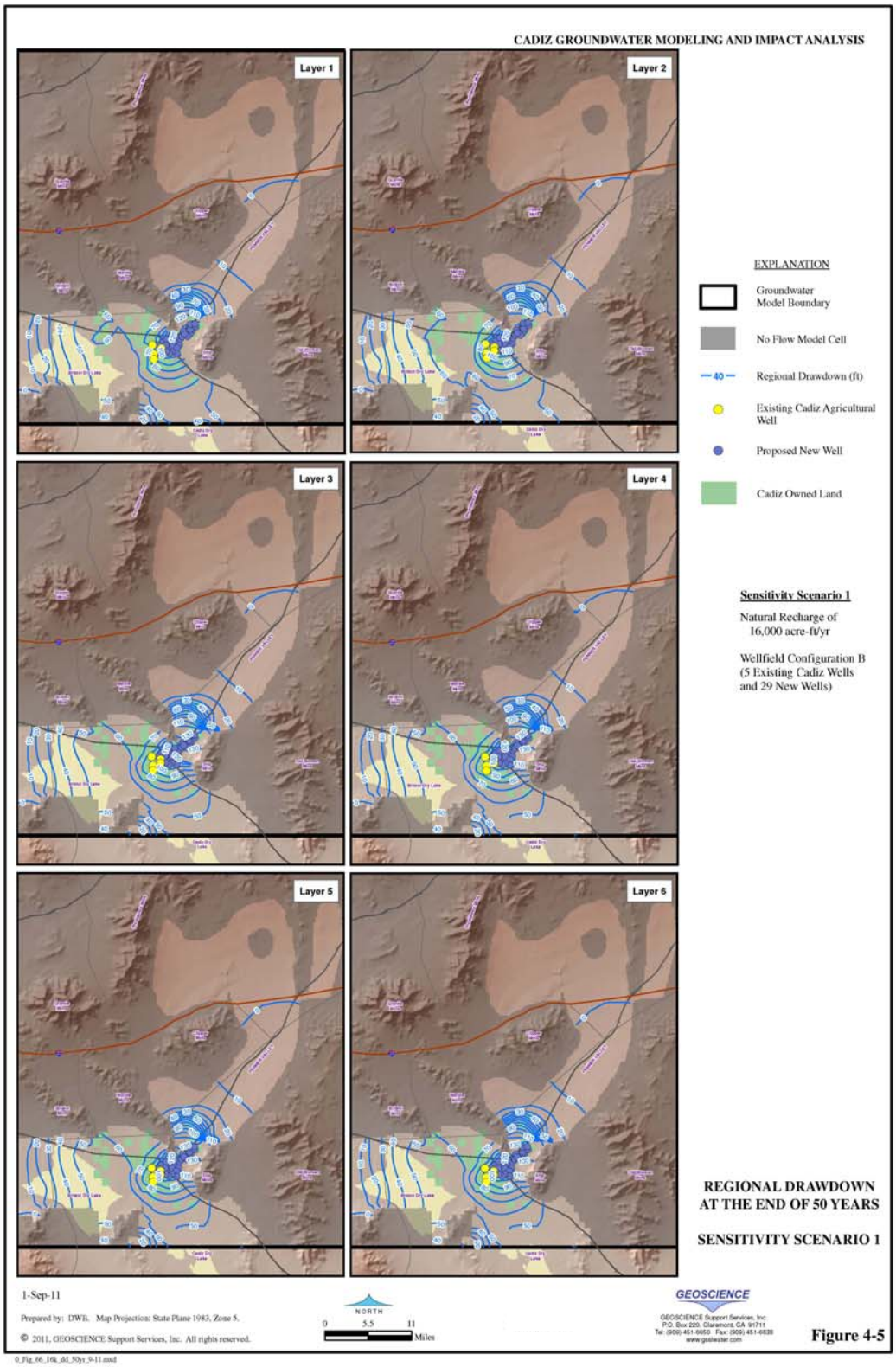
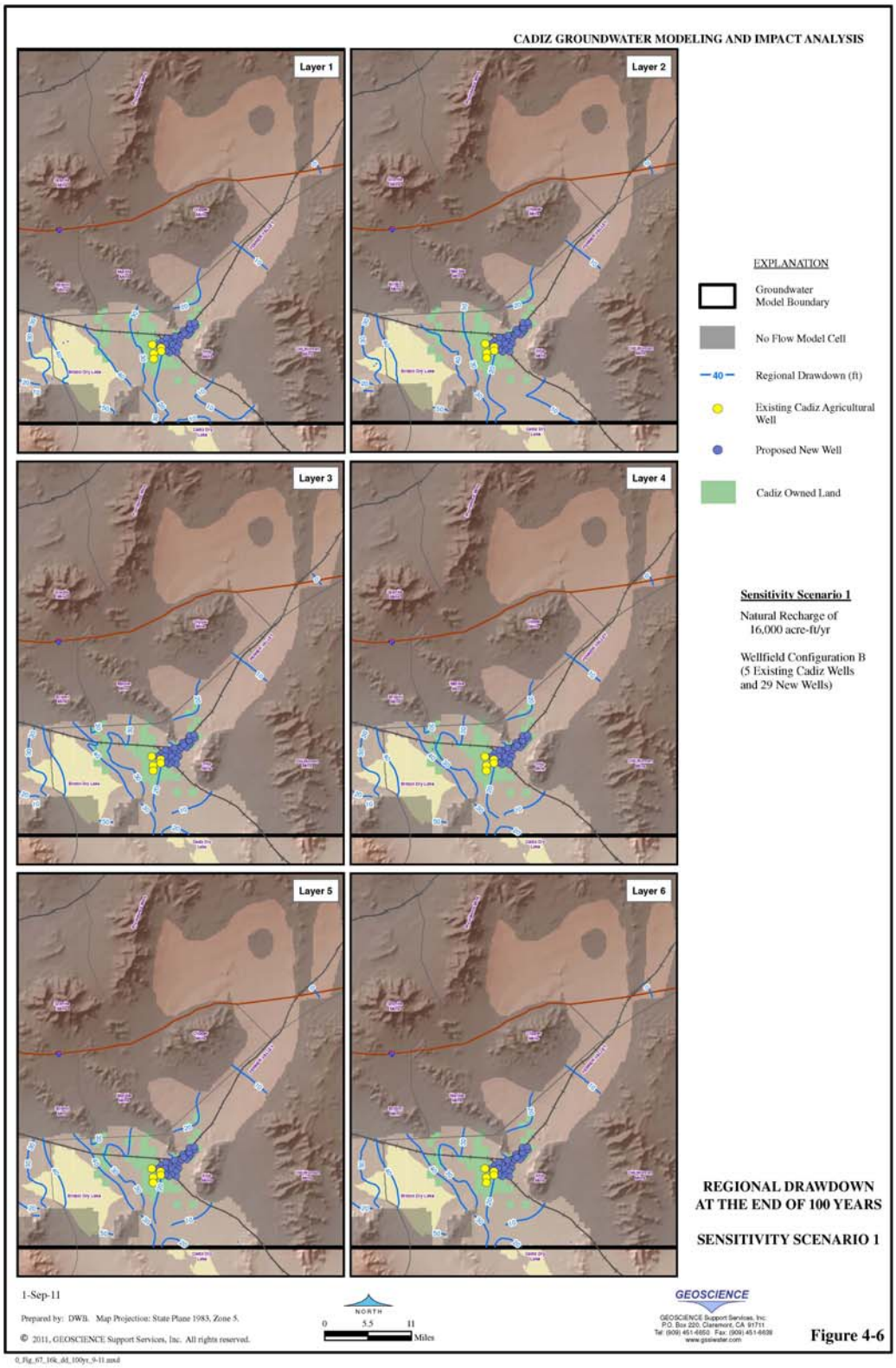
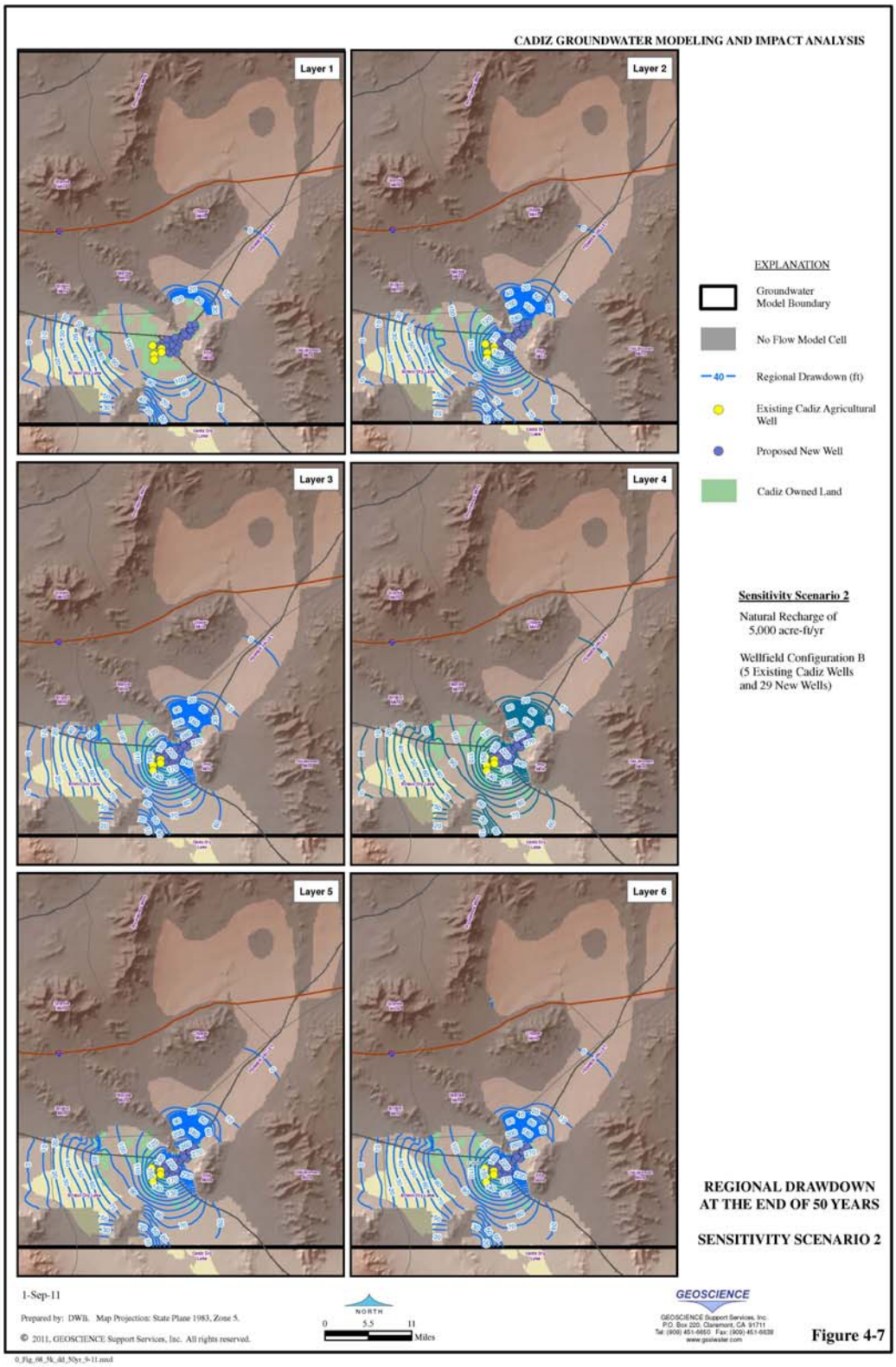

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Cadiz Owned Land
Sensitivity Scenario 1
Natural Recharge of 16,000 acre-ft/yr
Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)
REGIONAL DRAWDOWN AT THE END OF 50 YEARS
SENSITIVITY SCENARIO 1
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0 5.5 11
Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel. (909) 451-6650 Fax. (909) 451-6638
www.geoswater.com
0_Fig_66_16k_dd_50yr_9-11.mxd

Figure 4-5


CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Cadiz Owned Land
Sensitivity Scenario 1
Natural Recharge of 16,000 acre-ft/yr
Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)
REGIONAL DRAWDOWN AT THE END OF 100 YEARS
SENSITIVITY SCENARIO 1
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0
5.5
11
Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gsiwater.com
Figure 4-6


CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Cadiz Owned Land
Sensitivity Scenario 2
Natural Recharge of 5,000 acre-ft/yr
Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)
REGIONAL DRAWDOWN AT THE END OF 50 YEARS
SENSITIVITY SCENARIO 2
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0
5.5
11
Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gsiwater.com
Figure 4-7

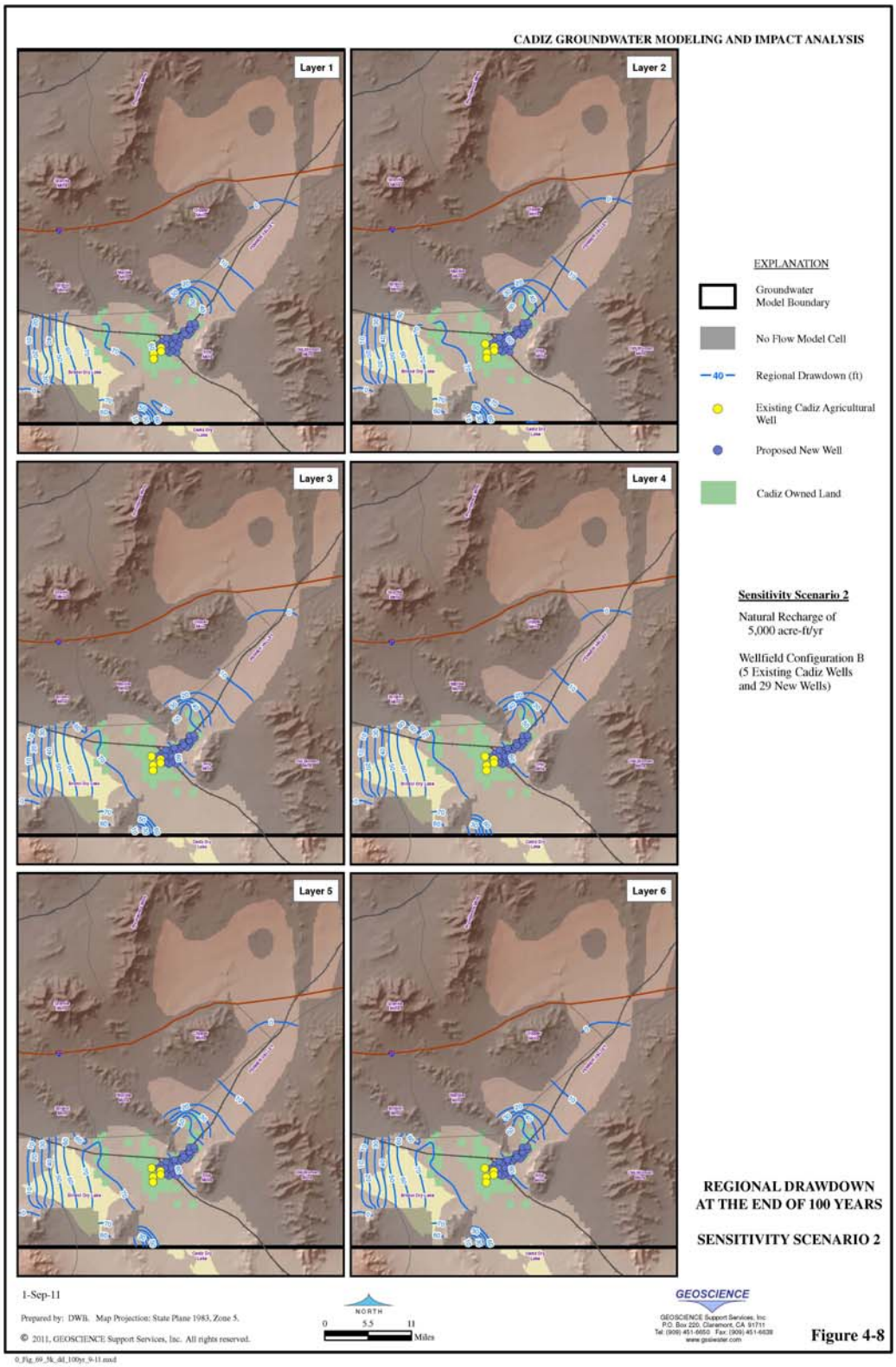

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
EXPLANATION
Groundwater Model Boundary
No Flow Model Cell
40
Regional Drawdown (ft)
Existing Cadiz Agricultural Well
Proposed New Well
Cadiz Owned Land
Sensitivity Scenario 2
Natural Recharge of 5,000 acre-ft/yr
Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)
REGIONAL DRAWDOWN AT THE END OF 100 YEARS
SENSITIVITY SCENARIO 2
1-Sep-11
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.
NORTH
0
5.5
11
Miles
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel. (909) 451-6650 Fax. (909) 451-6638
www.geoswater.com

Figure 4-8

4.1.2.4 Depth to Groundwater

Table 4-3 shows the predicted depth to groundwater during the 100 year model simulation period at selected locations including the center of the Project wellfield, the existing Cadiz Inc. wells, the edge of the Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake. (Geoscience, September 1, 2011). There is no chronic decline in groundwater levels attributable to the Project: groundwater levels decline for a specific purpose during pumping in order to capture groundwater that is flowing to the dry lakes. The Project operations are for a limited term (50 years) in which the Project objectives can be achieved. Thereafter, groundwater levels will recover upon cessation of pumping.

TABLE 4-3: GROUNDWATER MODEL DEPTH IMPACTS

Location	Time	Depth to Groundwater (feet)			
		Existing	Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	End of 50 Years	354	435	486	627
	End of 100 Years		351	371	412
Existing Cadiz Inc. Wells	End of 50 Years	156	197	241	315
	End of 100 Years		154	181	219
Edge of Bristol Dry Lake	End of 50 Years	33	68	95	118
	End of 100 Years		42	74	108
Center of Bristol Dry Lake	End of 50 Years	18	50	63	54
	End of 100 Years		33	62	79
Edge of Cadiz Dry Lake	End of 50 Years	7	21	59	72
	End of 100 Years		10	17	68

4.1.2.5 Saline/Freshwater Interface

Geoscience used the SEAWAT-2000 variable density groundwater flow and solute transport model to predict the movement of the saline/freshwater interface as a result of Project pumping. The location of the current saline/freshwater interface is defined by

the location of the 1,000 mg/L total dissolved solids (TDS) concentration contour, which is based on groundwater quality data from historical data from wells in the area.

Results of the modeling indicate that the saline/freshwater interface in the Bristol Dry Lake area would move up to 10,400 feet northeast during years 1-50 under the Project Scenario, up to 9,700 feet under Sensitivity Scenario 1, and up to 6,300 feet under Sensitivity Scenario 2. During years 50-100, after Project pumping has ceased, the saline/freshwater interface would continue to move northeast, reaching a total distance of 11,500 feet, 11,100 feet, and 9,200 feet under the Project Scenario, Sensitivity Scenario 1, and Sensitivity Scenario 2, respectively. Table 4-4 summarizes the maximum migration distance of the saline/freshwater boundary. (Geoscience, September 1, 2011). This extent of subsurface migration of saline/freshwater interface is not considered to be a significant adverse environmental impact because there are no known or projected beneficial users of fresh (<1,000 mg/l) groundwater in the affected area, nor is there any vegetation that uses the groundwater table in the affected area (see discussion below).

TABLE 4-4: SALINE/FRESHWATER BOUNDARY MIGRATION

Model Scenario	Maximum Migration of Saline/Freshwater Boundary at Year 50	Maximum Migration of Saline/Freshwater Boundary at Year 100
Project Scenario	10,400 ft Northeast	11,500 ft Northeast
Sensitivity Scenario 1	9,700 ft Northeast	11,100 ft Northeast
Sensitivity Scenario 2	6,300 ft Northeast	9,200 ft Northeast

4.1.2.6 Groundwater in Storage

Based on its groundwater model, Geoscience determined that the cumulative annual change in groundwater storage would reach a maximum of -1,090,000 acre-feet (a negative sign represents a decline in groundwater storage) in year 50 under the Project Scenario conditions. This change in storage reflects ongoing evaporation from the dry lakes of approximately 244,000 af and about 33,000 af of water contributed from

interbed storage ("squeezing" of water out of fine-grained units, which results in the compaction as discussed below), so an additional net loss of about 211,000 af during the initial 50 years, in addition to pumping beyond the natural recharge rate. Groundwater modeling shows that additional evaporative losses could be reduced by implementing higher pumping rates to more quickly change the hydraulic gradients (such as pumping 75,000 afy for 25 years and then 25,000 afy for 25 years (Geoscience, September 20, 2011)). This temporary decline in storage is approximately 3% to 6% of the total groundwater in storage, which is estimated to be 17 to 34 million acre-feet. The groundwater in storage would begin to recover after the Project pumping stops in year 50, and the cumulative annual change in groundwater storage would be approximately -220,000 acre-feet in year 100 under the Project Scenario. Evaporative losses to the dry lakes accelerates through time as groundwater levels recover between years 50 and 100. Based on the rate of recovery projected for years 51 to 100, the groundwater in storage would fully recover in year 117 (i.e., 67 years after Project pumping stopped). The contribution of water from interbed storage increases and the losses due to evaporation from the dry lakes decreases in the sensitivity scenarios. Table 4-5 summarizes the cumulative annual changes in groundwater storage as calculated from Geoscience's model simulations of the three scenarios. (Geoscience, September 1, 2011). This operation precludes the chronic decline of groundwater levels, as it establishes drawdown in groundwater levels for the purposes of capturing water that would otherwise discharge to the dry lakes and evaporate, then allows for recovery of groundwater levels subsequent to establishing this condition of capture.

TABLE 4-5: REDUCTION IN ALLUVIAL GROUNDWATER IN STORAGE

Model Scenario	Cumulative Annual Changes in Groundwater Storage at Year 50		Cumulative Annual Changes in Groundwater Storage at Year 100		Time to Full Recovery after Pumping Ceases in Year 50
	Volume (acre-feet)	% of Total Groundwater Storage	Volume (acre-feet)	% of Total Groundwater Storage	
Project Scenario	-1,090,000	3% - 6%	-220,000	1%	67 (year 117)
Sensitivity Scenario 1	-1,680,000	5% - 10%	-870,000	3% - 5%	103 (year 153)
Sensitivity Scenario 2	-2,160,000	6% - 13%	-1,870,000	6% - 11%	390 (year 440)

4.1.2.7 Potential Land Subsidence

Because the Project involves a temporary strategic lowering of groundwater levels as discussed above in Chapter 3, potential land subsidence is a concern that must be evaluated and monitored. In general, the potential for land subsidence corresponds to the magnitude of groundwater level decline and the thickness of the fine-grained layers in the aquifer. Based on the results of the Geoscience groundwater model, any predicted subsidence would occur gradually and be dispersed laterally over a large area from the Fenner Gap to the Bristol and Cadiz Dry Lakes. Table 4-6 summarizes the model-predicted land subsidence over time at selected locations including the center of the wellfield, existing Cadiz Inc. wells, the edge of Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake. (Geoscience, September 1, 2011.) This degree of potential land subsidence would not significantly impact the alluvial aquifer's storage capacity because consolidation of the aquifer will occur in clay and silt intervals, which do not contribute to the useable storage capacity. Potential subsidence in the range projected is also unlikely to harm any surface structures (for example, subsidence is not expected to exceed thresholds established for railroad tracks by the Federal

Railroad Administration Track Safety Standards Compliance Manual, April 1, 2007). Subsidence at, or below, the range projected in Table 4-6 is therefore not determined to be a significant environmental impact. This Management Plan nonetheless provides at Chapter 6 for monitoring and action criteria triggers, and potential corrective actions that may be taken in response to the triggering of those action criteria.

TABLE 4-6: MAXIMUM POTENTIAL LAND SUBSIDENCE

Location	Time	Maximum Potential Land Subsidence (feet)		
		Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 1
Center of Wellfield	End of 50 Years	0.2	0.4	0.7
	End of 100 Years	0.2	0.4	0.7
Existing Cadiz Wells	End of 50 Years	0.6	1.0	1.5
	End of 100 Years	0.6	1.0	1.5
Edge of Bristol Dry Lake	End of 50 Years	0.5	1.0	1.4
	End of 100 Years	0.5	1.0	1.7
Center of Bristol Dry Lake	End of 50 Years	0.9	1.7	1.2
	End of 100 Years	0.9	2.1	2.7
Edge of Cadiz Dry Lake	End of 50 Years	0.1	0.4	0.5
	End of 100 Years	0.1	0.4	0.6

4.2 Potential Impacts to Springs Within the Fenner Watershed

A potential adverse environmental impact that, depending on physical conditions, can result from lowering of regional groundwater levels is the cessation or reduction of flow from area springs. Native springs are present in the vicinity of the Project within the Fenner Watershed, as shown in Figure 4-9 (CH2M Hill, August 2011.) These springs support habitat of the desert environment, and some are located within the Mojave National Preserve and BLM-managed lands. Those springs closest to the proposed Cadiz extraction wellfield are located in the adjacent mountains and include: Bonanza Spring, Hummingbird Spring, and Chuckwalla Spring in the Clipper Mountains to the north; Willow Spring, Honeymoon Spring, Barrel Spring and Fenner Spring in the Old Woman and Piute Mountains on the east; and Van Winkle Spring, Dripping Spring, Unnamed-17BS1, Unnamed-17GS1, Granite Cove Spring, Cove Spring, BLM-1 and BLM-2 springs at the Southern End of the Providence Mountains. (*Id.*) The Bonanza Spring in the Clipper Mountains, which is the closest spring to the proposed extraction wellfield, is over 11 miles from the center of the Fenner Gap. (*Id.*) All Fenner Watershed springs, including Bonanza Spring, are located in hard rock formations substantially higher in elevation than the alluvial aquifer. (*Id.*)

CH2M HILL was retained to evaluate the potential that the lowering of groundwater levels, as proposed by the Project, could impact the flow from Fenner Watershed springs. The results of CH2M HILL's analysis are set forth in a report titled "Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs," dated August 3, 2011. CH2M HILL reviewed the groundwater flow modeling results reported by Geoscience (Geoscience, September 1, 2011.) and developed two conceptual models of the Bonanza Spring, which was chosen as an appropriate indicator spring of all springs in the Fenner Watershed because it is the closest spring to the Project's proposed wellfield, and thus would be the most likely to experience any effect from the Project of any of the Fenner Watershed springs.

In the first conceptual model (Concept-1), there is no physical connection of the springs to a regional groundwater table. This model is based on the absence of any information demonstrating a physical connection of the springs to a regional groundwater table, the elevation differences between the groundwater in the alluvial aquifer and elevation of the springs, and the distance between the saturated alluvial aquifer and springs. Under this concept, the spring is fed by upstream fracture flows that are not hydraulically connected to the regional water table, and thus flow rates at the spring are independent of groundwater levels in the alluvium, and no impacts would occur to the spring as a result of Project operations.

Although there is no information that demonstrates a direct hydraulic connection between the springs and a regional groundwater table, the second conceptual model (Concept-2) assumed that such a connection exists. A simple numerical groundwater flow model was developed around this concept to evaluate potential impacts under Concept-2, where hydraulic continuity is assumed, in which the regional water table forms the source of water to the springs. The model was a simple representation of a generic mountain system with similar characteristics to the Clipper Mountains, intended to evaluate the general response of a water table in fractured bedrock of mountains under various assumptions that are specific to the Bonanza Spring hydrogeologic conditions. The results of the Concept-2 model suggest that a ten foot decline in groundwater levels at the Project wellfield (an assumption derived from simulations by Geoscience discussed above) could result in about six to seven feet of drawdown at the springs after hundreds of years and assuming that the decline in the adjacent alluvial aquifer was maintained at ten feet of drawdown. For example, CH2M HILL explains that after about 100 years, the drawdown would only be about 25 percent of the potential maximum drawdown in the alluvial aquifer. In addition, it is possible that, depending on how muted the water table response is to annual changes in precipitation, natural fluctuations of groundwater levels at the spring due to climate variability could be of a similar order of magnitude to potential Project-induced drawdown at the springs. CH2M HILL determined that such an impact would not be material.

CH2M HILL further determined that potential impacts to other springs in the southern part of Fenner Watershed are expected to be de minimus and even more remote than hypothetical potential impacts on the Bonanza Spring because those springs are at higher elevations and greater distances from the adjacent alluvial aquifer compared to Bonanza Spring. Consequently, CH2M HILL determined that any Project effect on other springs in the Fenner watershed would be at most inconsequential.

In sum, because of the distance, change in elevation, and assumed lack of hydraulic connection between the fractured bedrock groundwater feeding the Fenner Watershed springs and the alluvial groundwater developed by the Project, there is no anticipated impact of the Project on Fenner Watershed springs, and even assuming hydraulic connection (as CH2M HILL modeled in Concept-2), any impact would not be material. Nonetheless, consistent with the recommendations of the Groundwater Stewardship Committee and as discussed in Chapters 5 and 6, this Management Plan provides for visual, non-invasive monitoring of spring flows from Bonanza Spring, Whiskey Spring, and Vontrigger Spring to confirm the modeling results.

4.3 Potential Impacts to Brine Resources Brine Resources at Bristol and Cadiz Dry Lakes

The brine groundwater at the Bristol and Cadiz Dry Lakes support two existing salt mining operations. These operations involve evaporation of the hyper-saline groundwater from the dry lakes to obtain remaining salts. Potential Project impacts to brine resources on Bristol and Cadiz Dry Lakes are limited to potential lowering of the groundwater or brine water levels within wells used by the salt mining operations

The density-dependent groundwater flow and transport modeling by Geoscience shows that groundwater levels beneath Bristol dry lake potentially will be lowered by 10 to 30 feet under the Project Scenario and as much as 80 feet under Sensitivity Scenario 2. These depths are well within the feasibility to continue to extract brine resources from the dry lakes. FVMWC will work with the mining operators on the dry lakes to discuss potential impacts (economic in additional to physical) and potential mitigation measures as appropriate.

4.4 Potential Impacts to Air Quality

The Project is in the Mojave Desert Air Basin (MDAB). The MDAB is an assemblage of mountain ranges interspersed with long broad valleys that often contain dry lakes. Many of the lower mountains which dot the vast terrain rise from 1,000 to 4,000 feet above the valley floor. Prevailing winds in the MDAB are out of the west and southwest. These prevailing winds are due to the proximity of the MDAB to coastal and central regions and the blocking nature of the Sierra Nevada Mountains to the north; air masses pushed onshore in Southern California by differential heating are channeled through the MDAB. The MDAB is separated from the Southern California coastal and Central California valley regions by mountains where highest elevation reaches approximately 10,000 feet, and whose passes form the main channels for these air masses.

The Mojave Desert is bordered on the southwest by the San Bernardino Mountains, which are separated from the San Gabriel Mountains by the Cajon Pass (4,200 feet). A lesser channel, the Morongo Valley, lies between the San Bernardino Mountains and the Little San Bernardino Mountains.

One potential adverse environmental impact that, depending on physical conditions, can result from dewatering of aquifers in the vicinity of dry lakes is the potential to materially increase fugitive dust from the playa surface, thereby increasing the severity of area dust storms. Examples of this problem have been documented in the Mojave

Desert at the Owens and Franklin Playas. To evaluate the potential for increased fugitive dust resulting from the Project, the consulting firm HydroBio was retained to evaluate whether the Project's intended groundwater production would have an adverse effect on the generation of dust from the surface playas of the Bristol and Cadiz Dry Lakes. The results of HydroBio's investigation are set forth in a report titled Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California, dated August 30, 2011.

HydroBio's investigation characterized the soil chemistry and structure on the Bristol and Cadiz Playas and the immediate margins to evaluate the relationship between groundwater and surface soils. (HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011.) HydroBio's study found that the soil and water chemistry of both Cadiz and Bristol Playas have very low quantities of the sodium salts of carbonate, bicarbonate and sulfate that are known to cause severe fugitive dust storms from Owens and Franklin Playas. (*Id.*) The study explains that Bristol Playa does produce fugitive dust from erosion by sand grains driven by high wind across the playa surface. In this process, the quantity of sand available on the playa margin is responsible for the magnitude of the dust release. The available sand appears to have diminished over time and this is hypothesized to be due to the action of a mix of weedy species that have grown increasingly dominant over the past 50 years. The severity of Bristol Playa fugitive dust is believed to be diminishing with time. (*Id.*) Importantly, the HydroBio study concluded that changes in groundwater level, which may result from the Project's groundwater production, will likely have no impact upon the amount dust production from the playas or severity of area dust storms. (*Id.*)

With respect to the Cadiz Playa, the study concluded that the Cadiz Playa appears to be the sink for the sand blown from the region of the Bristol Playa directly upwind to the northwest. (*Id.*) This sand tends to be stabilized by the growth of Russian thistle (tumbleweed). While the Cadiz Playa has the same soil and water chemistry as the Bristol Playa, the copious sand dunes around the shore, particularly in the north to northeast regions result in large amounts of available sand to erode the playa surface, thereby adding dust to area dust storms. (*Id.*) However, the HydroBio study concluded that the potential lowering of groundwater levels within the Cadiz Dry Lake will not affect the amount of dust or severity of dust storms emanating from the Playa. (*Id.*)

The HydroBio study explains that the reason that the potential lowering of water levels in the Bristol and Cadiz Playas will not affect fugitive dust concentrations and occurrence is that the chemistry of the soil comprising the playas is not of the type that causes an increase in fugitive dust as a result of lowered groundwater levels.

Specifically, the study explains that the chemistry of the Bristol and Cadiz Playas is low in carbonate, bicarbonate and sulfate ions that are implicated in other playas that produce major dust storms (such as Owens and Franklin Playas). Instead, the Bristol and Cadiz Playas playa contains chemistry that has been noted to induce surface stability (Ca, Na and Cl). Cadiz Playa appears to have the same chemistry. For these reasons, it is not anticipated that the Project will have any material effect on the concentration of dust emanating from the Bristol and Cadiz Playas nor the severity of area dust storms. Nonetheless, consistent with the recommendations of the Groundwater Stewardship Committee and as discussed in Chapters 5 and 6 and the avoidance of doubt, this Management Plan provides for the installation and monitoring of two nephelometers to confirm these technical conclusions.

4.5 Potential Impacts to Project Area Vegetation

Another potential adverse environmental impact that, depending on physical conditions, can result from lowering of groundwater levels is the lowering of groundwater tables that are accessed by area vegetation, thereby causing the stress or death of that vegetation. Vegetation in environments like that found in the Project area, provides important stabilization of soils against the action of wind erosion. The consulting firm HydroBio was retained to evaluate whether the Project's intended groundwater production would have an adverse effect on the occurrence and health of area vegetation. The results of HydroBio's investigation are set forth in a report titled, Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California, dated September 1, 2011. The HydroBio study concludes that there is no connection of vegetation with groundwater in the Project area, and hence, no vegetation will be affected by changes in water table elevation. (HydroBio, September 1, 2011.)

HydroBio began its investigation by locating the most likely vegetation in the area potentially affected by the planned groundwater pumping. This "most likely" cover was identified by its higher activity (denser growth, larger plants) than all other locations around the Bristol Playa. Observations of the Cadiz Playa indicated that this region could be eliminated from concern because the vegetation around the playa is generally no more verdant than the surrounding area, hence obviously receiving no promotion from groundwater. HydroBio observed that the lowermost edge of the higher shrub zone was the region with higher vegetation activity that appeared to have the highest potential for connection of vegetation to groundwater. (*Id.*)

The HydroBio study explains that there are three shrub species that grow around the Bristol Playa: creosote bush [Larrea tridentata], cattle saltbush [Atriplex polycarpa] and

four wing saltbush [Atriplex canescens]. Of these, the only species that may act as a phreatophyte (a plant species that uses groundwater), is the four-wing saltbush, and that this species is specifically a facultative phreatophyte, meaning it can benefit from but does not require shallow groundwater. (*Id.*) To determine whether any of the area four-wing salt brush in the area are presently accessing groundwater, HydroBio reconstructed a curve for depth to water (DTW) versus elevation based on hydrographic data collected in the region of the Cadiz Ranch. A DTW point was added on the Bristol Playa that was reconstructed using photogrammetry. The study found that together, these points describe a highly linear relationship of DTW versus elevation above sea level (r2 = 99.9%). (*Id.*) Based on the robust and accurate relationship of the DTW curve, HydroBio estimated the DTW at the lowermost edge of the higher vegetation cover – the location most likely to have a vegetation/groundwater connection - was 65 feet. Root excavations of four-wing saltbush have been measured to reach a maximum of 25 feet on only rare occasions when soils and hydrology permit but typical root depths for the species average about 13 feet. Thus, based on measured and estimated DTW, the HydroBio study concluded that the shallowest water table position is 40 feet below the record rooting depth for the four-wing salt brush – the only species that could be potentially affected by groundwater decline. HydroBio therefore concluded that there is no connection of vegetation with groundwater in the region Project area. (*Id.*) HydroBio further hypothesized that the promotional effect of periodic surface flows from the upstream catchments is the reason for the apparent promotion of this vegetation. (*Id.*)

4.6 Potential Impacts to the Colorado River and its Tributary Sources of Water

It is assumed that the groundwater that would be extracted by the Project at the Fenner Gap is not tributary to the Colorado River because the aquifer systems within the Fenner, Bristol and Cadiz Watersheds are believed to be a closed basin, isolated from aquifer systems to the east that are tributary to the Colorado River by bedrock and groundwater divides. It is important to ensure that the Project groundwater is not tributary to the Colorado River for several reasons. First, the Colorado River is fully appropriated and rights to divert water therefrom are governed by a complex set of federal and state laws. Material extractions of tributary groundwater could reduce flows in the Colorado River, thus frustrating the administration of the Colorado River and affected environmental resources.

It is also important to confirm that the Project groundwater is not tributary to the Colorado River for purposes of satisfying the provisions of the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (Guidelines) administered by the U.S. Bureau of Reclamation

(Reclamation), for purposes of establishing Intentionally Created Surplus (ICS) credits under the Guidelines for potential Project participants that have contracts with the Reclamation for diversions from the Colorado River. Under the Groundwater Conservation and Recovery Component of the Project, groundwater that is non-tributary to the Colorado River would be introduced into the Colorado River Aqueduct as "new," non-tributary water. For potential participants who have contracts with Reclamation for Colorado River water, the receipt of Project water creates the opportunity to establish ICS Credits based on the use of non-tributary water supplies in lieu of Colorado River diversions pursuant to Reclamation contracts. This opportunity could allow a participant to further augment its water supplies and improve overall water supply reliability. To qualify for ICS credits under the Guidelines, the surplus water used in lieu of Colorado River diversions must be non-tributary to the Colorado River.

While the assumption that the Project groundwater is non-tributary to the Colorado River is supported by substantial physical evidence (e.g., bedrock and groundwater divides), two monitoring wells (one existing and another to be installed) on property owned by Cadiz within the adjacent Piute Watershed that is tributary to the Colorado River will be monitored for the purpose of further demonstrating no interconnection exists.

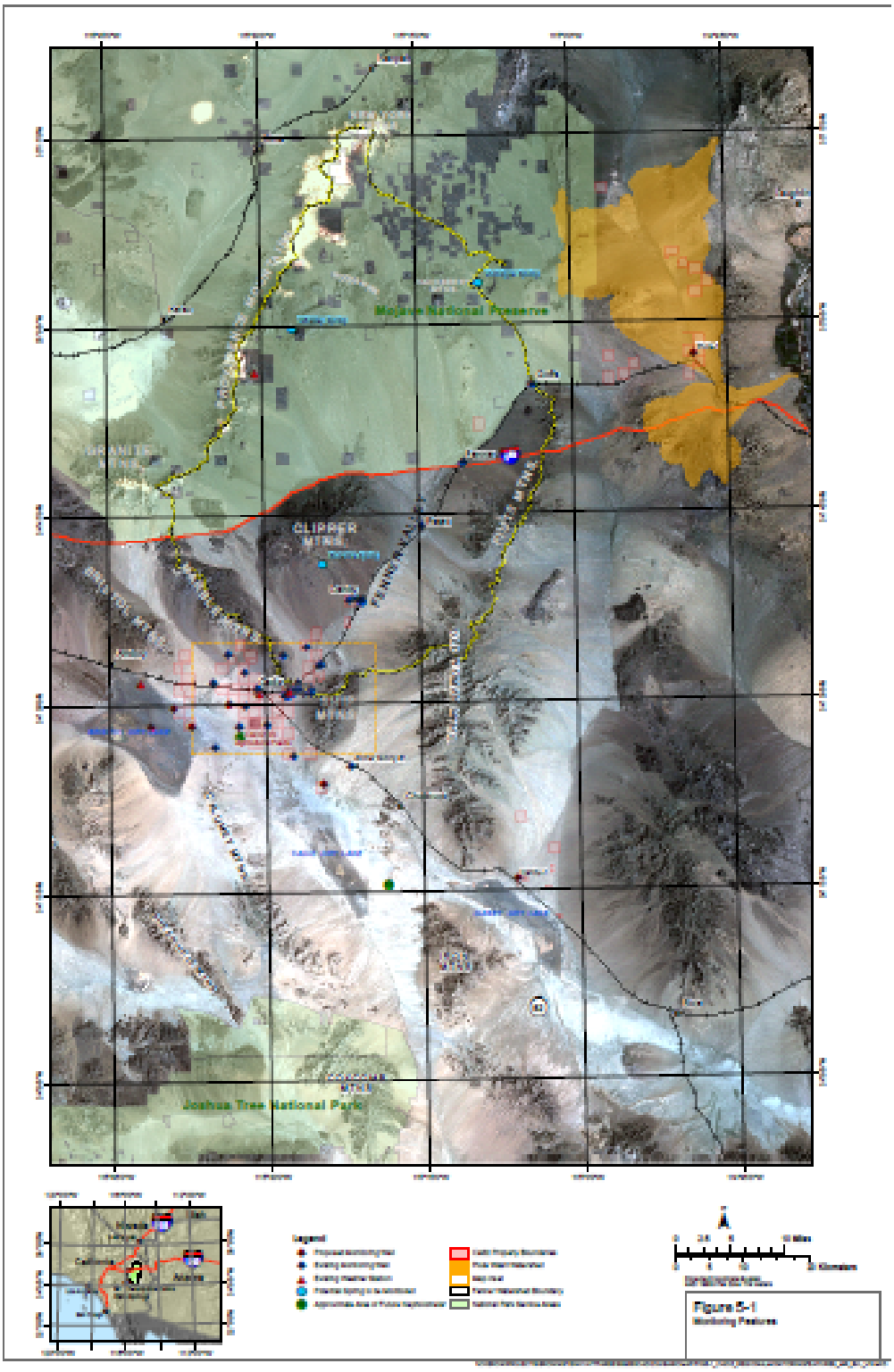
CHAPTER 5
MONITORING NETWORK

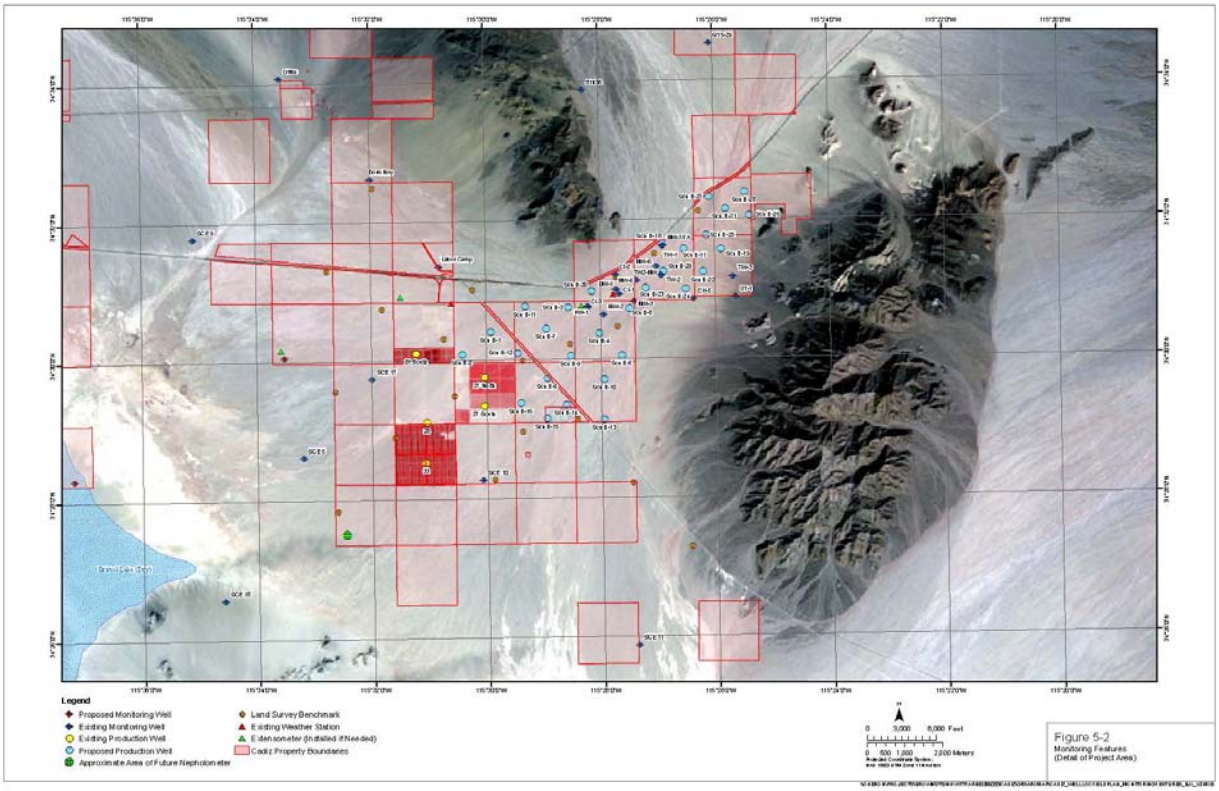
To ensure continued protection of the watershed and other resources, a comprehensive monitoring network has been developed to assess and continually evaluate the technical aspects of the Project, and any potential impacts to critical resources during the life of the Project, as designated in Chapter 4. The development of the monitoring network was based on the groundwater flow model that has been developed to better understand the hydrogeologic impacts of the Project's proposed groundwater production. The groundwater flow model will be continuously refined as additional monitoring data are obtained. (See discussion of groundwater flow model in Chapter 4).

This Management Plan will be implemented with a set of monitoring features and parameters as discussed in this Chapter. As new data becomes available, the monitoring features may be refined to ensure protection of critical resources in and adjacent to the Project wellfield area. If FVMWC proposes a refinement to monitoring features, it will submit a written proposal describing the refinement along with supporting data and materials to the TRP for review and recommendation to SMWD.

SMWD will make a final decision on FVMWC's proposal through the decision-making process described in Chapters 6 and 8.

A total of twelve different types of monitoring features have been identified for assessing potential impacts to critical resources during the term of the Project, as identified in Chapter 4. A summary of these twelve types of monitoring features, as well as monitoring frequencies and parameters to be monitored is provided in Tables 5-1 and 5-2. Generalized locations are shown in Figures 5-1 and 5-2.


Mojave National Preserve
CLIPPER MTNS.
Joshua Tree National Park
Figure 5-1



Installation of certain monitoring features, where construction of facilities is required, will be subject to site-specific approval and permitting by applicable regulatory agencies. Cadiz will complete and deliver all needed permits for monitoring facilities as soon as practicable within the pre-operational phase. FVMWC will construct all facilities that are agreed to in this Management Plan and for which permits have been received. Construction of these facilities will be completed within one year of receipt of permits. If the implementation of monitoring features currently contained in this Management Plan is not approved, FVMWC will evaluate and implement alternate monitoring sites subject to approval by SMWD (with review and receipt of recommendations by the TRP), and the applicable regulatory agencies.

The following text describes in detail the various proposed monitoring features.

5.2 Springs (Feature 1)

An inventory of 28 known springs within the Fenner Watershed was completed by the USGS (USGS, 1984). Locations of these springs are shown on Figure 5-3. As discussed in detail in Chapter 4, the potential for Project impacts to these springs has been evaluated. It is not anticipated that the Project will have any impact on the springs. Nonetheless, this Management Plan provides for quarterly monitoring of the Bonanza Spring as an "indicator spring" because it is the spring that is in closest proximity to the

Project wellfield (approximately 11 miles from the center of Fenner Gap), and of all springs within the Fenner Watershed, this one would be the first one to be affected by the Project, if it were somehow possible to be in hydraulic connection with the alluvial aquifers, which appears unlikely. The Whisky and Vontrigger Springs, which are located beyond the Project's projected effects on groundwater levels in the alluvial aquifers of the Fenner Watershed, will also be monitored to compare variations in spring flow from those springs to variations in spring flow from the Bonanza Spring to assist in determining whether any material reduction of flow at the Bonanza Spring is attributable to the Project operation, or instead, is attributable to regional climate conditions.

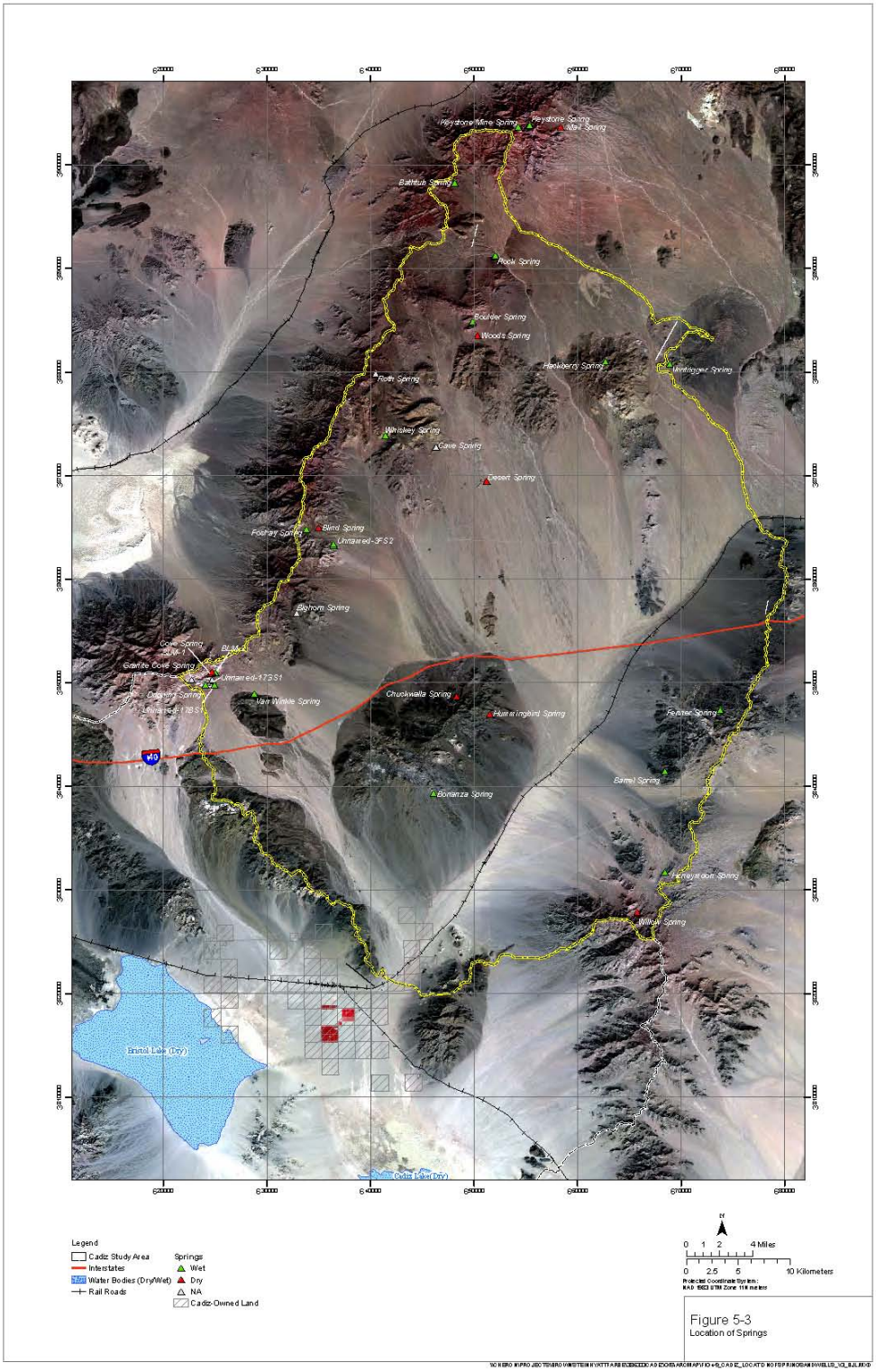


Figure 5-3
Location of Springs

The springs will be monitored by visual observations and flow measurements. Visual observations will include starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing water, conductivity,

pH and temperature of water, any colorations of water, and general type and extent of vegetation.

5.3 Observation Wells (Features 2)

A total of 15 existing observation wells and 2 new observation wells will be used to monitor groundwater levels during the Project (see Tables 5-1 and 5-2). Locations of these wells are shown on Figures 5-1 and 5-2. Six of these wells were installed in the 1960's by Southern California Edison as part of a regional investigation (wells whose designation begins with "SCE"). Four of the observation wells (Labor Camp, Dormitory, 6/15-29, 6/15-1) are owned and monitored by Cadiz as part of their agricultural operation. Existing well CI-3 was installed in Fenner Gap during the pilot spreading basin test for the Project. Existing wells at Essex, Fenner, Goffs, and Archer Siding #1 are related to railroad operations or municipal supply. All of these existing wells will be utilized provided that appropriate permission and approval is obtained.

One new well, Piute-1, will be installed in the Piute Watershed, north of the Fenner Watershed, and is tributary to the Colorado River. This well will be installed on property owned by Cadiz and will be used as a "background" monitoring well to monitor undisturbed groundwater levels in an adjacent watershed, to provide information on groundwater level variations due to climatic variations only. In addition, this will serve to demonstrate that the Project will not impact groundwater that is tributary to the Colorado River.

Another new well, Danby-1, will be installed in the Danby Watershed to the east. Similar to Piute-1, this Danby-1 observation well will be used to demonstrate that impacts on groundwater levels do not extend beyond the Cadiz watershed on the west. This well will also provide information on regional groundwater level conditions and is expected to provide additional background monitoring and information groundwater level changes that may be due to climatic variations as well.

Groundwater levels will be measured in accordance with the monitoring procedure presented in Appendix B[2]. All water samples would be collected according to the protocol described in Appendix C. Field parameters such as groundwater temperature, pH, electrical conductivity, and total dissolved solids (TDS), will be collected at each well during well purging and prior to sampling. Samples from each well will be analyzed for the general mineral and physical parameters specified in Appendix D. In addition, all samples collected during the pre-operational phase will also be analyzed

[2] These procedures are being reviewed for consistency and will be made available on October 26.

for bromide, boron, iodide barium, arsenic, hexavalent chromium, total chromium, nitrate, and perchlorate. The sample analytical protocol is presented in Appendix D.

Groundwater monitoring frequency will be revisited as determined appropriate by the decision-making process should any of the action criteria be exceeded, as discussed in Chapter 6.

5.4 Proposed Observation Well Clusters (Feature 3)

Three well clusters will be established in the immediate vicinity of the Project wellfield (see Figure 5-2). These cluster wells will provide a basis to compare groundwater level and water quality changes in both the shallow and deep portions of the alluvial and bedrock aquifer systems. Two well clusters, using existing monitoring well MW-7, MW-7a, and TW-1, and TW-2 and TW-2MW will be established for monitoring in the immediate vicinity of the Project. The screened intervals are in the upper alluvial, carbonate aquifer, and bedrock. The third cluster well combination will be installed in the area between Bristol Dry Lake and the Project wellfield to monitor groundwater elevations and water quality. All new Project monitoring wells shall be designed, installed, and completed in manner consistent with all applicable state and local regulations, and industry standards. Monitoring will occur as presented in Tables 5.1 and 5.2.

5.5 Project Production Wells (Feature 4)

Data from the well field (new project wells and existing Cadiz agricultural wells) will be collected to provide information on the groundwater levels and discharge rates. Each well will be equipped with a flow meter to monitor well discharge and a sounding tube for obtaining groundwater level measurements. Production data from the project wells will be verified using totaled readings of flow at CRA.

5.5.1 *Existing Cadiz Agricultural Wells*

The Cadiz agricultural operation owns and operates seven agricultural wells used for irrigation, which are located west and southwest of Fenner Gap (see Figure 1-3). Five of the seven Cadiz irrigation wells could be incorporated into the Project wellfield (Wells 21S, 27N, 27S, 28 and 33).

5.5.2 *New Production Wells*

The Project wellfield would consist of approximately 29 additional production wells to be located as shown on Figure 5-2. Each new well would be completed to a depth of

about 1,000 feet (see Figure 5-4). This well design may be modified based on observations in the field and expectations of drawdown that may be encountered during Project operations. The total capacity of the wellfield would allow for a pumping range of 25,000 afy to 75,000 afy. All new Project production wells shall be designed, installed, and completed in manner consistent with all applicable state and local regulations, and industry standards and be equipped with flow meters.

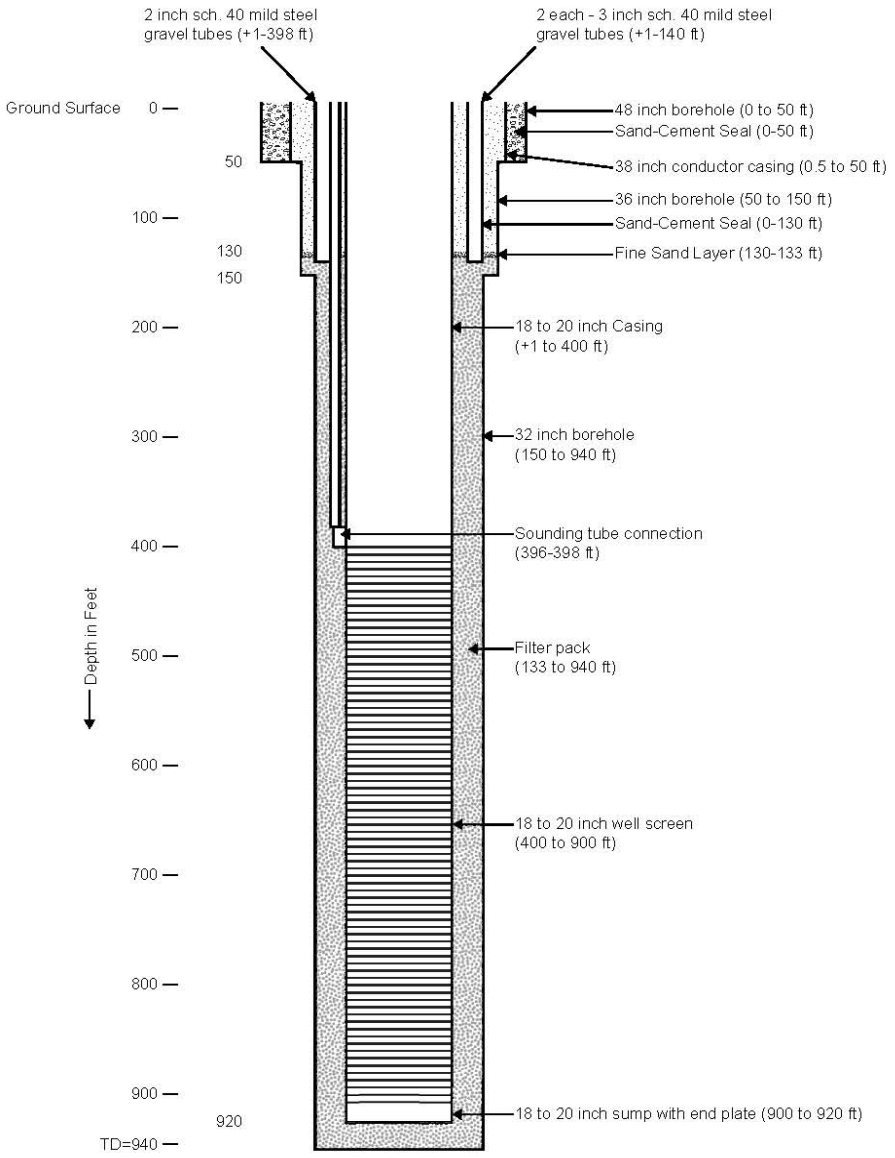


FIGURE 5-4
Conceptual Well Design Diagram

SCO386303.AA.05 well_design.ai 10/11

5.6 Land Surface Monitoring (Feature 5)

A network of approximately 20 land survey benchmarks will be installed at the approximate locations shown on Figure 5-2 to monitor changes in land surface elevation should they occur. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1:50,000). Each benchmark will be established and surveyed by a California licensed land surveyor. All locations will be dependent upon permitting from the appropriate agencies. Benchmark surveys will be conducted on an annual basis during the term of the Project (see Table 5-1).

Pre-operational baseline Interferometric Synthetic Aperture Radar ("InSAR")will be used to evaluate potential impacts in conjunction with the benchmarks. FVMWC will obtain surveyed baseline land surface elevations which then will be compared to each other along with any InSAR data collected during the course of the Project. The InSAR data would be used to monitor relative changes of land surface elevation that could be related to aquifer system deformation in the Project area. This pre-operational InSAR data (collected at two separate times during the year prior to the operational phase of the Project) will complement the land survey data to establish changes in land surface elevations. During the operational phase, annual benchmark surveys will be conducted and InSAR images will be obtained and evaluated every five years to evaluate potential impacts. During the post-operational phase, InSAR data and benchmark survey will be obtained every five years (Table 5-1). InSAR images will be obtained and evaluated more frequently, along with benchmark surveys if determined appropriate by the TRP and authorized by SMWD, should trends be observed which may lead to action criteria being exceeded as discussed in Chapter 6.

5.7 Extensometers (Feature 6)

To evaluate potential impacts during the operational phase, FVMWC will construct three extensometers in the area of the highest probability of subsidence (see Figure 5-2). The extensometers will be constructed to continuously measure non-recoverable compaction of fine-grained materials interbedded within the alluvial aquifer systems.

5.8 Flowmeter Surveys (Feature 7)

Downhole flowmeter surveys will be generated in five selected new extraction wells. This is expected to be a one-time activity. The flowmeter surveys will provide data regarding vertical variation in groundwater flow to the well screens. Depth-specific water quality samples will also be collected to assess vertical variation of groundwater

quality in the Project wellfield area. Data will be used to help refine geohydrologic parameters regarding layer boundaries used in the groundwater models.

5.9 Proposed Observation Well Clusters At Bristol Dry Lake (Feature 8)

A total of three new observation well clusters will be installed and monitored in the vicinity of Bristol Dry Lake during the initial phases of the Project (see Table 5-1 and Figure 5-2). Two well clusters will be located along the eastern margin of Bristol Dry Lake to monitor the effects of Project operations on the movement of the fresh water/saline water interface (see Figure 5-2). One additional well cluster will be installed on the Bristol Dry Lake playa to monitor brine levels and chemistry at different depths beneath the dry lake surface. This well cluster will be positioned in relation to the well clusters at the margin of the dry lake so as to provide optimum data for the density-dependent transport model.

A typical observation well cluster completion is illustrated on Figure 5-5. Screened intervals for each of the wells within each cluster will be determined from logging of cuttings and geophysical logging of the deep borehole which will be drilled first. Each deep well will be completed with PVC or other suitable well casing and screen to allow for dual induction geophysical logging. Shallow wells will be completed with PVC or other suitable well casing and screen.

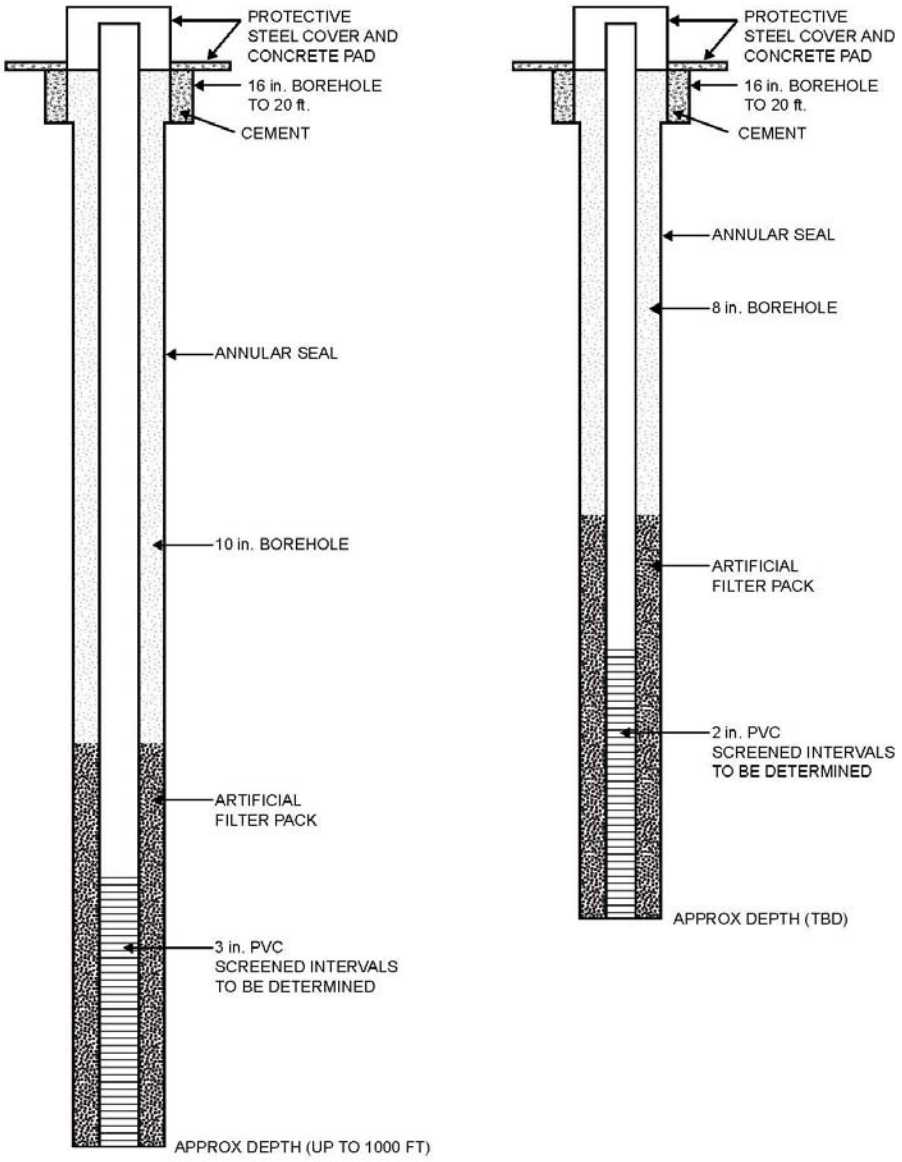


FIGURE 5-5
Typical Observation Well Cluster

SC0396303.AA.05 well_cluster.ai 10/11

During the pre-operational phase, static groundwater levels will be monitored on a continuous basis from each well cluster using downhole pressure transducers. Project monitoring will begin immediately following well installation and development.

5.10 Proposed Observation Well Clusters At Cadiz Dry Lake (Feature 9)

One well cluster will be located along the northern margin of Cadiz Dry Lake to monitor the effects of Project operations on the movement of the fresh water/saline water interface in this area (see Figure 5-1). During the pre-operational phase, static groundwater levels will be monitored on a continuous basis from each well cluster using downhole transducers. Project monitoring will begin immediately following well installation and development and continue through the post-operational period.

5.11 Gamma-Ray/Dual Induction Downhole Geophysical Logs (Feature 10)

Gamma-ray and dual induction electric logs will be run for the deepest observation wells of each well cluster to be installed at the dry lakes (four total). These Downhole geophysical techniques allow for the measurement of groundwater electrical conductivity with depth and could be conducted in observation wells constructed of PVC casing and screen.

Gamma-ray/dual induction geophysical logs will be run as a one-time measurement to be conducted during observation well cluster installation during the pre-operational phase of the Project.

5.12 Weather Stations (Feature 11)

Data from four existing weather stations will be collected over the course of the Project (see Figures 5-1). Existing weather stations include the Mitchell Caverns weather station (located in the Providence Mountains), the Project weather station (located in Fenner Gap adjacent to the spreading basins), the Cadiz CIMIS station (operated by/for CDWR at the Cadiz Field Office), and the Amboy weather station (located near Bristol Dry Lake in the town of Amboy).

The Mitchell Caverns weather station would provide precipitation, temperature, and other climatic data for the mountain regions of the Fenner watershed. The Fenner Gap weather station would provide climatic data in the immediate vicinity of the Project area. The Amboy and Cadiz Field Office weather stations would provide climatic data representative of the lowest area of the regional watershed. Data obtained from the weather stations will incorporated into the water resource models described in Chapter 4, along with complementing data analysis of Feature 12.

5.13 Air Quality Monitoring (Feature 12)

5.13.1 *Monitoring at Bristol and Cadiz Dry Lakes*

The relationship between groundwater and the surface of Bristol and Cadiz Dry Lakes has been evaluated in a technical study conducted by HydroBio.[3] The technical study concludes that unlike some other playas in the arid Southwest such as Owens and Franklin Playas, the soil and water chemistry of both Cadiz and Bristol Dry Lakes have very low quantities of the sodium salts of carbonate, bicarbonate and sulfate that are known to generate excessive fugitive dust in high wind storms. Rather, the Bristol and Cadiz Dry Lakes are characterized by sodium and calcium chlorides that maintain rigid structure when desiccated, reducing the amount of loose dust on the ground surface that can be lofted by the wind. This surface crust is not aided or maintained by direct contact or indirect contact through capillary action with the groundwater.

Under current conditions, dust storms are not uncommon in the valley as sand particles saltate across the desert floor, dislodging other sand particles and lofting dust into the air.[4] Under current conditions, depth to groundwater in some areas beneath the dry lakes is over 60 feet below ground surface, and the surface soils in these areas exhibit the same crusty surface as areas with shallow groundwater. This crusty surface soil provides some resistance to wind erosion and limits dust emissions. It is not reliant on groundwater. Therefore, drawdown of the groundwater beneath the dry lakes will have no effect on surface soils and therefore no affect on dust emissions in the valley.

To verify the condition of the dry lakes consistent with recommendations of the Groundwater Stewardship Committee and to provide additional data on the environment of the area, FVMWC will install two nephelometers one downwind from Bristol Lake and one downwind of Cadiz Dry Lake to establish a set of baseline data of visibility in the valley. These nephelometers will be placed on privately-owned property, and outside the wind shadow of the agricultural properties.

In addition, FVMWC will conduct annual visual observations at four points on each of the dry lakes to record surface soil conditions. The visual observations will note soil texture and record susceptibility to wind erosion. Photographs of the soil will be taken. This data will record conditions over time on the two dry lakes surfaces at the same locations each time.

---

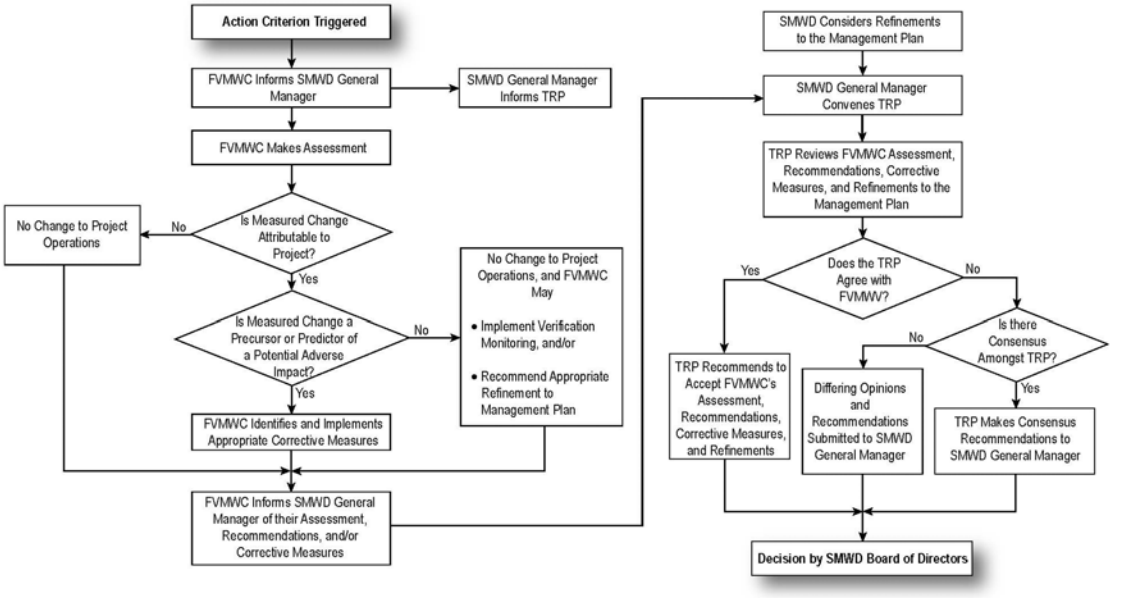
[3] HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011, pg. i

[4] HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011, pg. 6

These nephelometers will provide data on a daily basis that records opacity of the air, measuring the effect of dust on visibility. Data will be collected in the pre-operational phase of the Project and in the early years of the Project, establishing a baseline before groundwater levels beneath the dry lakes are affected. Since wind velocity and dust storms are highly variable, the data will record trends over time. Data will also be collected during the operational and post-operational phase of the Project and compared to baseline data to evaluate whether Project operations have impacted air quality. A summary of these data and data analysis from the nephelometers will be submitted annually to the TRP. This analysis will inform the TRP on the environmental setting, augment the weather station data, and provide information for the long term management of the facilities in the valley.

CHAPTER 6
MONITORING AND MITIGATION OF PROJECT IMPACTS TO CRITICAL RESOURCES (ACTION CRITERIA, DECISION-MAKING PROCESS AND CORRECTIVE MEASURES)

This Management Plan identifies specific quantitative criteria (action criteria) that will "trigger" review to determine whether an observed change in conditions relating to critical resources is attributable to the Project operations, and if so, which specific corrective measures would be implemented to avoid adverse impact to critical resources. It is the intent of this Management Plan to identify deviations from baseline conditions, along with deviations from groundwater model projections, at monitoring features as early as possible in order to identify and prevent the occurrence of material adverse impacts to critical resources as a result of Project operations. A decision-making process has been developed, which outlines the process to be followed in the event deviations from model projections develop, or that an action criterion is triggered, or when refinements to the Management Plan are considered. Figure 6-1 shows the decision logic that will be used during the course of the Project. Finally, potential corrective measures to be implemented, if appropriate, are identified. Critical resources, action criteria, the decision-making process, and potential corrective measures are discussed in this Chapter 6 and summarized in Table 6-1.



FVMWC = Fenner Valley Mutual Water Company
SMWD = Santa Margarita Water District
TRP = Technical Review Panel

FIGURE 6-1
Decision-Making Process
Groundwater Management, Monitoring, and Mitigation Plan Cadiz Conservation, Recovery, and Storage Project

CH2MHILL

The initial action criteria and corrective measures presented in this Management Plan are considered conservative. FVMWC may propose refinements to the action criteria and monitoring network after additional data has been accumulated which indicates that the monitoring is unnecessary. However, any such refinement would occur in accordance with the terms of this Management Plan. If FVMWC proposes a refinement to action criteria or monitoring features, it will submit a written proposal describing the refinement along with supporting data and materials to the TRP. The TRP will then issue a recommendation concerning the proposed refinement to SMWD, which as lead agency for the Project under CEQA, will determine whether the refinement is warranted based on all available technical data and is otherwise consistent with all CEQA findings adopted by SMWD in conjunction with its approval of the Project EIR. SMWD will make a decision regarding the proposed refinement in accordance with the decision-making process presented here, in Figure 6-1 and further described in Chapter 8. Action criteria are intended to be used as predictors of potential material adverse impacts to critical resources, and exceeding these criteria does not necessarily constitute a material adverse impact to critical resources.

The decision-making process followed in this Management Plan, if an action criterion is triggered or when SMWD considers refinements to the Management Plan, is illustrated in Figure 6-1 and described in detail as follows. If an action criterion (defined in this Chapter 6) is triggered, FVMWC will promptly inform the General Manager of SMWD and the members of TRP that an action criterion has been triggered, and commence the decision-making process described herein.

FVMWC will assess whether the triggering of any action criteria is attributable to Project operations. If FVMWC determines that the change is not attributable to Project operations, it will make no change to Project operations and promptly submit the results of its assessment and determination to the TRP. Upon receipt of FVMWC's assessment and determination, where good cause exists, TRP may request additional data and analysis.

If FVMWC determines that the change is attributable to Project operations, it will assess whether the measured change is a precursor or predictor of a potential adverse impact and report its determination to TRP. If FVMWC determines that the measured change is not a precursor or predictor of a potential adverse impact, it would make no change to Project operations, but may implement verification monitoring and/or propose refinements to the Management Plan with notification to TRP. Such refinements may include modifications of the monitoring network (e.g. location, frequency, etc.) and the action criteria. FVMWC will promptly submit the results of any assessment, verification monitoring action taken, and/or proposed refinements to the Management Plan to the TRP.

If FVMWC determines that the measured change is a precursor or predictor of a potential adverse impact to a critical resource, it will identify and implement the appropriate corrective measures, and promptly inform the TRP of the result of its assessment and the corrective measures that it implemented.

After receiving the results of FVMWC's assessment and actions taken in response to any triggering of an action criterion, the TRP will convene within 30 days to determine whether it concurs with the assessment and the responsive actions taken by FVMWC (modifications of the monitoring network, corrective actions, etc.) Within 30 days of convening, the TRP will issue a written report to the General Manager of SMWD of its review of FVMWC's assessment and actions taken, including whether it concurs with the assessment and actions taken by FVMWC, and if it does not concur, the basis of its disagreement and any alternative recommended actions. The SMWD's Board of Directors will fully consider the findings and actions taken or recommended by FVMWC and the TRP, and as Lead Agency for the Project under CEQA, will issue a

final determination in its sole discretion whether FVMWC's assessment of the triggering of the action criterion, and responsive actions taken, are appropriate based on all available technical data and are otherwise consistent with all CEQA findings adopted by SMWD in conjunction with its approval of the Project EIR. If SMWD determines that FVMWC's assessment and/or actions taken are not appropriate, it may order FVMWC to take alternative actions, but only so long as those actions are provided within the potential corrective actions set forth in this Chapter. SMWD will issue its determination in writing to FVMWC and to each member of the TRP within 30 days of receipt of the TRP's written assessment. FVMWC shall promptly comply with the determination and instructions set forth in SMWD's written correspondence concerning the matter.

Communications by and to FVMWC, the TRP, and SMWD, as provided in this Chapter, shall be made by and to, respectively, a point of contact for the FVMWC designated by the FVMWC Board of Directors ("FVMWC Representative"), a member of the TRP designated by the TRP as its point of contact ("TRP Contact Member"), and the SMWD General Manager.

6.2 Third-Party Wells

It is the intent of the Project to operate without adverse material impacts to wells owned by neighboring landowners in the vicinity of the Project area, nor those operated in conjunction with salt mining operations on the Bristol or Cadiz Dry Lakes. To avoid such potential impacts, the groundwater monitoring network will include monitoring wells located near neighboring landholdings and on and adjacent to the dry lakes. Groundwater levels will be monitored on a monthly to semi-annual basis (see Table 5-1) during the pre-operational and operational periods, then annually during the post-operational period. Water quality will be monitored on a quarterly to annual basis during the pre-operational period, annually thereafter during the operational period of the Project, and tri-annually during the post-operational period (see Table 5-1).

6.2.1 *Action Criteria*

The action criterion shall be drawdown at the Danby observation well (adjacent to Clipper Mountains) greater than projected by the pre-operational groundwater flow simulation models or the receipt of written complaints by well owners regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes.

6.2.2 *Decision-Making Process*

If drawdown at the Danby observation well is greater than projected by the pre-operational groundwater model simulation results or a written complaint is received, the decision-making process will be implemented as follows:

- FVMWC will determine if water level changes, decreased yields, increased pumping costs, and/or degraded water quality in neighboring landowner wells or the salt mining operations on the Bristol and Cadiz Dry Lakes are attributable to Project operations;
- If such water level changes, decreased yields, increased pumping costs and/or degraded water quality are determined to not be attributable to Project operations, then no action would be taken and FVMWC would discontinue its arrangement to provide water;
- If such water level changes, decreased yields, increased pumping costs and/or degraded water quality are determined to be attributable to Project operations, then further corrective measures would be implemented.

6.2.3 *Corrective Measures*

Upon receipt of the written complaint, and during the decision-making process, SMWD will arrange for an interim supply of water to the impacted party as necessary. Additional corrective measures that would be implemented at FVMWC's election may include one or more of the following actions:

- Deepen or otherwise improve the efficiency of the impacted well(s);
- Blend impacted well water with another local source;
- Construct replacement well(s);
- Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or
- Modify Project operations until adverse impacts are no longer present at the impacted well(s). Modifications to Project operations would include one or more of the following:
    - Reduction in pumping from Project wells; or

- Revision of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

6.3 Land Subsidence

Twenty land survey benchmarks will be established and surveyed by a licensed land surveyor on an annual basis to identify and quantify potential subsidence within the Project area (see Figure 5-1 and 5-2). Three extensometers will be constructed in areas of projected subsidence (see Figure 5-2). The extensometers, which would be monitored continuously from installation through the post-operational period, would verify if the land surface changes (also potentially identified from land surveys and InSAR satellite data obtained and analyzed every five years through post-operational period) are due to (1) subsidence due to groundwater withdrawal; or (2) other mechanisms (e.g. regional tectonic movement).

6.3.1 *Action Criteria*

The decision-making process will be initiated if the action criteria are triggered. The action criteria are: 1) land subsidence and subsidence rate are greater than projected by the groundwater flow simulation model for an equivalent elapsed time; 2) a change in the ground surface elevation of more than 0.5 feet or of a magnitude which impacts existing infrastructure within the Project area; or 3) more than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks.

6.3.2 *Decision-Making Process*

If the action criterion is triggered, the decision-making process will be implemented as follows:

- FVMWC will determine if the subsidence is attributable to Project operations.
- If land surface elevation changes equal to or in excess of the action criteria are determined to not be attributable to Project operations, then no action would be required, and FVMWC may propose refinement of the action criteria or monitoring network;
- If land surface elevation change equal to or in excess of the action criteria are determined to be attributable to Project operations, then an assessment

will be made to determine whether the subsidence constitutes a potential adverse impact to the aquifer or surface uses. Adverse impact includes the determination that there will be damage to surface structures as a result of differential settlement or fissuring, or general subsidence sufficient to alter natural drainage patterns or cause damage to structures, or a non-recoverable loss of aquifer storage capacity that affects the beneficial uses of the storage capacity of the aquifer system. A compaction of the silts, clays, or other fine materials will not result in loss of useable storage capacity. If no such adverse impacts are identified, potential actions may include:

  - No action; or
  - Refinement of the action criteria; or
  - Verification monitoring, including a field reconnaissance to assess and detect any differential settlement; or
  - Revision of the benchmark survey and/or InSAR monitoring frequency.

- If land surface elevation changes equal to or in excess of the action criterion are determined to be attributable to Project operations, and the changes constitute a potential adverse impact in the Project area, then corrective measures would be implemented.

6.3.3 *Corrective Measures*

Corrective measures that would be implemented may include one or more of the following actions:

- Modification of wellfield operations to arrest subsidence. Modifications to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells; or
  - Revision of pumping locations within the Project wellfield; or
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or

- Repair any structures damaged as a result of subsidence attributable to Project operations.

6.4 Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes

A network of "cluster type" observation wells will be established between the Project wellfield and the margins of Bristol and Cadiz Dry Lakes (see Figures 5-1 and 5-2). Groundwater TDS concentrations in the well clusters will be monitored on a quarterly basis during the pre-operational period of the Project, semi-annually throughout the operational period, and annually during the post-operational period of the Project.

6.4.1 *Action Criteria*

The action criteria are, 1) monitored increases in TDS that are higher than projected by the groundwater flow simulation models or, 2) a change in TDS concentration in excess of 1,000 mg/l in monitoring wells sited along the saline/freshwater interface line projected by Geoscience as part of their impact assessments. If such a TDS change is measured, the decision-making process will be initiated.

6.4.2 *Decision-Making Process*

If the action criterion is triggered, the decision-making process will be implemented as follows:

- FVMWC will determine if the changes are attributable to Project operations;
- If groundwater TDS concentration changes equal to or in excess of the action criterion in the observation wells near the projected saline/freshwater interface (easterly of the margins of the dry lakes) are determined to not be attributable to Project operations, then no change in Project operations would be required and FVMWC may propose refinement of the action criteria;
- If groundwater TDS concentration changes equal to or in excess of the action criterion in the observation wells are determined to be attributable to Project operations, then an assessment will be made whether the TDS concentration changes constitute a potential adverse impact to beneficial use of the aquifer. If no such impacts are identified, potential actions may include:

- No action; or
- Refinement of the action criteria; or
- Verification monitoring; or
- Revision of the number of monitoring wells and/or monitoring frequency of the observation well clusters at the margins of the dry lakes.

- If groundwater TDS changes equal to or in excess of the action criteria in observation wells are determined to be attributable to the Project, and the changes constitute a potential adverse impact to beneficial use of the aquifer, then corrective measures will be implemented.

6.4.3 *Corrective Measures*

Corrective measures that would be implemented may include one or more of the following actions:

- Deepen or otherwise improve the efficiency of the impacted well(s); or
- Blend impacted well water with another local source; or
- Construct replacement well(s); or
- Pay the impacted well owner for any increased material pumping costs incurred by the well owner;
- Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells; or
  - Revision of pumping locations within the Project wellfield; or
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse affect on existing wells; or
- Modification of Project operations to reestablish the natural hydraulic gradient and background concentrations at the margins of Bristol and Cadiz Dry Lakes through one or more of the following:

- Reduction in pumping from Project wells
- Revision of pumping locations within the Project wellfield
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact

OR

- Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

6.5 Brine Resources Underlying Bristol and Cadiz Dry Lakes

A network of "cluster type" observation wells will be established between the Project wellfield and the margins of Bristol and Cadiz Dry Lakes (see Figures 5-1 and 5-2). Groundwater levels will be monitored on a continuous basis throughout the term of the Project.

6.5.1 *Action Criteria*

The decision-making process will be initiated if action criteria are triggered. The action criteria are, 1) changes in groundwater levels larger than projected by the groundwater model simulations or, 2) changes in groundwater or brine water levels of greater than 50 percent of the water column above the intake of any of the salt mining companies' wells in comparison to pre-operational static levels in cluster wells at the margins of the dry lakes. If such groundwater/brine water level change is measured, the decision-making process will be initiated.

6.5.2 *Decision-Making Process*

If the action criteria are triggered, the decision-making process will be implemented as follows:

- FVMWC will determine whether the change in groundwater/brine level change is attributable to Project operations;
- If groundwater/brine level changes equal to or in excess of the action criteria in the observation well clusters at the margins of the dry lakes are determined to not be attributable to Project operations, then no change to

Project operations would be required, and FVMWC may propose refinement of the action criteria;

- If groundwater/brine level changes equal to or in excess of the action criteria in the observation well clusters at the margins of the dry lakes are determined to be attributable to Project operations, then an assessment will be made to determine whether the groundwater/brine level changes constituted a potential adverse impact to brine operations on the dry lakes. Adverse impact includes changes to brine chemistry or yields from existing brine production wells or trenches attributable to Project operations. If no such impacts are identified, potential actions may include:
  - No action; or
  - Refinement of the action criteria; or
  - Verification monitoring; or
  - Revision of the monitoring frequency at the observation well clusters at the margins of the dry lakes.
- If groundwater/brine level changes equal to or in excess of the action criteria in observation well clusters at the margins of the dry lakes are determined to be attributable to Project operations, and the changes constitute a potential adverse impact to brine operations on the dry lakes, the corrective measures will be implemented;

6.5.3 *Corrective Measures*

Corrective measures that would be implemented may include one or more of the following actions:

- Modification of Project operations to reestablish the natural groundwater/brine levels at the margins of Bristol and Cadiz Dry Lakes. Modifications to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells; or
  - Revision of pumping locations within the Project wellfield; or

- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or
- Installation of an injection wells to mitigate the impact.

- Compensation to mining operators for the additional costs of pumping.

6.6 Adjacent Basins, Including The Colorado River and its Tributary Sources of Water

Adjacent basins will be monitored to provide verification that the project does not impact groundwater levels in these adjacent basins. Because the Bristol, Cadiz, and Fenner Watersheds are assumed to be closed watersheds, it is expected that the observation wells will demonstrate no Project impact. Baseline groundwater conditions observed in these adjacent basins will also provide information on climatic change effects on groundwater levels on a regional basis.

The Piute Watershed is tributary to the Colorado River. Groundwater flow from this watershed ultimately discharges to the Colorado River, so it is a part of the water resource of the Colorado River. As discussed above, it would be an adverse impact if this groundwater flow was impacted by Project Operations. The Piute-1 observation well will provide data on groundwater levels in this basin. In addition, the Piute-1 well is located approximately equi-distant from the next southerly well from the proposed Goffs observation well, so this well can be compared to these observations to assess groundwater level differences between these wells, if any.

The Danby basin is immediately to the east. A new observation well, Danby-1, will provide information on groundwater conditions in this adjacent basin.

6.6.1 *No Action Criteria; Verification Monitoring*

Because the Bristol, Cadiz, and Fenner Watersheds are assumed to be closed watersheds that are isolated from aquifer systems in neighboring basins by bedrock and groundwater divides, no action criteria are necessary to protect these critical resources. However, to accommodate requests of stakeholders in the Danby area, and to demonstrate the lack of any hydrogeologic connectivity between the alluvial groundwater developed by the Project and the Piute Basin, the monitoring wells in these adjacent basins, along with all the other Project observation wells, will be monitored to verify these factual conclusions.

6.7 Springs

As discussed at Section 4.2 of Chapter 4 above, because of the distance, change in elevation, and lack of hydraulic connection between the fractured bedrock groundwater feeding the Fenner Watershed springs and the alluvial groundwater developed by the Project, the Project is not anticipated to affect the spring flow within any of the on Fenner Watershed springs.

6.7.1 *No Action Criteria; Verification Monitoring*

Because the Project is not anticipated to have any effect on the spring flows in any of the Fenner Watershed springs, no action criteria are necessary to protect this critical resource. However, consistent with the recommendations of the Groundwater Stewardship Committee, and as a conservative monitoring protocol, visual observation and flow estimates shall be performed at the Bonanza Spring in the Clipper Mountains, the Whisky Springs in the Providence Mountains (near Colton Hills), and Vontrigger Spring in the Vontrigger Hills, east of the Hackberry Mountains, no less often than quarterly during the pre-operational and operational period of the Project and annually during the post-operational period. The Bonanza Spring will be monitored as an "indicator spring" because it is the spring that is in closest proximity to the Project wellfield (approximately 11 miles from the center of Fenner Gap). The Whisky and Vontrigger Springs will be monitored to compare variations in spring flow from those springs to variations in spring flow from the Bonanza Spring to verify that any material reductions of flow at the Bonanza Spring is not attributable to the Project operation, and is instead attributable to climate conditions.

6.8 Air Quality

As described above, a network of observation wells will be established between the project wellfield and Bristol and Cadiz Dry Lakes (see Figures 5-1 and 5-2). Groundwater levels will be monitored in many wells on a continuous basis throughout the term of the project.

FVMWC will install two nephelometers downwind from Bristol and Cadiz Dry Lakes to establish a set of baseline data of visibility in the valley, along with providing air quality data throughout the duration of Project operations. In addition, FVMWC will conduct annual visual observations at four points on each of the dry lakes to record surface soil conditions. The visual observations will note soil texture and record susceptibility to wind erosion. Photographs of the soil will be taken. This data will record conditions over time at the same locations on each of these Dry Lake surfaces.

6.8.1 *Verification Monitoring*

Air quality in the Cadiz Valley and MDAB is a critical resource. Since the groundwater is not connected in any way to the erosion potential of the dry lake surface soils, the Critical Resource could not be adversely affected by the proposed Project. Lowering groundwater levels beneath the dry lakes will not increase dust generation from the dry lakes. Therefore, no action criteria are necessary to protect this critical resource. However, consistent with the recommendations of the Groundwater Stewardship Committee, for the avoidance of any doubt, and as a conservative monitoring protocol, nephelometers will be installed and monitored to verify that the Project does not increase dust generation from the dry lakes.

These nephelometers will provide data on a daily basis that records opacity of the air, measuring the effect of dust on visibility. Data will be collected in the early years of the Project, establishing a baseline before groundwater levels beneath the dry lake are affected and will continue during Project operations. Since wind velocity and dust storms are highly variable, the data will record trends over time. Data from the nephelometers will be analyzed by the FVMWC, with the results of the analysis submitted annually to the TRP. This data will inform the TRP on the environmental setting, augmenting the weather station data, and provide information for the long term management of the facilities in the valley. The TRP will provide recommendations over time regarding modifications to the verification data collection activities if needed.

6.8.2 *Action Criteria*

The following action criteria are provided at the request of the County of San Bernardino and out of an abundance of caution. The decision-making process will be initiated if the action criteria are triggered. The action criteria is: changes in air quality that exceed baseline conditions over a five-year moving average. If such air quality changes are measured, the decision-making process will be initiated.

6.8.3 *Decision-Making Process*

If the action criteria is triggered, the decision-making process will be implemented as follows:

- FVMWC will determine whether the change in air quality is attributable to Project operations;

- If air quality changes equal to or in excess of the action criteria in one or both nephelometers are determined to not be attributable to Project operations, then no change to Project operations would be required;

- If air quality changes equal to or in excess of the action criteria in the nephelometers are determined to be attributable to Project operations, the corrective measures will be implemented.

6.8.4 *Corrective Measures*

- Modification of Project operations to re-establish baseline level air quality levels. Modifications to Project operations would include one or more of the following:

  - Reduction in pumping from Project wells;

  - Revision of pumping locations within the Project wellfield;

  - Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

CHAPTER 7
CLOSURE PLAN AND POST-OPERATIONAL REPORTING

A Closure Plan will be developed as part of this Management Plan to ensure that no residual effects of Project operations will result in adverse impacts to critical resources (as defined in Chapter 4) in or adjacent to the Project wellfield area during the 50 years of Project operations or during the post-operational phase.

A Closure Plan will be prepared by FVMWC at the sooner of, 1) when static groundwater levels in the Project wellfield area have declined by an average of 200 feet from pre-operational levels, or 2) no later than at year 25 of Project operations. FVMWC will coordinate with the TRP, who will provide input and guidance throughout the development and refinement of a draft Closure Plan. The final Closure Plan will be approved by SMWD, as the lead agency for the Project, as it determines appropriate in its discretion after consideration of the draft plan developed by FVMWC in coordination with the TRP. The Closure Plan will monitor groundwater levels and groundwater quality for a minimum period of 10 years to protect critical resources and groundwater quality for beneficial uses as required by federal and state law, including the requirements of the California Regional Water Quality Control Board, Colorado River Basin Region. The Closure Plan shall also require that all Project wells that are

abandoned be destroyed in manner consistent with all applicable state and local regulations, and industry standards. The provisions and mitigation obligations under this Management Plan will be in effect and run concurrently with the term of the Closure Plan. Once prepared, the Closure Plan will be reevaluated every five years in consultation with the TRP. Such reevaluation may include refinements to the Closure Plan. Any modification to closure plan must be approved by SMWD.

Under this Management Plan, FVMWC will review and analyze groundwater levels, water quality information, air quality and all other monitoring data; as well as prepare the annual reports for review by TRP and approval by SMWD. One purpose of the annual reports is to identify any actions that would be taken with the objective to ensure that any decline in pre-operational static groundwater levels would not exceed 100 feet at the 10 years after cessation of pumping from Project operations (Closure Groundwater Levels), or lead to projections of adverse impacts to critical resources during or after the post-operational phase.

As noted in Section 4.2 of the EIR, all pumping of groundwater in the Project area by the Cadiz Agricultural Development will be subject to the provisions of this Management Plan, with plans to phase out the agricultural operations once the Project is fully operational. With the combination of the Cadiz Agricultural Development and the Project, there may be declines in static groundwater levels at the termination of Project operations. Implementation of the Closure Plan is intended to ensure that the closure groundwater levels are not exceeded, and that the groundwater quality will be protected for beneficial uses as described in the policies of the Regional Water Quality Control Board, Colorado River Basin Region, including any applicable new or revised standards that may be adopted by the Regional Water Quality Control Board.

CHAPTER 8
TECHNICAL REVIEW PANEL

An integral part of this Management Plan involves regular and ongoing review of data collected during the term of the Project. The understanding and analysis of the data will require technical expertise. For this reason, a Technical Review Panel (TRP) will be organized for the purpose of monitoring and advising on technical aspects of the Project as set forth in this Chapter 8.

8.1 Members

The TRP shall consist of one technical representative appointed by the FVMWC one technical representative appointed by the County, and a third technical representative

jointly selected by the technical representatives from FVMWC and the County.. All appointments shall be in the discretion of the County and FVMWC parties, but all three members of the TRP shall possess professional technical qualifications appropriate to the tasks of the TRP (e.g., state certifications in engineering, hydrology, or geology) and must have a minimum of ten years professional experience in working in the groundwater field. In the event the County and FVMWC representatives cannot agree on the designation of the third representative, they may petition San Bernardino Superior Court for the appointment of the third technical representative.

8.2 Responsibilities

As discussed above in Chapter 6, the TRP shall be responsible for reviewing and advising SMWD with respect to FVMWC's assessment of any triggering of action criterion concerning a potential impact to a critical resource, corrective measures adopted, and any proposed refinements to the Management Plan.

The TRP shall coordinate with FVMWC to review and monitor Project data and conditions in the northern Bristol/Cadiz sub-basin, as well as in the larger watershed area and adjacent region, including all information set forth for monitoring and reporting pursuant to Chapter 9 below, and shall issue recommendations to SMWD. The TRP shall also undertake or cause to be made studies which may assist in determining the migration of the saline/freshwater interface and the occurrence of land subsidence as appropriate. FVMWC shall have the primary responsibility for collecting, collating and verifying the data required under the monitoring program, and shall present the results thereof in annual filings with the TRP, and shall also make all raw data available to the TRP via an electronic network (e.g. web page within 90 days of its collection) or other appropriate means to enable regular updates on Project operation and management activities.

The TRP shall also approve annual reports developed by FVMWC as provided for in Chapter 9 below.

TRP's costs will be borne by the FVMWC, including those of the technical representatives, provided that annual costs do not exceed $50,000 per year, escalated by 2% per year.

8.3 TRP Convening, Determinations, and Reporting

As discussed above in Chapter 6, the TRP shall convene as necessary to review and advise SMWD with respect to FVMWC's assessment of any triggering of action criterion concerning a potential impact to a critical resource, corrective measures

adopted, and any proposed refinements to the Management Plan. The TRP shall also convene at least once every year to discuss and take action with respect to its other responsibilities set forth in this Chapter 8. Convening of the TRP may occur by face-to-face meetings, telephone conferencing, or video conferencing.

The TRP shall designate one of its members as the Contact Member. The Contact Member shall take minutes of all convening meetings of the TRP, which shall be submitted to the General Manager of SMWD and the FVMWC Representative within 10 days of the TRP convening.

Determinations of the TRP shall require the affirmative agreement of at least two of the TRP Members, and the Contact Member shall notify the General Manager of SMWD and the FVMWC Representative in writing within 10 days of a determination of TRP being issued.

CHAPTER 9
MONITORING AND REPORTING

9.1 Project Data Monitoring

Monitoring is essential to making informed decisions regarding the prospective impacts of Project pumping. FVMWC will be responsible for preparation of the annual reports beginning one year after commencement of project construction, which will contain the following components:

- Summary of precipitation from climate stations;
- Baseline groundwater level and water quality conditions (as referenced in the EIR). Presentation of baseline conditions will include groundwater level elevation contours, water quality contours, and a figure showing the results of the initial land survey;
- Tables summarizing annual groundwater production for each project extraction well and cumulative extraction from the Project;
- Tables summarizing depth to static water level and groundwater elevation measurements for all observation wells;
- Report on Bonanza, Whiskey and Vontrigger Springs, including visual observations such as starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing

water, conductivity, pH and temperature of water, any colorations of water, and general type and extent of vegetation

- Hydrographs for all production and observation wells;
- Groundwater elevation contours;
- Tables summarizing water quality analyses for the observation wells;
- Results of land subsidence monitoring surveys and any changes relative to baseline;
- Summary tables of any data collected from wells owned by neighboring landowners in proximity to the project area (provided that permission was granted for such data collection);
- Summary of project developments, such as changes in storage or extraction operations or construction of new production wells;
- Discussion of project storage and extraction operations, and trends in groundwater levels and groundwater quality as compared to the baseline conditions;
- Updated groundwater flow, transport and density-dependent model results;
- Tables summarizing changes in frequency and severity of dust mobilization recorded on Bristol and Cadiz Dry Lakes and analysis correlating dust emissions with wind speed and direction, groundwater levels underlying the dry lakebeds and soil surface chemistry;
- Tables and figures (wind roses) summarizing wind data from regional meteorological towers addressing wind speed and direction, and stability frequency distributions. This data would be collected for five years. Data collection may be extended if required by the General Manager of the SMWD;
- Summary of FVMWC assessments, proposed refinements to the Management Plan, and corrective measures.

9.2 Project Reports

9.2.1 *Annual Reports*

Each year during the operational and post-operational periods of the Project, an annual report shall be prepared that shall include a summary of, and analysis of the implications of, all Project data listed for monitoring above.

9.2.2 *Five-Year Reports*

As discussed in Chapters 2 and 4 above, it is anticipated that as the Project proceeds, new data and analysis as well as any new Project operational considerations will be used to refine the calibration of the Project's various water resources models. It is also appropriate to periodically report on observed trends in observed data from the monitoring features and predictions of future trends. Thus, a "Five-Year Report" shall be prepared five years from commencement of construction, and on every five-year anniversary thereafter. The Five-Year Report shall report on the following matters in addition to the contents of previous annual reports:

- Changes to the number or locations of monitoring features;
- Changes in monitoring frequency;
- Changes in monitoring technology;
- Refinements of action criteria for critical resources;
- Refinements of models;
- Modifications of this Management Plan;
- Summary of total project storage and extraction operations;
- Documentation of any trends in groundwater levels evident from the monitoring data;
- Hydrogeologic analysis and interpretation of all project storage and extraction operations during the five-year period;
- Hydrogeologic analysis and interpretation of all water level elevation, water quality, and land survey data collected during the five-year period;

- Results of refined model output from the INFIL3.0 model, saturated groundwater flow and solute transport models, the density dependent groundwater flow model and the solute transport model;

- Detailed evaluation of impacts (if any) of project operations on surface or groundwater resources;

- Proposed refinements to the Management Plan to address any identified inadequacies; and

- Summary of project operations designed to prevent declines in static groundwater levels in excess of an average of 300 feet from pre-operational levels at the end of project operations or no more than an average of 100 feet after 10 years from cessation of pumping within the Project wellfield, or lead to projections of adverse impacts to critical resources during or after the post-operational phase.

- Documentation of any trends in water quality measurements evident from the monitoring data;

- Contours of the most recent static groundwater level elevations and groundwater level elevation changes over the previous five years;

- Documentation of any impacts to wells owned by neighboring landowners (provided that permission was granted to monitor such wells);

- Tables summarizing changes in frequency and magnitude (to the extent that can be determined from the data) of dust mobilization recorded on Bristol and Cadiz Dry Lakes, and analysis correlating wind-mobilized particulate matter with wind speed and direction, groundwater levels underlying the dry lakebeds, and soil moisture on the lakebed surfaces; and;

- Summary of regional wind data (in the first Five-Year Report, and subsequent reports as applicable) with conclusions for potential for project-mobilized lakebed dust to be transported throughout the Mojave Desert region; and;

- Recommendation for revisions to the Closure Plan.

All Five-Year Reports will include electronic data files and model input and output files. The annual reports will be available to agencies, organizations, interest groups, and the general public upon written notification to SMWD. All Five-Year Reports shall be distributed to the lead and cooperating agencies, San Bernardino County, and made available to the public electronically.

9.2.3 *Report Preparation and Approval Process*

The draft reports as provided for in this Chapter shall be prepared by FVMWC and submitted to the TRP on or before May 1 of each year for Annual Reports, and on or before December 31 for Five-Year Reports. The TRP shall then review the report and determine whether any recommended edits or additions are appropriate, which it shall provide to the General Manager of the SMWD within 45 days of receipt from FVMWC. SMWD shall then consider the report and any recommended edits or additions by TRP, and thereafter issue a final report, which shall be approved by SMWD's Board of Directors. SMWD shall thereafter make the report available in hard form at its offices and electronically on SMWD's website.

Table 5.1

Critical Resource Area	Feature No.	Monitoring Features[a]		No.	Pre-Operational Monitoring Frequency			Operational Monitoring Frequency[b]			Post-Operational Monitoring Frequency		
								Extraction					
					Water Level	Water Quality	Other Monitoring	Water Level	Water Quality	Other Monitoring	Water Level	Water Quality	Other Monitoring
Springs	**1**	**Springs, Monitoring**	Existing	3	-	-	Quarterly, Visual Observations and Flow at 3 Springs	-	-	Quarterly, Visual Observations and Flow at 3 Springs	-	-	Annual, Visual Observations and Flow 3 Springs
Aquifer System	**2**	**Observation Wells (16 total)**	Existing	13	Monthly	4 Quarterly, 8 Annually	-	Monthly for First 3 Months of Cycle, then Semi-Annually	Annually	-	Annually	Triannually	-
			Existing	2	Continuous	Annually	-	-	Annually	-	Annually	Triannually	-
			New	2	Monthly	Quarterly	-	Monthly for First 3 Months of Cycle, then Semi-Annually	Annually	-	Annually	Triannually	-

	3	**Project Area Well Clusters - Saturated Zone Only (1 x 3 well cluster + 2 x 2 well cluster = 3 total Clusters)**	Existing	7 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (Until No Longer Deemed Necessary)	Annually	-
	4	**Production Wells (34 total)**	Existing	5	Depth to Water Upon Completion	Sample after completion	-	Continuous	Composite Quarterly	Summarize Data Monthly	Annually	-	-
			New	29	Depth to Water Upon Completion	Sample after completion	-	Continuous	Composite Quarterly	Summarize Data Monthly	Annually	-	-
	5	**Land Surface Elevation Surveys (20 total)**	New Benchmark	20	-	-	Annually, reduce if warranted	-	-	Annually, reduce if warranted	-	-	Annually, reduce if warranted
			InSAR (New)	2/yr (If Warranted)	-	-	Once	-	-	Every 5 years	-	-	Twice at 5-year interval
	6	**Extensometer (3 total)**	New	3	-	-	Establish baseline	-	-	Records Daily	-	-	Summarize data annually
Aquifer System (con't)	**7**	**Flowmeter Surveys (5 total)**	New	5	-	One Time	One Time	-	-	-	-	-	-
Bristol and Cadiz Dry Lakes	**8**	**Bristol Dry Lake Well Clusters (2 per Cluster x 3 total Clusters)**	New	3 clusters 6 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (until no longer deemed necessary)	Annually as necessary	-

	9	**Cadiz Dry Lake Well Clusters (2 per Cluster x 1 total Clusters)**	New	1 cluster 2 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (until no longer deemed necessary)	Annually as necessary	-
	10	**Gamma / EM Logs (up to 6 total)**	New	6	-	-	One Time	-	-	-	-	-	-
Other (Regional)	**11**	**Weather Stations (4 total)**	Existing	3	-	-	Records Daily	-	-	Records Daily	-	-	-
			Cadiz Field Office	1	-	-	Records Hourly	-	-	Records Hourly	-	-	-
Air Quality	**12**	**Nephelometers**	New	2	-	-	Hourly	-	-	Hourly	-	-	-

NOTES:

a - See Table 5-2 for details of monitoring features.

b - Monitoring frequencies pertain to the initial monitoring period of each program operational phase. Monitoring frequency may be increased or decreased based on the initial monitoring results.

Table 5.2

Critical Resource Area	Feature No.	Feature Type	When Monitored	Name	State Well Number	Location Coordinates[a]	Monitoring Protocol		
							Water Level	Water Quality	Other Monitoring
Springs in the Mojave National Preserve and BLM Wilderness Area	1	Springs, Monitoring	Pre-Operational Operational Post-Operational	Bonanza Spring	NA	34° 41' 08" N 115° 24' 20" W	-	-	See Section 5.1 and 6.1
		Springs, Monitoring	Pre-Operational Operational Post-Operational	Whiskey Spring	NA	34° 59' 52" N 115° 26' 59" W	-	-	See Section 5.1 and 6.1
		Springs, Monitoring	Pre-Operational Operational Post-Operational	Vontrigger Spring	NA	35° 03' 20" N 115° 08' 52" W	-	-	See Section 5.1 and 6.1
Aquifer System	2	Observation Well	Pre-Operational Operational Post-Operational	Dormitory	5N/14E-5F1	34° 32' 38" N 115° 31' 57" W	Transducer, See Sections 5.2 and 6.3	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	6/15-1	6N/15E-01H	34° 38' 23" N 115° 21' 22" W	Transducer, See Sections 5.2 and 6.4	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	6/15-29	6N/15E-29P1	34° 34' 20" N 115° 26' 04" W	Transducer, See Sections 5.2 and 6.4	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-11	4N/14E-13J1	34° 25' 51 N 115° 27' 25" W	Transducer, See Sections 5.2 and 6.5	See Appendices B, C & D	-

Aquifer System	2	Observation Well	Pre-Operational Operational Post-Operational	CI-3	5N/14E-24D2	34° 30' 40" N 115° 28' 01" W	Transducer, See Sections 5.2 and 6.6	See Appendices B, C & D	-
		Observation Well	Pre-OperationalOperationalPost-Operational	Archer Siding #1	4N/15E-24E1	34° 25' 11" N115° 21' 57" W	Manual,See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Essex	8N/17E-31	34° 43' 49" N 115° 14' 53" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Fenner	8N/17E-2	34° 48' 59" N 115° 10' 40" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Goffs	10N/18E-26	34° 54' 57" N 115° 03' 44" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Labor Camp	5N14E-16H1	34° 31' 22" N 115° 30' 46" W	Transducer, See Sections 5.2 and 6.6	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-5	5N/14E-32N1	34° 28' 17" N 115° 32' 37" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-9	5N/13E-14B1	34° 31' 36" N 115° 35' 18" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-10	5N/14E-34Q1	34° 28' 22" N 115° 29' 59" W	Manual, See Appendix B	See Appendices C & D	-

Aquifer System	2	Observation Well	Pre-OperationalOperationalPost-Operational	SCE-17	5N/14E-29B1	34° 29' 54" N115° 31' 58" W	Manual,See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-18	5N/13E-11R1	34° 26' 37" N 115° 34' 59" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Danby-1	TBD	34° 15' 58" N 115° 06' 05" W	Manual, See Appendix B	See Appendices C & D	
		Observation Well	Pre-Operational Operational Post-Operational	Piute-1	TBD	34° 57' 22" N 114° 48' 16" W	Manual, See Appendix B	See Appendices C & D	
	3	Project Area Well Cluster-Groundwater (3 well Cluster)	Pre-Operational Operational Post-Operational	MW-7a MW-7 TW-1	TBD	34° 31' 39" N 115° 26' 55" W	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Allunium/Carbonates/Bed rock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	TW-2MW TW-2	TBD	34° 31' 13" N 115° 26' 57" W	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Allunium//Bedrock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	New Cluster Well	TBD	34° 31' 13" N 115° 26' 57" W	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Allunium/Bedrock
	4		Operational	28	5N/14E-28Q1	34° 31' 05" N 115° 29' 59" W	-	-	See Sections 5.4
			Operational	27N	5N/14E-27B1	34° 29' 54" N115° 29' 59" W	-	-	See Sections 5.4

Project Area Aquifer			Operational	27S	5N/14E-27Q1	34° 28' 14" N 115° 29' 59" W	-	-	See Sections 5.4
	4		Operational	21S	5N/14E-21P1	34° 30' 08" N 115° 31' 12" W	-	-	See Sections 5.4
			Operational	33	5N/14E-33K1	34° 28' 32" N 115° 31' 07" W	-	-	See Sections 5.4
		New Production Wells (29 total)	Operational	TBD (see Figure 5-2)	TBD	TBD	-	-	See Sections 5.4
	5	Benchmark Stations (20 total)	Pre-Operational Operational Post-Operational	TBD	NA	TBD	-	-	See Sections 5.5 and 6.3
		InSAR (2 per year)	Pre-Operational Operational Post-Operational	NA	NA	NA	-	-	See Sections 5.5 and 6.3
	6	Extensometer (3 total)	Pre-Operational Operational Post-Operational	TBD	NA	TBD	-	-	See Sections 5.5 and 6.3
	7	Flowmeter Surveys (5 total)	Pre-Operational	TBD	TBD	TBD	-	-	See Section 5.7
Bristol and Cadiz Dry Lakes	8	Bristol Dry Lake Well Cluster[b]	Pre-Operational Operational Post-Operational	TBD	TBD	TBD	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
		Bristol Dry Lake Well Cluster[b]	Pre-Operational Operational Post-Operational	TBD	TBD	TBD	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-

		Bristol Dry Lake Well Cluster[c]	Pre-Operational Operational Post-Operational	TBD	TBD	TBD	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
	9	Cadiz Dry Lake Well Cluster[d]	Pre-Operational Operational Post-Operational	TBD	TBD	TBD	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
	10	Gamma/EM Logs (up to 6 total)	Pre-Operational	TBD	TBD	TBD	-	-	See Section 5.10
Other (Basin-wide)	11	Weather Station	Pre-Operational Operational Post-Operational	Amboy	NA	34° 31' 52" N 115° 41' 42" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational Post-Operational	Mitchell Caverns	NA	34° 56' 06" N 115° 30' 58" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational	Fenner Gap	NA	34° 30' 57" N 115° 27' 45" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational Post-Operational	Cadiz Field Office (CIMIS Station)	NA	34° 30' 49" N 115° 30' 39" W	-	-	See Section 5.11
Air Quality	12	Nephelometers	Pre-Operational Operational Post-Operational	TBD	NA	TBD			See Section 5.12

NOTES:

a - Location coordinates to be verified in the field during initial Pre-Operational activity.

b - Two new well clusters to be installed at eastern margin of Bristol Dry Lake (see Figure 5-1).

c - One new well cluster to be installed on Bristol Dry Lake (see Figure 5-1).

d - One new well cluster to be installed north of Cadiz Dry Lake (see Figure 5-1).

Also see Table 5-1 for details of proposed monitoring features and frequencies.

Table 6.1

Cadiz Groundwater Conservation Recovery and Storage Project

Summary of Action Criteria, Impacts and Corrective Measures

Potential Impact	Method of Measurement	Triggers (Action Criteria)	"Close Watch" Measures	Corrective Measures
Third-Party Wells	Groundwater observation wells	Groundwater levels in observation wells are lower than projected by groundwater model or written complaints stating adverse impacts to yields and/or increased pumping costs and/or degraded water quality in wells owned by neighboring landowners	Investigation to determine if caused by project operations, and significance of impact Provision of supplemental water to impacted party	Deepen or improve efficiency of impacted wells Blend impacted well water with another local source Construct replacement wells Modify project operations
Land subsidence	Benchmark stations; InSAR; extensometers	Land surface elevations changes greater than projected by subsidence model. Land surface elevation changes of greater than 0.5 ft within the project area More than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks	Determine if elevation changes were directly attributable to project operations Conduct ground surveys to look for evidence of differential compaction	Repair damaged structures Modification of project wellfield operations to arrest subsidence

Induced flow of lower-quality water from Bristol and Cadiz dry lakes	Groundwater observation wells and cluster wells at dry lakes	TDS concentration changes in excess of 1,000 mg/l in observation wells located near modeled simulated projection of boundary of freshwater/saline water interface	Determine if concentration changes are directly attributable to project operations Install additional observation wells to further assess saline water migration	Deepen or improve efficiency of impacted wells Blend impacted well water with another local source Construct replacement wells Compensation Modify project operations until adverse impacts are no longer present at the impacted well(s) Modification of project operations to re-establish the natural hydraulic gradient and background TDS concentrations near the margins of the dry lakes Installation of injection and/or extraction well(s) to manage TDS
Brine resources underlying Bristol and Cadiz dry lakes	Groundwater observation wells and cluster wells at dry lakes	Changes in brine water levels larger than projected by the groundwater model simulations, or changes in brine water levels of greater than 50 percent above water column of the brine company's pump intake in comparison to pre-operational static levels in cluster wells at the margins of the dry lakes	Determine if brine water level changes are directly attributable to project operations	Modification of Project operations to re-establish brine levels beneath the dry lakes Installation of injection and/or extraction well(s) Compensation
Adjacent groundwater basins	Groundwater observation wells	No action criteria necessary; verification monitoring only	None	None
Springs	Visual observation and manual flow measurements annually of bonanza, whiskey, and vontrigger springs and groundwater levels measurements in observation wells	No action criteria necessary; verification monitoring only	None	None

Air quality	Groundwater observation wells (cluster wells at dry lakes), open-air nephelometers	Changes in air quality that exceed baseline conditions over a five-year moving average	FVMWC to determine if change is air quality is attributable to Project operations	Modification of Project operations to re-establish baseline air quality levels

GROUNDWATER STEWARDSHIP COMMITTEE

October 2011 Summary of Findings and Recommendations
Cadiz Groundwater Conservation, Recovery and Storage Project

The Groundwater Stewardship Committee (GSC) is a multi-disciplinary panel of earth science and water professionals assembled to provide advice and comment on the proposed Cadiz Conservation, Recovery and Storage Project (Project). The GSC specifically reviewed:

1) Project operating strategies to maximize the beneficial use of groundwater without causing harm to the resource, natural and built environment and community, and

2) proposed monitoring and mitigation strategies to be incorporated into a groundwater management plan for the Project.

Maximizing beneficial use of groundwater is defined as reducing the loss of groundwater to evaporation from the dry lakes by pumping and delivery of this water to meet Southern California water demands. The roster of the GSC members is attached.

Project background.

The Project site is located at the base of the Fenner Valley Watershed and Orange Blossom Wash upgradient of the Bristol and Cadiz Dry Lakes. The combined area of these watersheds is in excess of 1,300 square miles. Cadiz, a private company, owns land, under which the bulk of the groundwater flows, and on which the Project facilities will be located. The GSC understands that the Company has access to the ARZC Railroad right of way that provides private pipeline access to the Colorado River Aqueduct. The GSC understands that Cadiz actively farms approximately 1,500 acres under prior land use approvals and could expand the operation to as many as 9,600 acres.

As proposed, the Project would be implemented in two phases. The first phase emphasizes control of hydraulic gradients by groundwater pumping that would provide for:

1) active capture of natural recharge, within the watershed, and

2) recovery of groundwater, presently in storage, that would otherwise continue to flow under natural gradients toward the dry lakes and be lost to evaporation.

The Project would withdraw an average of 50,000 acre-feet per year (AFY) over a 50-year period, with individual annual extractions varying in any year between 25,000 to 75,000 acre feet to suit the needs of the people of Southern California. The GSC understands that future water conservation would benefit from the dewatered storage in the aquifer (effectively a “subsurface reservoir”) and hydraulic control that will allow deep and secure storage of large quantities of imported water. Imported water can be stored as the volume of dewatered storage increases and elimination of hydraulic gradients away from the well field toward the dry lakes. The GSC did

not evaluate the technical proposals for future conservation. However, the GSC supports the general concept and is willing to review or comment upon any such proposals.

GSC findings and recommendations.

The GSC was presented with historical and new technical investigations of geology, hydrogeology, climatic data, groundwater recharge, groundwater conditions, water quality, air quality, and plant and vegetation surveys. These reports document no observed plant or wildlife that relies upon groundwater (except springs in the mountains, which are not dependent upon the alluvial aquifer from which the Project wells will extract groundwater). The GSC reviewed technical reports prepared by Cadiz consultants to evaluate potential impacts for the first phase of the Project in four specific areas including: (1) subsidence; (2) springs; (3) air quality; and (4) water quality degradation.

The most recent evaluation of natural recharge estimate is 32,500 acre-feet per year; however, a range of recharge estimates, higher and lower, has been developed by previous investigators. Therefore, to assess the potential magnitude of impacts, the modeling and impact analysis employed three different recharge scenarios; 5,000 AFY, 16,000 AFY and 32,000 AFY. The Project is designed to extract an average of 50,000 AFY regardless of actual natural recharge, so this range of natural recharge was assessed to examine the impacts of the Project extraction, allowing for conservative natural recharge estimates and assessment of potential impacts.

The anticipated withdrawal of groundwater in the proposed well field will intercept natural recharge and retrieve groundwater in storage that is currently escaping to the dry lakes. The range of potential evaporation from the dry lakes has been estimated to be between 12,000 AFY on the low end and as high as 143,000 AFY on the high end. However, actual evaporation is expected to balance actual recharge, so that long-term average annual recharge is equal to the long-term average annual evaporation off the dry lakes. Although there is some variability in the projected evaporation rates from the dry lakes, assuming the highest evaporation over a 100-year period, as much as 2.2 million acre-feet could be saved from evaporation, and used for public benefit if the Project is implemented as proposed. To achieve this objective, there will be potential drawdown in well-field groundwater levels that may range from 70 feet to 270 feet depending upon the actual quantity of natural recharge, variations in aquifer hydraulic properties, and well-field design. Based on the information available, the committee finds that the average annual extraction of 50,000 AFY for 50 years is feasible and that total average annual extraction of 50,000 AFY can be applied to the cumulative agricultural and Project demands. The GSC understands that if the Project is carried out as proposed, to produce an annual average of 50,000 AFY for delivery to Project participants, the agricultural use of groundwater is expected to cease.

The GSC reviewed and discussed the methods of investigation and evaluation and concludes that these analyses are reasonable and consistent with standard professional practice and adequately assess the four identified areas of potential impacts from the proposed Project, as described below.

Subsidence. Significant subsidence is not expected in any of the scenarios. The Fenner Gap area is underlain by sediments that are not rich in clays and silts, which are normally associated with subsidence. There is increasing silt and clay content in the alluvial aquifer sediments nearer the dry lakes, which is where subsidence, if any, is projected to be 2.7 feet under the lowest natural recharge scenario which creates the highest groundwater drawdown. Permanent compaction due to subsidence would not significantly impact the alluvial aquifer's storage capacity as consolidation of the aquifer will occur in clay and silt intervals, which do not contribute to the useable storage capacity anyway. However, we recommend that the Project managers consult with the railroad and pipeline companies and include extensive monitoring for early warning in the interest of safety. Monitoring through the use of extensometers, designated bench marks, In-SAR (interferometric synthetic aperture radar), and the ability to manage pumping patterns in concert with the monitoring in the event significant subsidence is observed would mitigate problems.

The springs. The springs in the watershed area rely on rainfall recharge of shallow fractured bedrock, and there is no evidence that the springs are dependent on the deep alluvial groundwater system from which the Project proposes to pump groundwater or that they will be affected in any way by the pumping. All of the springs are more than 11 miles away and are located in fractured crystalline (granitic and metamorphic) rocks at substantially higher elevations than the alluvial aquifer from which the Project wells will pump groundwater. Therefore, pumping in the alluvial aquifer in the Project well field should not affect groundwater levels in these crystalline rocks, so it will not adversely impact springs. Nevertheless, the GSC supports ongoing observation of the springs and the flow conditions as proposed, including the closest spring (Bonanza Spring), and several more distant springs (such as Whiskey and Vontrigger) for comparison and to account for climatic changes.

Air quality. The GSC reviewed the technical reports provided on the Bristol and Cadiz Dry Lakes that conclude that these dry lakes do not pose a substantial risk of elevated dust levels arising from the underlying sediments being dewatered. High concentration of chloride salts in the surface soils act to bind the surface soils so as to minimize soil becoming airborne as dust. The GSC also reviewed the technical report on the dry lakes that revealed that plant life in the area of the dry lakes is precipitation and runoff fed and does not rely upon groundwater. The evidence presented in these reports seems conclusive. However, verification monitoring is strongly recommended to confirm these conclusions. Monitoring can be relaxed if these findings are further proven during Project operations.

Water quality. The migration of saline (> 1,000 mg/l) groundwater towards the well field is predicted by modeling to be less than 12,000 feet. The modeling demonstrates that the movement is not increased under the higher drawdown levels that are associated with the lower recharge rates, as these scenarios have low aquifer transmissivity. There are no known or projected beneficial users of fresh (<1,000 mg/l) groundwater in the affected area. However, monitoring and mitigation elements of the groundwater management plan are proposed to monitor this condition. If necessary and appropriate, the migration could potentially be stabilized through either extraction of saline groundwater (which possibly could be used by the salt mines), injection of fresh water to create a barrier to mitigate further migration, or alteration of pumping patterns. These approaches are reasonable.

Concluding summary

The GSC finds that the average annual extraction of 50,000 AFY for 50 years is feasible. The GSC concludes that the monitoring, proposed action criteria, and mitigation elements are reasonable and, if adopted, should provide assurance against harm resulting from the conservation, recovery, and beneficial use of groundwater as proposed in the Project. The GSC recommends that proposed monitoring elements be adopted and incorporated into a groundwater management plan for the Project.

GROUNDWATER STEWARDSHIP COMMITTEE
MEMBERS

- Jack Sharp, Professor of Geology, University of Texas (Chair)
- Terry Foreman, CH2M Hill
- Dennis Williams, Geoscience
- Bill Blomquist, Indiana University
- Andrew Stone, American Ground Water Trust
- Greg Thomas, Natural Heritage Institute
- Bob Wilkinson, The Bren School of Environmental Science and Management, University of CA at Santa Barbara
- Steve McCaffrey, University of the Pacific, McGeorge School of Law
- Rod Banyard, Australia Water Policy Branch, Department of Environment and Water Resources
- Tim Parker, Parker Groundwater
- Toby Moore, Golden State Water Company
- Charles Groat, Director of the Center for International Energy and Environmental Policy, University of Texas

Dr. John M. Sharp, Professor Geology, University of Texas

EDUCATION:
Ph.D., 1974, M.S., 1974, University of Illinois. Ph.D. dissertation: An Investigation of Energy Transport in Thick Sequences of Compacting Sediments.
32 semester hours, Midwestern University. Business Administration (attended nights while in the U.S. Air Force). Emphasis on economics and management science.
B. Geological Engineering with Distinction, 1967, University of Minnesota (emphasis on rock mechanics, porous media flow, and site development). B.Geol.E. thesis: Eastern Minnesota Copper Prospects, 43p.

PROFESSIONAL EXPERIENCE:
The University of Texas, Austin, Texas: 1982-present, currently David P. Carlton Professor of Geology
C.S.I.R.O. Centre for Groundwater Studies, Adelaide, Australia, 1994, visiting scientist
U.S. Geological Survey, Reston, Virginia, 2010 , visiting scientist
University of Missouri, Columbia, Missouri: 1974 -1982, associate professor
University of Illinois, Urbana, Illinois: 1971-1974, Teaching Assistant and Research Fellow
U.S. Air Force: 1967-1971 – Captain (civil engineering)

SELECTED SERVICES TO PROFESSION:
Geological Society of America: President and Councilor; Executive Committee; Finance Committee; GSA representative to the Council of Scientific Society Presidents; Editor, Environmental and Engineering Geoscience; GSA Representative to U.S. Committee, International Assoc. of Hydrogeologists; Associate Editor, Geological Society of America Bulletin; Chairman, Hydrogeology Division

American Institute of Hydrology: Chairman, Board of Registration; Executive Committee; Vice President for Academic Affairs; Registration Board; Editorial Board: Hydrological Science and Technology

National Research Council: Advisory Committee on the Waste Isolation Pilot Plant (WIPP)

International Association of Hydrogeologists: Scientific Advisory Committee, 2012 International Conference on Groundwater in Fractured Rocks, Prague, Czech Republic; North American Scientific Advisory Committee,2012 39th Congress, Niagara Falls, Canada; Executive Committee & Finance Committee (US National Committee); Treasurer; Chairman (US National Committee); co-editor, Selected Papers Volume 9, Groundwater in Fractured Rocks; Vice Chairman, Commission on Education and Training; Vice President; Associate editor, Journal of Hydrogeology
Council of Scientific Society Presidents:; 2010 Treasurer; 2009-2011 Board of Directors

Other miscellaneous services to profession:

Editor board, Aqua mundi
Biological Advisory Team for the Barton Springs/Edwards AquiferConservation District
Edwards Aquifer Authority, Aquifer Sciences Advisory Panel
Luminant Energy (formerly Texas Utilities Co.) Environmental Steering Committee

Terry Foreman, Vice-President, CH2M Hill, Thousand Oaks, CA

Terry Foreman's roles at CH2M HILL include Senior Hydrogeologist, Vice President and the Thousand Oaks Area Office Manager. Mr. Foreman's technical expertise is in the management and development of groundwater resources, including water supply development, conjunctive use of surface waters, groundwater, and recycled water, remediation of contaminated groundwater, and regulatory support. Mr. Foreman has over 30 years of consulting experience in water resources projects, mostly in the Southwestern United States. Mr. Foreman has served as project manager for the Las Posas Basin ASR project, the largest ASR project in California, the West Basin Water Recycling Program Injection Barrier Project, which involves injection of highly treated wastewater into the 9-mile long West Coast Basin Seawater Intrusion Barrier, the Dominguez Gap Seawater Intrusion Barrier Extension project. Mr. Foreman has authored over 30 technical papers and presentations. Mr. Foreman received his Bachelors and Masters degrees in Geology from the University of Missouri – Columbia. He is a Registered Geologist and Certified Hydrogeologist in California. He is on the Board of Directors of the American Ground Water Trust, where he has held offices of Secretary, Vice Chairman, and Chairman (2002). He is the President of the Central Coast Branch of the Groundwater Resources Association of California.

Dennis Williams, Geoscience

Dr. Dennis E. Williams, founder and president of the Southern California based firm GEOSCIENCE Support Services, Inc. has over 35 years of experience in ground water hydrology. During that time he has directed geohydrologic investigations domestically and worldwide which includes the design and supervision of construction of over 800 deep large-scale municipal and irrigation water supply wells. Dr. Williams also pioneered the use of slant wells for desalination feedwater supply. He has been a consultant to the United Nations and several foreign governments and is currently a part-time research professor at the University of Southern California's Civil and Environmental Engineering Department where he has taught graduate level courses in geohydrology and ground water modeling since 1980. Dr. Williams is currently directing research on ground water and wells at USC's geohydrologic laboratory which houses the largest sand-tank model in the world. Dr. Williams is author of over 30 publications on ground water and wells and was the principal author of the Handbook of Ground Water Development (John Wiley & Sons, 1990); the Handbook was awarded Honorable Mention in the

Engineering Category of the Fifteenth Annual Awards for Excellence in Professional and Scholarly Publishing by the Association of American Publishers. Dr. Williams was also chief reviewer for the American Society of Civil Engineers (ASCE) Manual of Water Well Design, Construction, Testing and Maintenance and primary author for two chapters, Water Well Construction, and Developing and Testing, and of Appendix Example of Water Well System Design (currently in press). Dr. Williams is a contributor for three entries in the Encyclopedia of Water: "Radial Wells", "Well Tests", and "Well Screens" published by John Wiley and Sons. Dr. Williams is a technical consultant to the American Water Works Association (AWWA) Standards Committee for Wells (ANSI/AWWA A100-04).

William Blomquist, Dean, School of Liberal Arts, Indiana University

William Blomquist is Dean of the School of Liberal Arts, Professor of Political Science, and Adjunct Professor of Public and Environmental Affairs, at Indiana University Purdue University Indianapolis (IUPUI). He is also an affiliated faculty member of the Workshop in Political Theory and Policy Analysis, and the Center for Earth and Environmental Science. The focus of his teaching is American government and public policy.

He received his B.S. in Economics (1978) and M.A. in Political Science (1979) from Ohio University, and his Ph.D. in Political Science (1987) from Indiana University. He joined the IUPUI faculty in 1987.

His research interests concern governmental organization and public policies, with a specialization in the field of water institutions and water management. He is the author or co-author of several publications related to these topics, including the books Dividing the Waters (1992), Common Waters, Diverging Streams (2004), and Integrated River Basin Management through Decentralization (2006), and articles in Society and Natural Resources, Political Research Quarterly, Water Resources Research, and Natural Resources Journal, among others.

His research has been supported by the United States Geological Survey, the United States Advisory Commission on Intergovernmental Relations, the National Water Research Institute, the National Science Foundation, the United States Environmental Protection Agency, and The World Bank. He serves on the Board of Directors of the American Ground Water Trust, the Research Advisory Board of the National Water Research Institute, and a study committee of the National Research Council on sustainable underground water storage.

He has provided formal and informal consultation to the United States Advisory Commission on Intergovernmental Relations, the U.S. Bureau of Reclamation, Sandia National Laboratories, the International Center for Self-Governance, and local agencies involved in the management of water supplies in Southern California. He led an inter-agency planning process involving 33 agencies in Orange County, California, and has facilitated workshops for the Santa Ana Watershed Project Authority, the University of California-Davis, and the University of California-Irvine.

Andrew Stone, Executive Director, American Ground Water Trust

Andrew Stone is a hydrogeology graduate from London University with additional academic qualifications in geology, geography and education. He has over thirty five years of ground

water experience in Africa and the U.S. as a university professor, ground water consultant and ground water advocate & educator. He has first-hand experience of ground water exploration, well design and source protection in a wide variety of geologic environments. As the director of the AGWT's education programs he has convened and coordinated over one hundred conference programs related to geothermal technology, well design, ground water management, aquifer storage recovery, conjunctive use, water banking, and asset management. From 1990 to 2003 he taught an annual course on Groundwater Protection Policy at Antioch New England University. In recognition of his work in promoting ground water resource education in the US, he received the 1998 National Ground Water Association "Oliver Award" for outstanding contributions to the ground water industry.

The American Ground Water Trust (AGWT) is a non-profit education organization with programs that include teacher training, and conferences and workshops that focus on resources, technology and environmental issues. The AGWT promotes sustainable use and resource protection. AGWT programs provide science-based information to professionals, the public and decision-makers.

Gregory Thomas, Founder and President, Natural Heritage Institute

Gregory A. Thomas, J.D., is the founder and president of the Natural Heritage Institute. Greg has practiced natural resources law since 1974, primarily for non-profit conservation organizations. In the 1970's, he played a central role in the enactment of much of the foundational federal laws in the energy and environmental field. He was a senior staff attorney with the Natural Resources Defense Council's international program, and became the managing attorney of its San Francisco office. He was a Fulbright Professor and advisor to the national environmental ministry of China, and he taught law at UCLA and UC Berkeley. Greg's practice has encompassed many areas of natural resource management, including water resources, energy, air quality, biodiversity, environmental planning, and international conservation. He has 35 years experience in litigation, administrative trials, legislative advocacy, policy analysis, institutional design, and consensus building processes. At NHI, he develops and manages large-scale projects in California, throughout the United States and internationally.

Dr. Robert C. Wilkinson, The Bren School of Environmental Science and Management, University of CA at Santa Barbara

Dr. Robert C. Wilkinson is Director of the Water Policy Program at the Bren School of Environmental Science and Management at the University of California, Santa Barbara, and he is a Lecturer in the Environmental Studies Program at UCSB. Dr. Wilkinson's teaching, research, and consulting focus on water policy, energy, climate change, and environmental policy issues. Dr. Wilkinson is also a Senior Fellow with the Rocky Mountain Institute. Dr. Wilkinson advises businesses, government agencies, and non-governmental organizations on water policy, climate research, and environmental policy issues. Additionally, Dr. Wilkinson advises various federal agencies including the, US DOE National Renewable Energy Laboratory and the US EPA on water and climate research, and he served as coordinator for the climate impacts assessment of the California Region for the US Global Change Research Program and the White House Office of Science and Technology Policy. He has worked extensively in Western Europe, every country of Central Europe from Albania through the Baltic States, and throughout the former Soviet Union including Siberia and Central Asia.

Stephen McCaffrey, University of the Pacific, McGeorge School of Law

Stephen C. McCaffrey is a Distinguished Professor and Scholar at the University of the Pacific, McGeorge School of Law in Sacramento. Professor McCaffrey served as a member of the International law Commission of the United Nations (ILC) from 1982-1991 and chaired the Commission's 1987 Session. He was the ILC's special rapporteur on the Law of the Non-Navigational Uses of International Watercourses from 1985 until 1991, when the Commission provisionally adopted a full set of draft articles on the topic. The ILC's draft articles formed the basis for the 1997 United Nations Convention on the same subject. Professor McCaffrey served as Counselor on International Law in the Office of Legal Advisor, U.S. Department of State, from 1984-1985. He was counsel to Slovakia in the *Gabcikovo-Nagymaros Project* case decided by the International Court of Justice in 1997 and currently serves as counsel to Nicaragua in the *Navigational and Related Rights* case (Costa Rica v. Nicaragua). He also advised India in the *Bagihar HEP* case, before the Neutral Expert appointed under the 1960 Indus Waters Treaty. He has served as Legal Adviser to both the Nile River Basin Negotiating Committee and the Palestinian Authority/PLO and was a member of the U.S. National Research Council's Committee on the Scientific Bases of Colorado River Basin Water Management. Professor McCaffrey's publications include *The Law of International Watercourses* (Oxford University Press, 2d ed. 2007), *Understanding International Law* (Lexis Publishing, 2006) and *International Environmental Law & Policy*, with Edith Brown Weiss, Daniel Magraw and A. Dan Tarlock (Aspen, 2d ed., 2007).

Rod Banyard, Australia Water Policy Branch, Department of Environment and Water Resources

Rod is a civil engineer who has worked in the Western Australian public sector as an engineer, administrator, legal advisor and policy developer for forty years. Rod has recently worked in the Commonwealth public sector, responsible for the development of legislation to implement the National Plan for Water Security. He has extensive experience in the areas of water engineering, groundwater development, water resource management, policy development, legislative drafting and administration that allows him to develop practical solutions to water resource management problems.

Tim Parker, Parker Groundwater

Tim Parker is a nationally recognized groundwater expert and currently is with Parker Groundwater in Sacramento, California, a firm he founded in 2009. He has worked in private and public sector, was formerly with Schlumberger, Law, Dames & Moore, and has worked for California Department of Water Resources, California Geological Survey, and Department of Toxic Substances Control. Mr. Parker's groundwater experience spans more than 25 years and includes water policy analysis, groundwater resources development, groundwater recharge, groundwater management, modeling, monitoring, contaminant hydrogeology, and geologic carbon sequestration. He is a California Professional Geologist, Certified Engineering Geologist, and Certified Hydrogeologist. Tim serves the Groundwater Resources Association of California as a Director and Legislative Committee Chair, the California Groundwater Coalition as Director, and American Ground Water Trust as Chair. He is a member of the Public Advisory Committee for the development of the 2013 California Water Plan, and the Oversight Work Group for Pilot Projects for the Nationwide Ground Water Monitoring Network, under the Subcommittee on Ground Water, Advisory Committee on Water Information, U.S. Department of the Interior. Mr. Parker recently served as a Director on the National Ground Water Association-Association - Scientists and Engineers Division. Mr. Parker coauthored the books

California Groundwater Management published by GRA in 2005, and *Potential Groundwater Quality Impacts Resulting from Geologic Carbon Sequestration* published by the Water Research Foundation in 2009.

Toby Moore, PhD, PG, CHG, Golden State Water Company

Dr. Moore is the Water Resources Manager and Chief Hydrogeologist for Golden State Water Company, a California based investor-owned water utility and subsidiary of American States Water Company. GSWC operates 38 water systems and has a diverse portfolio of water rights managed by Dr. Moore's department. This includes groundwater extractions in 17 groundwater basins throughout California. Toby has a multidisciplinary background in geology, geochemistry, hydrogeology, and biology. He received his Bachelor's degree in Biology and his Doctorate in Geology, both from UCLA. He also holds registrations in the State of California as a Professional Geologist and Certified Hydrogeologist. With over 18 years of professional experience in Water Resources and environmental consulting, Toby has been focusing his expertise on water resource development, water quality and contaminant fate and transport. Toby also currently serves as a Director on the California Groundwater Coalition, a Director on the Pomona Valley Protective Association, Technical Advisory Member of the Southern Branch of the California Groundwater Resources Association and a committee member of the Joint Management Committee of the Alamitos Barrier Project.

Charles G. Groat, PhD, Director of the Center for International Energy and Environmental Policy, University of Texas

Chip Groat is Director of the Center for International Energy and Environmental Policy, Associate Director of the Energy Institute, and Director and Graduate Advisor of the Energy and Earth Resources Graduate Program. He holds the John A. and Katherine G. Jackson Chair in Energy and Mineral Resources in the Department of Geological Sciences, Jackson School of Geosciences, and is Professor, LBJ School of Public Affairs at The University of Texas at Austin. He assumed these positions in June 2005 after serving 6 ½ years as Director of the U.S. Geological Survey, having been appointed by President Clinton and retained by President Bush. He served as interim dean of the Jackson School of Geosciences at UT from July 2008 to August 2009.

Prior to his position with the U.S. Geological Survey, he was Associate Vice President for Research and Sponsored Projects at The University of Texas at El Paso following a term as Director of the Center for Environmental Resource Management and Professor of Geological Sciences there. His previous experience includes Associate Director and Acting Director of the Bureau of Economic Geology and Associate Professor of Geological Sciences at The University of Texas at Austin; Chairman of the Department of Geological Sciences at The University of Texas at El Paso; State Geologist and Director of the Louisiana Geological Survey; Assistant to the Secretary of the Louisiana Department of Natural Resources administering the Coastal Zone Management and Coastal Protection programs; Professor of Geology and Geophysics and Director of the

Center for Coastal, Energy and Environmental Resources at Louisiana State University; and Executive Director of the American Geological Institute.

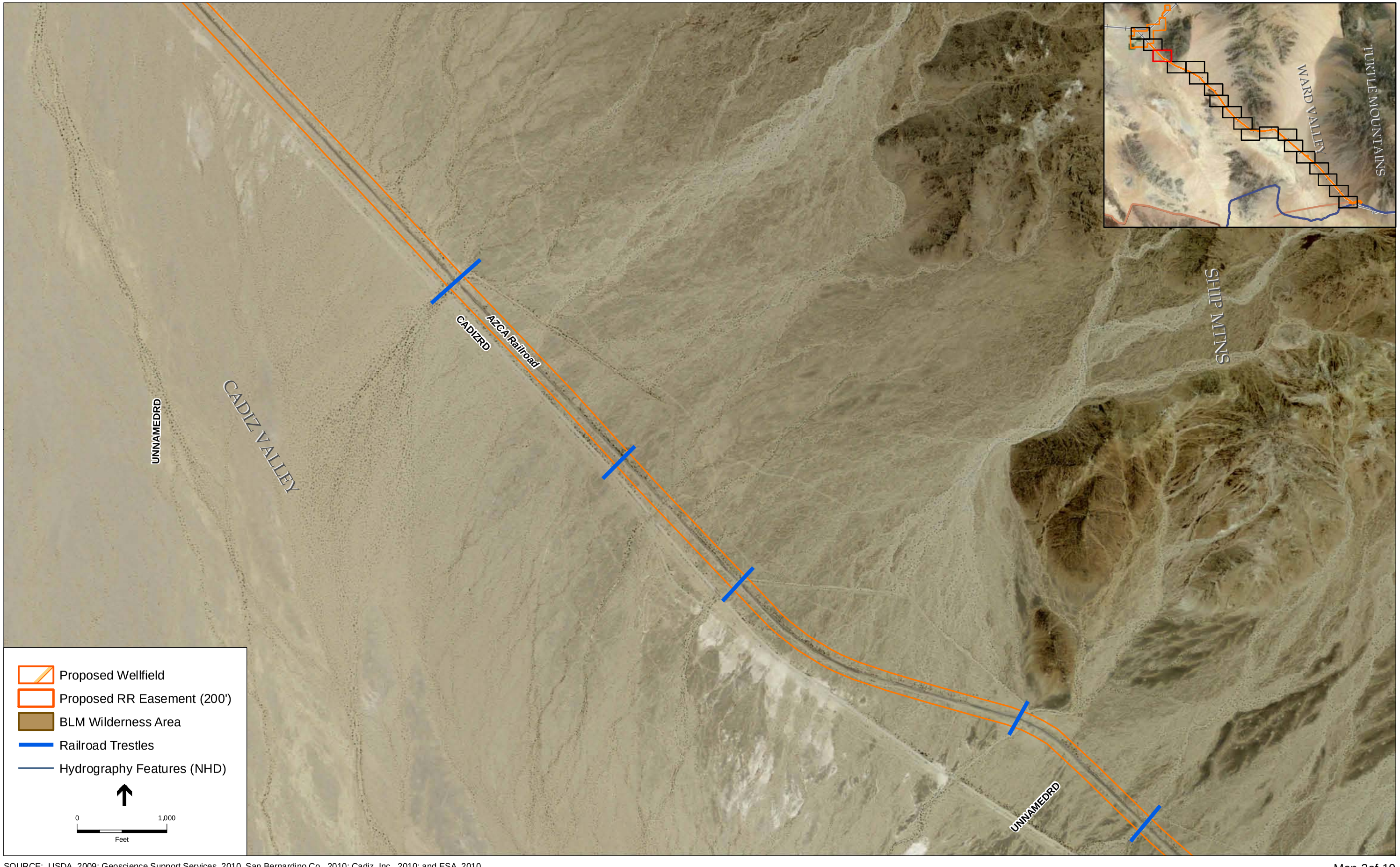
He has been a member of the National Research Council Board on Earth Sciences and Resources and the Outer Continental Shelf Policy Board. He is a past President of the Association of American State Geologists and of the Energy Minerals Division and Division of Environmental Geosciences of the American Association of Petroleum Geologists.

His degrees in geology are from the University of Rochester (A.B.), University of Massachusetts (M.S.), and The University of Texas at Austin (Ph.D.)

His current interests focus on advancing the role of science and engineering in shaping policy and informing decisions, and on ways to increase the integration of the science disciplines as a means of improving the understanding of complex resource and environmental systems.

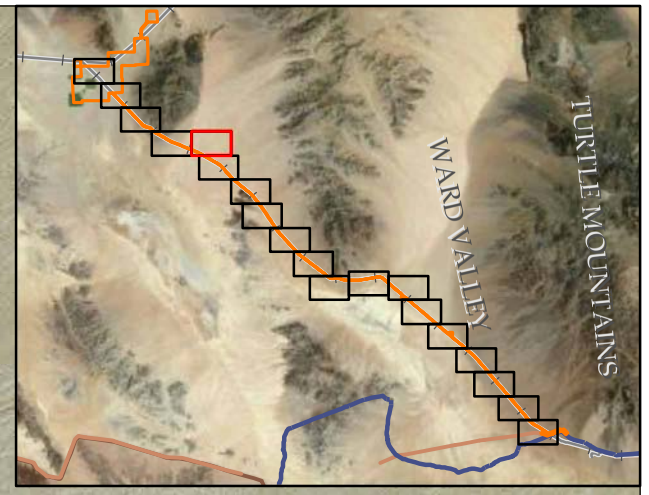
SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



AZCA Railroad

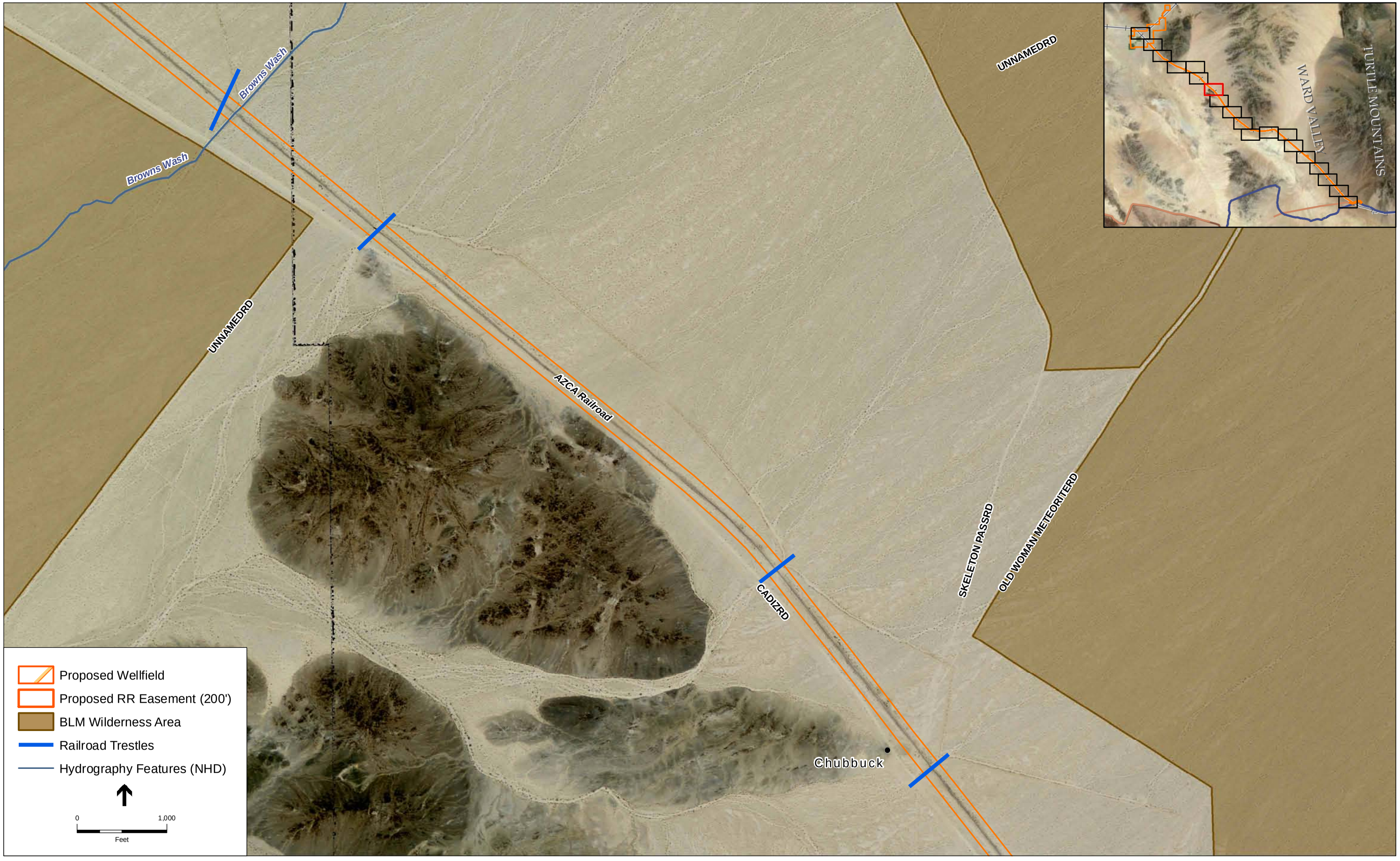
UNNAMEDRD

Proposed Wellfield
Proposed RR Easement (200')
BLM Wilderness Area
Railroad Trestles
Hydrography Features (NHD)

0 1,000
Feet

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

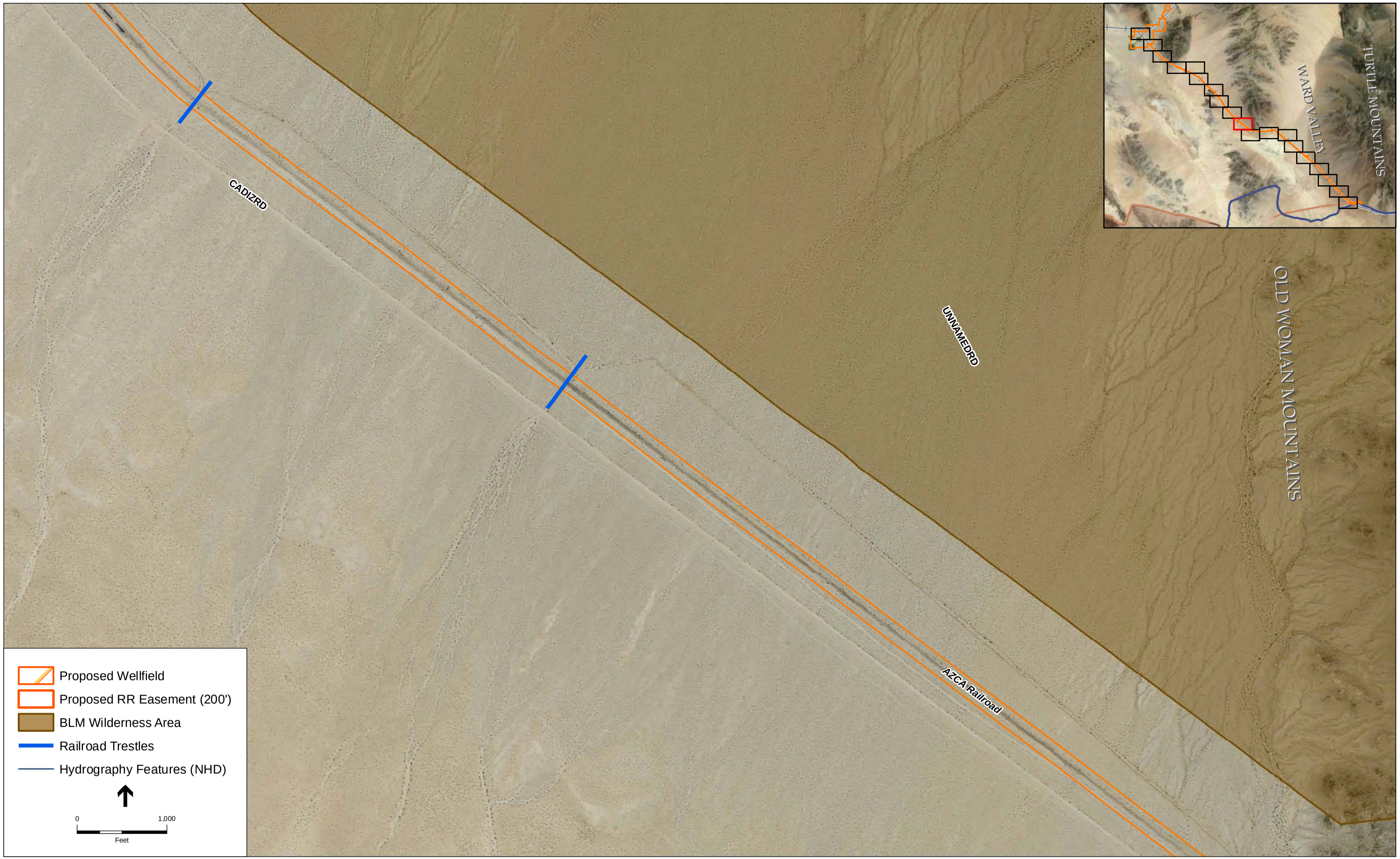
SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

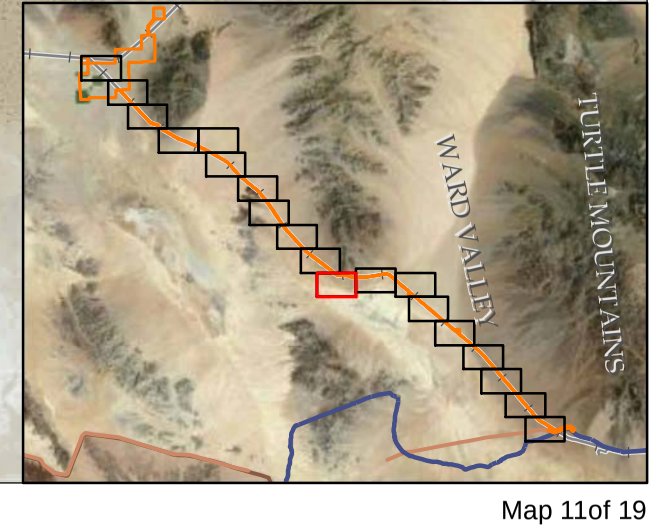
AZCA Railroad

CADIZRD

UNNAMEDRD

UNNAMEDRD

Danby Dry Lake



Proposed Wellfield

Proposed RR Easement (200')

BLM Wilderness Area

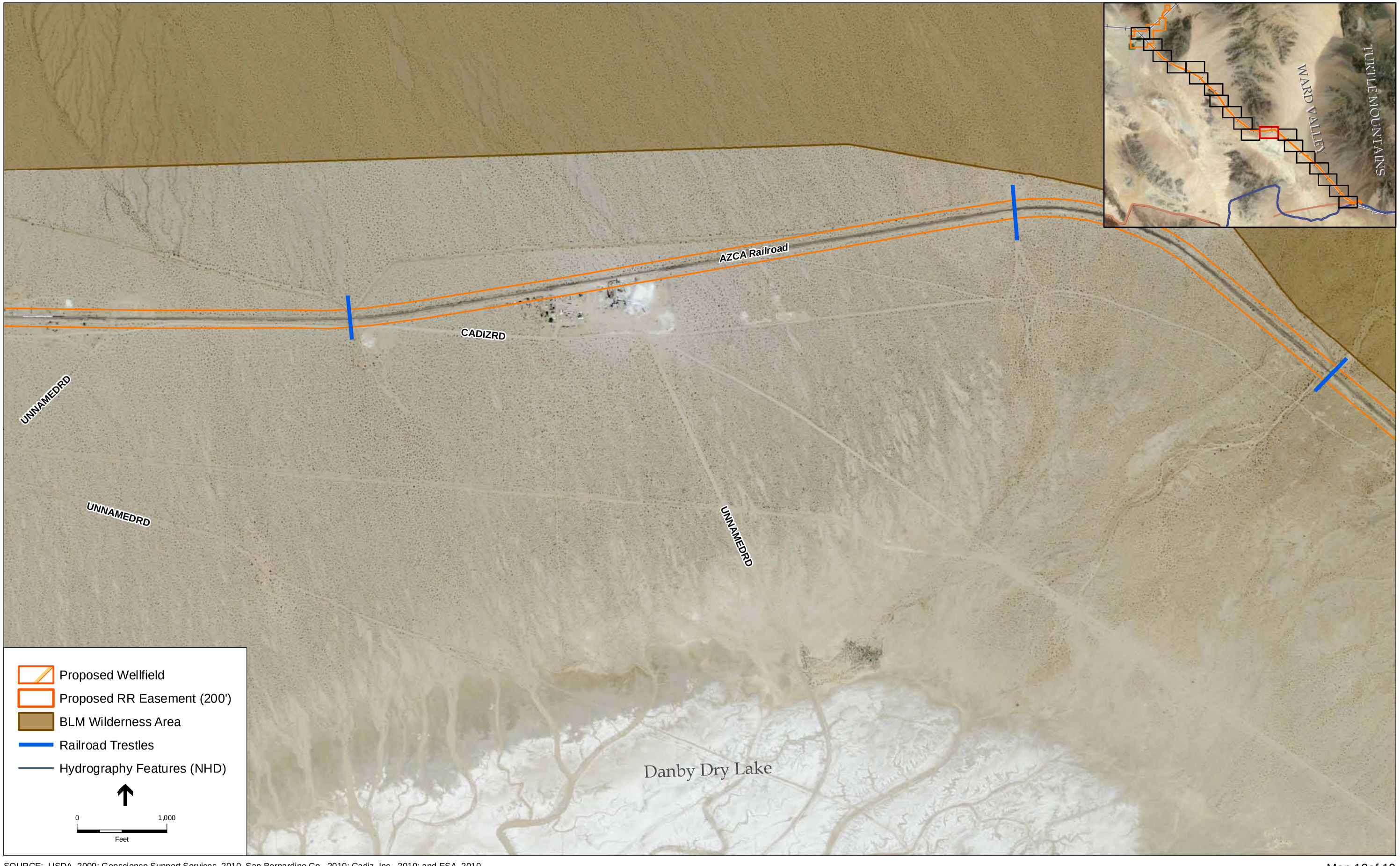
Railroad Trestles

Hydrography Features (NHD)

0 1,000

Feet

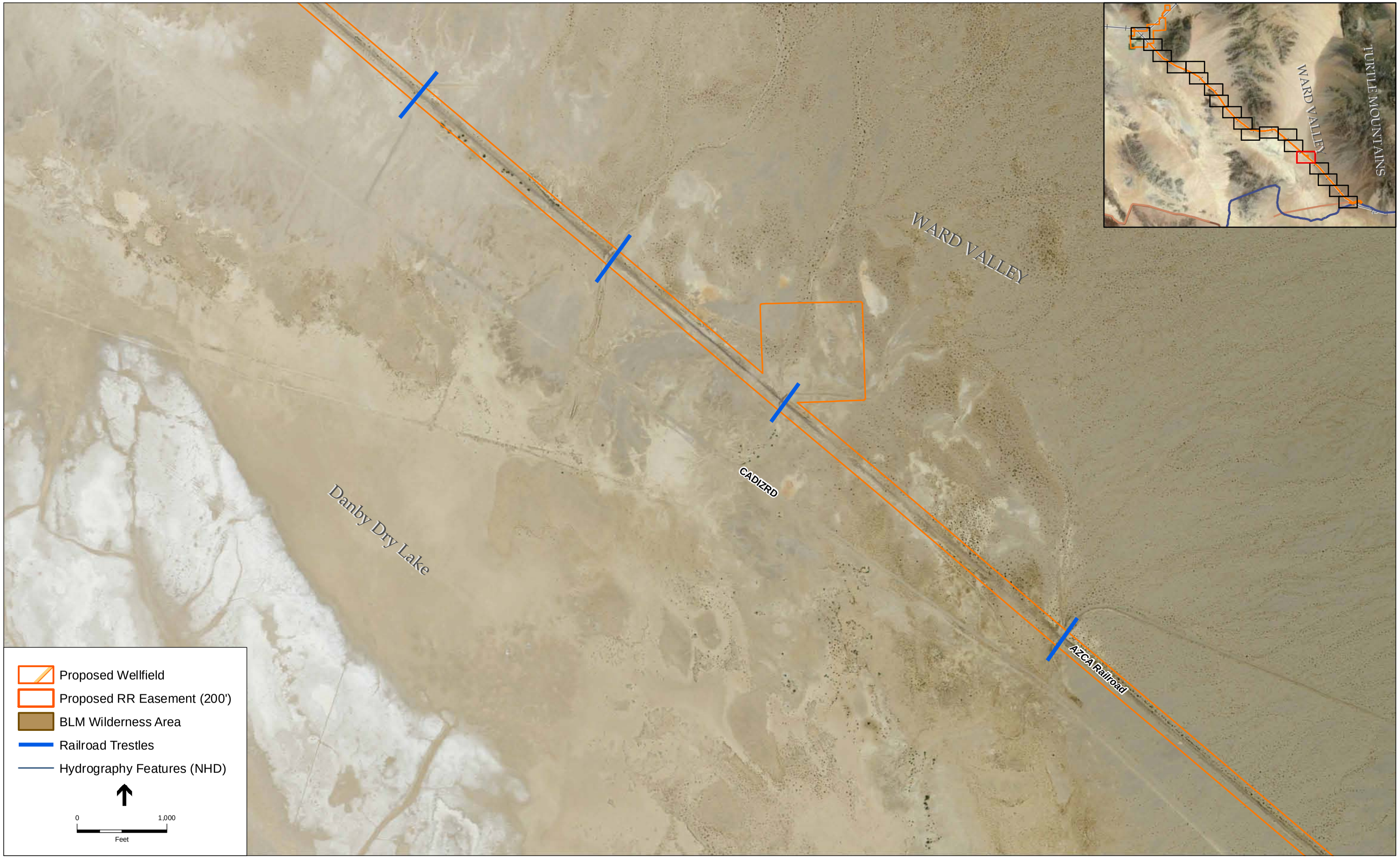
SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010



SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

SOURCE: USDA, 2009; Geoscience Support Services, 2010, San Bernardino Co., 2010; Cadiz, Inc., 2010; and ESA, 2010

Map 19of 19
Cadiz Groundwater Project

Power Requirements Analysis
Technical Memorandum

Cadiz Groundwater Conservation and Storage Project
San Bernardino County, California
Phase I

November 18, 2010

Prepared by:

9755 Clairemont Mesa Blvd, Suite 100
San Diego, CA 92124
858.614.5000

Ron Craig, PE	Project Manager
Paul Findley, PE	Project Engineer
Makrom Shatila, PE	Project Engineer
Bruce Cooke, PE	Electrical Engineer

PE STAMP

RBF JN: 65-100075

TECHNICAL MEMORANDUM

To: Scott S. Slater, Esq. **JN:** 65-100775

From: Makrom Shatila
Bruce Cooke
Paul Findley

Date: November 18, 2010

Project: Cadiz Groundwater Conservation and Storage Project

Subject: **Phase I – Power Requirements and Supply Analysis**

Background

Cadiz, Inc. (Cadiz) is a publicly traded renewable resources company founded in 1983. Cadiz owns 34,000 acres of largely contiguous land in the Cadiz and Fenner valleys, located in the eastern Mojave Desert. In the early 1990's, Cadiz recognized the potential for developing a water supply project on its properties and reached out to partner with water supply agencies. In 1999, Black and Veatch conducted a feasibility study titled *Cadiz Groundwater Storage and Dry-Year Supply Program* (dated November 1999). The study evaluated the operation of a groundwater storage and transfer project, in collaboration with Metropolitan Water District of Southern California (MWD). The project would have involved transporting surplus Colorado River water to the project site, recharging it through a series of recharge basins, storing the water, and then extracting the stored water during times of drought. The feasibility study demonstrated a significant potential for water supply development, yet MWD decided not to pursue the project in 2001.

Cadiz continues to pursue the development of a water supply project which emphasizes water conservation by capturing natural recharge in the Fenner and northern Bristol valleys that would otherwise discharge to the Bristol and Cadiz dry lakes and evaporate. In July 2010, CH2MHill conducted additional studies to assess the quantity of groundwater flowing through the Fenner Gap area and published its findings in a study titled *Cadiz Groundwater Conservation and Storage Project* (dated July 2010). The additional studies and groundwater modeling demonstrated that several thousands of acre-feet of water could be recovered from the Fenner Gap area. These significant findings have led Cadiz to consider developing a well field extraction project, which would extract groundwater from the Fenner Gap area and convey it to the Colorado River Aqueduct (CRA) to be purchased by MWD as an additional regional water supply.

Introduction

Several studies (some mentioned previously), have proposed various project components for the Cadiz Groundwater Conservation and Storage Project. These components consist of a well field; large diameter conveyance pipeline; forebay(s), and high service pump station(s).

RBF Consulting (RBF) has been contracted to provide technical support for further development of the Cadiz Groundwater Conservation and Storage Project. The purpose of this technical memorandum (TM) is to develop the approximate power requirements for Phase I of the project. Phase I of the project consists of groundwater extraction and conveyance to the Colorado River Aqueduct (CRA). This would be accomplished with a well field, conveyance pipeline, and intermediate pump station (IPS). Each project component is briefly described below and illustrated in Exhibit A.

Cadiz Well Field

The well field would be approximately 4,000 acres located on Cadiz property in the Fenner Gap area (see Exhibit A). The well field would consist of approximately 30 wells, each well approximately 1,000 feet deep. Each well would pump approximately 2,500 gpm. The entire well field is anticipated to extract 50,000 – 100,000 acre-feet per year (afy) of groundwater from the Fenner Gap area.

Conveyance Pipeline

The extracted groundwater would be conveyed to the CRA through a large diameter pipeline. The pipeline is approximately 42 miles long, ranging in size from 60-inch to 96-inch diameter. In 2008, Tetra Tech provided a preliminary engineering analysis for the proposed pipeline alignment along the Arizona and California (ARZC) railroad alignment titled *ARZC Railroad Alignment* (dated July 2008). RBF has updated the pipeline hydraulics, using the previous Tetra Tech alignment study as a basis. The revised conveyance pipeline alignment can be divided into four (4) segments as listed in Table 1.

Table 1
Conveyance Pipeline Description

Pipeline Segment	Length		Diameter	Description	
	ft.	mi.	in.	From	To
1	63,000	12	60	Well Field	Tunnel
2	12,000	2	96	Chubbuck Tunnel	
3	69,000	13	60	Tunnel	IPS
4	79,330	15	84	IPS	CRA
Total	**223,330**	**42**			

Segment 1 consists of 63,000 linear feet (LF) of 60-inch diameter pipe to convey extracted groundwater from the well field to the newly proposed Chubbuck tunnel (Segment 2).

Segment 2 consists of a 96-inch diameter pipeline, tunneled approximately 12,000 LF through the Chubbuck area, which is the high point in the conveyance system (elev. ~ 1,021 ft MSL). The well field pumps would convey the extracted groundwater (Segment 1) to the horizontal storage tank (Segment 2), and the water would then gravity flow to the intermediate forebay (segment 3).

Although the Chubbuck Tunnel reduces the pumping head on the well field pumps by approximately 15-20 feet, the main purpose of the tunnel is to operate as a free water surface horizontal storage tank. Three options were considered to handle the high point in the system. Due to surge concerns, breaking head at the high point using a tank was the favorable option. The first (1) option was to not utilize storage (do not break head) and pump through the high point. This design would require air release valves which would be exposed to the harsh desert climate (very hot summers and very cold winters), and therefore would have to be routinely inspected to insure proper operation in the event of sudden pressure loss. If the air release valves fail, the potential impacts could be catastrophic. The second option (2) was to construct a vertical storage tank near the high point. This was determined not feasible since Cadiz does not own any land near Chubbuck and can not construct a tank in the railroad easement. The third (3) option was to tunnel a large diameter (96-inch) nearly horizontal pipeline that would operate as a storage tank. Stand pipes would be used to break head in the pipeline.

Segment 3 consists of 69,000 LF of 60-inch diameter pipe to convey groundwater from the Chubbuck Tunnel terminus to the intermediate forebay and pump station. The water would discharge from the horizontal storage tank (Segment 2) and gravity flow to the intermediate forebay. The IPS would then pump the water to the CRA (Segment 4).

Segment 4 consists of 79,330 LF of 84-inch diameter pipe, which conveys water from the IPS to the CRA. The pipeline diameter for Segment 4 is enlarged due to the pumping operations in the CRA as described in the following subsection (*intermediate pump station*).

Intermediate Forebay and Pump Station

The intermediate forebay and pump station (IPS) would be located on Cadiz owned property between the Milligan and Sablon areas (refer to Exhibit A). The extracted groundwater would gravity flow from the Chubbuck Tunnel to the proposed intermediate forebay, near the low point of the conveyance pipeline alignment. The forebay is approximately 15 acres in size and 10 feet deep, based on the pumping requirements of the MWD Colorado River Aqueduct. Refer to the *Operations and Hydraulics* section of this TM for IPS conceptual design criteria.

The proposed site to locate the IPS and forebay has several benefits. First, the Cadiz owned property is suitable to construct a large surface area forebay without purchasing additional parcels. Second, existing high voltage power lines, owned and operated by Southern California Edison (SCE), transect the Cadiz owned property. This is beneficial if electrical grid power would be used to operate the IPS and Cadiz well field.

Operation and Hydraulics

Cadiz Well Field

The Phase I Cadiz well field covers an approximate area of 4,000 acres and would operate at an average production rate of 50,000 afy. Peak production rates in wet years could reach 75,000 - 100,000 afy. The extracted water is pumped approximately 63,000 LF in a 60-inch diameter pipeline to the Chubbuck Tunnel. The well pumps are assumed to operate 24 hours/day, 365 days/year. The average ground surface elevation of the well field is approximately 900 ft MSL. The pumping water level is approximately 300 feet below ground surface (bgs). The crown of the proposed Chubbuck Tunnel is at an elevation of approximately 1,010 ft MSL. Therefore, the static lift of the well field pumps is approximately 420 feet, assuming 10 additional feet of head loss due to drawdown and well losses. Refer to Table 2 for the Cadiz well field conceptual design criteria.

Table 2
Cadiz Well Field Pumping Hydraulics Summary

Well Field Production	Pipeline Flow Rate[1]	Pipeline Velocity[2]	Static Head	Dynamic Head	TDH
afy	mgd	ft/s	ft	ft	ft
50,000	45	3.5	420	40	460
75,000	67	5.3	420	85	505
100,000	90	7.0	420	145	565

1. Flow rate based on 24 hrs/day, 365 days/year, well field production.
2. Based on 60-inch diameter pipeline.

Intermediate Pump Station

The Phase I IPS would operate at a constant pumping rate of approximately 220 cfs (142.2 mgd) due to constraints by downstream MWD CRA pumping plants. The MWD CRA pumping plants contain constant speed pumps, which pump at a rate of approximately 220 cfs (142 mgd). Therefore, the water pumped from the IPS must be able to meet one 220 cfs MWD pump. The IPS would be located at an approximate ground elevation of 660 ft MSL and pump water to the CRA forebay, with an approximate elevation of 887 ft MSL, through approximately 79,330 LF of 84-inch diameter pipe. Therefore, the static lift of the IPS is approximately 227 feet.

The intermediate forebay would be receiving approximately 45 mgd (50,000 afy) extracted groundwater, 24 hours/day from the Cadiz Well Field. Since the constant speed IPS pumps would be operating at a much higher flow rate than the well field pumps, the forebay would fill and drain throughout a 24-hour period. The IPS is assumed to operate for 8 hours/day at a constant flow rate of approximately 220 cfs (142 mgd) to pump 50,000 afy to the Colorado River aqueduct. Refer to Table 3 for the IPS conceptual design criteria.

Table 3
Intermediate Pump Station Hydraulics Summary

Pipeline Flow Rate[1]		Pipeline Velocity[2]	Static Head	Dynamic Head	TDH
cfs	mgd	ft/s	ft	ft	ft
220	142	5.7	227	83	310

1. Flow rate based on MWD CRA constant speed pumps.
2. Based on 84-inch diameter pipeline.

Power Requirements

Cadiz Well Field

As mentioned in the previous section, the Cadiz well field is assumed to extract groundwater from the Fenner Gap area 24 hours/day, 365 days/year. The average annual power requirements for the Phase I Cadiz well field are listed in Table 4.

Table 4
Cadiz Well Field Power Requirements

Well Field Production	TDH	Average Power Requirement[1]		Annual Power Requirement[2]
afy	ft	hp	kW	kWh
50,000	460	4,250	3,160	30,800,000
75,000	505	7,000	5,200	50,700,000
100,000	565	10,400	7,800	75,600,000

1. Average power requirement based on 85% pump efficiency.
2. Annual power requirement based on 90% motor transfer efficiency, 24hrs/day, 365 days/yr.

Intermediate Pump Station

As mentioned previously, the IPS is assumed to operate for 8 hours/day, 365 days/year, to pump approximately 50,000 afy of extracted groundwater to the Colorado River Aqueduct. The average annual power requirements for the Phase I IPS are listed in Table 5.

Table 5
Intermediate Pump Station Power Requirements

Flow rate		TDH	Average Power Requirement[1]		Annual Power Requirement[2]
cfs	mgd	ft	hp	kW	kWh
220	142	310	9,100	6,800	22,000,000

1. Average power requirement based on 85% pump efficiency.
2. Annual power requirement based on 90% motor transfer efficiency, 8hrs/day, 365 days/yr.

Power Delivery Options

This tech memo will examine three (3) options for supplying power to the well field and intermediate pump station (IPS), which are listed below. Additionally, methods to utilize hydro power as well as solar power generation will be addressed.

- All Electric
- All Natural Gas
- Hybrid Combinations

All Electric Power

Currently, no distribution voltage power lines are located in the vicinity of the well field or IPS with enough capacity to provide the needed power. One option for an electric supply is to take power from a 230kV power line that runs nearby the proposed location of the IPS. This is the same transmission power line that continues to the MWD Iron Mountain pumping plant. According to the Black & Veatch (B&V) report, this 230kV power line has sufficient capacity to feed this project, since a 10 MW load addition is only 25 amps at 230kV. A substation would need to be constructed as close as practical to the line to transform down to a sub-transmission voltage to distribute to the IPS and well field. Since a 230kV line represents a major SCE transmission line, and maintenance of a 230kV substation requires highly trained personnel, it is believed that SCE would design, construct, and maintain the substation. Depending on contractual agreements, Cadiz would pay for part or all of its cost.

The cost of a 230kV substation has significant variability depending on whether a new substation is built or an add-on to an existing substation can be done. The B&V report assumed that components could be added to the existing 230kV substation located at the MWD Iron Mountain pumping plant and a 69kV transmission line could be built from the pumping plant, back to the well field. This would be technically feasible but would require SCE/MWD buy in for construction at the substation and an easement through Bureau of Land Management (BLM) land from the pumping plant to the new pipeline alignment along the ARZC railroad. Construction of a high voltage transmission line along this route would encounter significant environmental permitting resistance and may not be feasible. Construction of a new 230kV substation near the IPS should solve this issue, as transmission lines could be located almost exclusively on Cadiz owned land. Therefore, a 34.5kV line would extend to the IPS and along the railroad alignment to the well field to provide power to these locations. The 34.5kV line allows the use of medium voltage switch gear at both locations without an additional substation.

The construction of a 230kV substation has two significant obstacles. The first is that SCE may refuse to construct a 230kV substation for the relatively small loads of the project. The loads of the Cadiz project would normally be fed from lines that would be 34.5kV or less, so it would be unusual to tap into a 230kV line. The second is that the design and construction of the substation could take up to two (2) years due to the uniqueness and complexity of the design. In addition, the control of design and construction of the substation would be totally out of Cadiz hands so that any problems or delays could adversely affect the project.

Phasing is another factor to consider, which allows the ability to put in and pay for partial system components in the first phase of the project and add components in later phases if the project grows in capacity. The all electric supply does not lend itself to this approach, as the least substation constructed at this voltage would have ample capacity for any ultimate project supply needs. Due to potential permitting, cost, and construction timeframes, it is suggested that this approach not be viewed as a primary desired approach.

Key conclusions concerning electric power:

- Substation expense could be very high.
- Substation design and construction not in Cadiz control.
- Ultimate supply capacity needs to be installed in first phase (no phasing).

All Natural Gas Power

In this option, all prime movers at both the well field and the IPS would be natural gas engines. A 30-inch high pressure gas line (#1903), owned and operated by El Paso Corporation, is located parallel to the ARZC railroad tracks, which is located near both the proposed well field and IPS locations. Brief discussions with El Paso Corp personnel, determined that the El Paso Natural Gas pipeline has a capacity of approximately 500 million scf/day and has sufficient capacity to supply gas to the project. The gas engines option would consume approximately 3 million scf/day. The application process to connect to the pipeline and construction of the tie-in connection would take approximately six (6) months. The application process takes approximately six (6) weeks, while construction could take upwards of 22 weeks.

Diesel fueled engines for powering the IPS pumps or for generating power is not recommended since diesel engines can not be permitted for permanent continuous operation. In addition, they assume to have higher costs and lower reliability of delivering large quantities of diesel fuel by truck compared to the availability of natural gas from the El Paso natural gas pipeline.

At the IPS, five (5) Waukesha P9390 engines (4 duty, 1 standby) would power each pump to convey the base case of 50,000 afy, or approximately 220 cfs for 8 hours a day. These engines are industrial rated units designed for continuous operation and can be air quality permitted using standard catalytic converters. The engines are specifically designed for natural gas applications and are capable of running continuously for 1.5 years with a minor overhaul and 3 years between a major overhaul. At the expected running demand of approximately one third, the maintenance intervals could be extended to several years. The economics section gives lifecycle costs for the engines for comparative purposes. A small microturbine unit could generate auxiliary power for the station.

Cost will be summarized in the economics analysis, but as a brief indication of operating costs, the Waukesha engines can produce power at the equivalent rate of $0.07/kWh, which will be substantially cheaper than purchased power and other than the connection to the gas line, the project would be completely under Cadiz control.

While the Waukesha engines are ideal for the IPS, the high number, cost, and maintenance associated with the 20 or more engines required for direct pumping at each well head makes this option unrealistic. This is the major reason that the previous B&V study recommended the all electrical approach. A more practical approach that combines the advantages of gas and electric (hybrid) is presented in the next section.

Key conclusions concerning gas power:

- Connecting to the natural gas line (#1903) is considered feasible.
- Cost and maintenance of 20 or more gas engine well pumps is impractical.
- Gas engine driven pumps at the IPS does make sense.

Hybrid Power Combinations

As mentioned previously, a hybrid power combination, which combines the advantages of gas and electric is a more practical approach to supply power for this project. Several scenarios are possible, but two hybrid power combinations have been deemed practical for this project. Each hybrid option assumes five (5) Waukesha natural gas engines at the IPS, and electric motor drivers for each well head at the Cadiz Well Field.

Hybrid Option 1

The first hybrid option would upsize the existing 12kV power line that runs along the road near the well field. The viability of this approach would largely be determined by the ultimate load of the well field. For the 50,000 afy production, the 4,250 hp load could possibly be served by an upgraded power line. Typically, the substation that feeds the existing line should be within 10-15 miles of the site, but this would need to be verified by SCE as well as the capacity of the existing substation. SCE requires that an application for service be submitted to them prior to any action on their part. If the existing line could be upgraded, this would be the most cost effective solution for power at the well field. While some control over the power supply is lost as SCE would control the upgrading of their lines, this is not expected to present any major problems as low voltage power lines and substation upgrades are relatively standard for SCE.

Hybrid Option 2

The second hybrid option assumes a Solar® Turbine generator would be installed at the well field to generate sufficient power for each well pump motor. The turbine generators are rated for continuous operation and are readily permitted for air quality. These units produce power at an equivalent rate of $0.07/kWh which makes them very attractive from an electrical cost standpoint. Power generated on site would be distributed at a voltage appropriate for the well pump motors. The turbines are designed to run continuously for several years without overhaul. The service agreement which would be purchased with the turbines includes all minor service needed on the unit as well as a complete replacement of the turbine every three years (two day downtime to install replacement turbine). A major advantage of this approach is that the total installed cost is less than the use of gas engine pumps and the control over the project remains in Cadiz hands.

The only significant issue is the connection to the gas line and the gas purchase agreement, which is not expected to be a major issue. Solar® was asked if they or anyone they work with would be willing to provide, install, and maintain the generating unit and supply power to Cadiz under a purchase power agreement and their response was that it is not practical for units in this size range. As previously mentioned, Solar® will provide the entire maintenance needs for the unit under their service agreement.

Key conclusions concerning hybrid power:

- Project control remains with Cadiz.
- Produced power cost is cheaper than if purchased (unless existing line can be upgraded at well field).
- Project can be phased. Additional engines or power producing turbines could easily be added for future increased capacity.

Hydro and Solar Power Options

Hydro Power Generation

Hydro power generation potentially exists at the IPS site under the current design scenario. As mentioned previously, extracted groundwater would gravity flow from the Chubbuck Tunnel to the intermediate forebay and pump station (Segment 3). This segment of pipeline would be 60-inch diameter, approximately 69,000 LF, with an elevation change of approximately 345 ft. Table 5 demonstrates potential energy that could be recovered (power generation) using turbines.

Table 5
Potential Conveyance Pipeline Recoverable Energy

Well Field Production	Static Drop	Dynamic Head Loss[1]	Recoverable Energy	
afy	ft	ft	Head (ft)	kW[2]
50,000	345	45	300	1,230
75,000	345	95	250	1,530
100,000	345	160	185	1,510

1. 60-inch diameter pipeline.
2. Assuming combined turbine and generator efficiency of 70%.

Hybrid Option 3

In order to recover power the hydro unit would need a tie in to a power source which unfortunately would not exist if the gas engine option at the IPS were utilized. A power line would need to be constructed along the railway alignment to deliver the power back to the well field, and this will be assumed for purposes of the analysis. The total hydro power cost with a 12kV transmission power line would be approximately $7.5 million (refer to Table10 for a complete breakdown of costs for this option. A simple payback for 10,800,000 kWh per year at

$0.07/kWh would be approximately 10 years, which would be appropriate if the Solar® turbine were producing power at the well field. If power was purchased at $0.11/kWh from SCE, the payback would be approximately 6.5 years.

Solar Power Generation

Similar to hydro power, if solar power generation is installed at the IPS site, a transmission power line would need to be installed running back to the well field. For purposes of this analysis, the cost of the line will be included, but obviously, the cost of the line could be shared between solar and hydro if both were installed. The cost for a 1,000 kW solar unit and power line would be approximately $10 million. The simple payback at $0.07/kWh would be 40 years and at $0.11/kWh would be 25 years, both assuming no tax credits. A 1,000 kW unit would supply less that 25% of the energy needs of the well field, and then only during daylight. The payback periods are very long partly due to having to complete with cheaply produced electricity rather than higher prices that SCE would pay for solar power.

Since it is clear that solar power generation is highly capital intensive and realistically never pays back, a small unit (less than 100 kW) could be considered for the well field area. It could connect to the well field power grid and supply some power as a demonstration of a good faith green effort. Another factor to consider is even if a significant amount of solar power were installed; all the remaining electrical generation would have to be installed at its full capacity regardless, as it would have to be available when solar was not producing.

Power Cost Analysis

This section will develop capital and operations and maintenance (O&M) costs directly associated with the four (4) power supply options previously proposed in this TM and listed below. In addition, a 20-year power supply cost life cycle analysis will be conducted to determine the total annual cost, dollars per acre-foot ($/AF), and dollars per equivalent kWh ($/kWh), based solely on power supply costs. These values **are not** representative of total project costs, since total project capital and O&M costs are not included which are assumed similar for each power supply option.

- **All Electric:** Power supplied to IPS and well field by new substation and power lines.
- **Hybrid Option 1:** Gas engines at IPS, upgrade power lines at well field.
- **Hybrid Option 2:** Gas engines at IPS, Solar® turbine power generation at well field.
- **Hybrid Option 3:** Gas engines at IPS, Solar® turbine power generation at well field, Hydro power generation at IPS.

Capital, Operations, and Maintenance Costs

The capital and O&M costs associated with each of the four power supply options listed above are provided in Table 7 through Table 10. The assumptions used to generate the capital and O&M costs are listed below:

- Costs provided in 2010 dollars;
- Electricity purchased at a rate of $0.11/kWh (SCE);
- Natural gas purchased at a rate of $0.45/therm ($4.50/million BTU) (El Paso Corp.);
- Waukesha gas engines (IPS) capital and maintenance costs provided by Valley Power;
- Solar® Turbine capital and maintenance costs provided by Solar®.
- Additional capital cost provided by RBF electrical engineering department.

Table 7
All Electric – Capital and O&M Costs[1]

Description	Capital Cost	Annual O&M Costs[2]	
		Maintenance	Electricity[3]
Pump motors, switchgear, distribution @ well field	$1,800,000	$45,000	$3,390,000
Pump motors, switchgear, distribution @ IPS	$1,250,000	$12,000	$2,420,000
230kV substation	$6,000,000	-	-
34.5kV transmission line between IPS & well field	$5,000,000	$10,000	-
TOTALS	**$14,050,000**	**$67,000**	**$5,810,000**

Table 8
Hybrid Option 1 – Capital and O&M Costs[1]

Description	Capital Cost	Annual O&M Costs[2]	
		Maintenance	Electricity/ Fuel[3]
Pump motors, switchgear, distribution @ well field	$1,800,000	$45,000	$3,390,000
Upgrade SCE power lines @ well field	$1,000,000	-	-
Pump engines, gas site distribution, controls @ IPS	$8,500,000	$135,000	$891,000
Gas connection, distribution, from main line to well field	$750,000	-	-
TOTAL	**$12,050,000**	**$180,000**	**$4,281,000**

Table 9
Hybrid Option 2 – Capital and O&M Costs[1]

Description	Capital Cost	Annual O&M Costs[2]	
		Maintenance	Fuel[3]
Pump motors, switchgear, distribution @ well field	$1,800,000	$45,000	-
Solar® Turbine @ well field	$4,500,000	$450,000	$1,247,400
Pump engines, gas site distribution, controls @ IPS	$8,500,000	$135,000	$891,000
Gas connection, distribution, from main line to well field	$750,000	-	-
TOTAL	**$15,550,000**	**$630,000**	**$2,138,400**

[1] 2010 dollars.
[2] Based on 50,000 afy well field extraction and IPS pumping.
[3] Electricity cost based on $0.11/kWh. Fuel cost based on $0.45/therm ($4.50/million BTU).

Table 10
Hybrid Option 3 – Capital and O&M Costs[1]

Description	Capital Cost	Annual O&M Costs[2]	
		Maintenance	Fuel[3]
Pump motors, switchgear, distribution @ well field	$1,800,000	$45,000	-
Solar® turbine @ well field	$4,500,000	$450,000	$810,000
Pump engines, gas site distribution, controls @ IPS	$8,500,000	$135,000	$891,000
Gas connection, distribution, from main line to well field	$750,000	-	-
Hydro power generation system	$5,000,000	$25,000	-
12kV transmission line between IPS & well field	$2,500,000	-	-
TOTAL	**$23,050,000**	**$655,000**	**$1,701,000**

[1] 2010 dollars.
[2] Based on 50,000 afy well field extraction and IPS pumping.
[3] Fuel cost based on $0.45/therm ($4.50/million BTU).

Life Cycle Analysis

A power supply cost life cycle (present worth) analysis was conducted for each power supply option described previously. The capital costs associated with each power option, which are presented in Table 7 through table 10, were amortized over a 20-year period using a net discount rate of 3%. The net discount rate is based on an assumed inflation rate of 3% and an assumed interest rate of 6%.

In addition to the annual maintenance and fuel costs associated with the Waukesha gas engines (listed in Table 7 through Table 10), the engines require additional maintenance overhaul costs every 7 years (based on 8 hours of operation per day). The Waukesha gas engines require approximately $27,000 of annual maintenance, per engine. In year 7, the gas engines require approximately $83,500 of additional maintenance (top end overhaul), per engine, and in year 14, approximately $125,000 (bottom end overhaul), per engine.

Assumptions to conduct the life cycle power cost analysis are listed below:

- **Life Cycle Period:** 20 Years beginning year 2010;
- **Net Discount Rate:** 3.0% (based on 3% inflation and 6% interest);
- **Capital and O&M Costs:** Table 7 through Table 10;
- **Waukesha Gas Engines O&M:** Overhaul costs included every 7 years.
- **Well field extraction:** 1,000,000 acre-feet over 20 years;
- **Power requirements:** 1,056,000,000 kWh (equivalent) over 20 years.

Refer to Table 11 on the following page for a comparison of each power options life cycle cost analysis, based on 20-years of operation. Refer to Table A through Table D in the Appendix for the complete 20-year analysis (year by year) for each power option.

Table 11
Power Supply Cost Life Cycle Analysis Comparison[1]

Power Option	Total Capital Cost[2]	Total O&M Cost[3]	Total Cost[3]	Present Worth	Equivalent Annual Power Cost	
					$/AF[3]	$/kWh[4]
All Electric	$18,900,000	$117,500,000	$136,400,000	$104,500,000	$136	$0.13
Hybrid Option 1	$16,200,000	$90,300,000	$106,500,000	$81,500,000	$106	$0.10
Hybrid Option 2	$20,900,000	$56,600,000	$77,500,000	$59,400,000	$78	$0.07
Hybrid Option 3	$31,000,000	$48,200,000	$79,100,000	$60,600,000	$79	$0.07

[1] 2010 dollars.
[2] Based on total amortized payments for 20 years, assuming 3% net discount rate.
[3] Based on 20 years of operation.
[4] Based on 1,000,000 acre-feet well field extraction over 20 year period.
[5] Based on 1,056,000,000 equivalent kWh consumed over 20 year period.

Conclusion and Recommendations

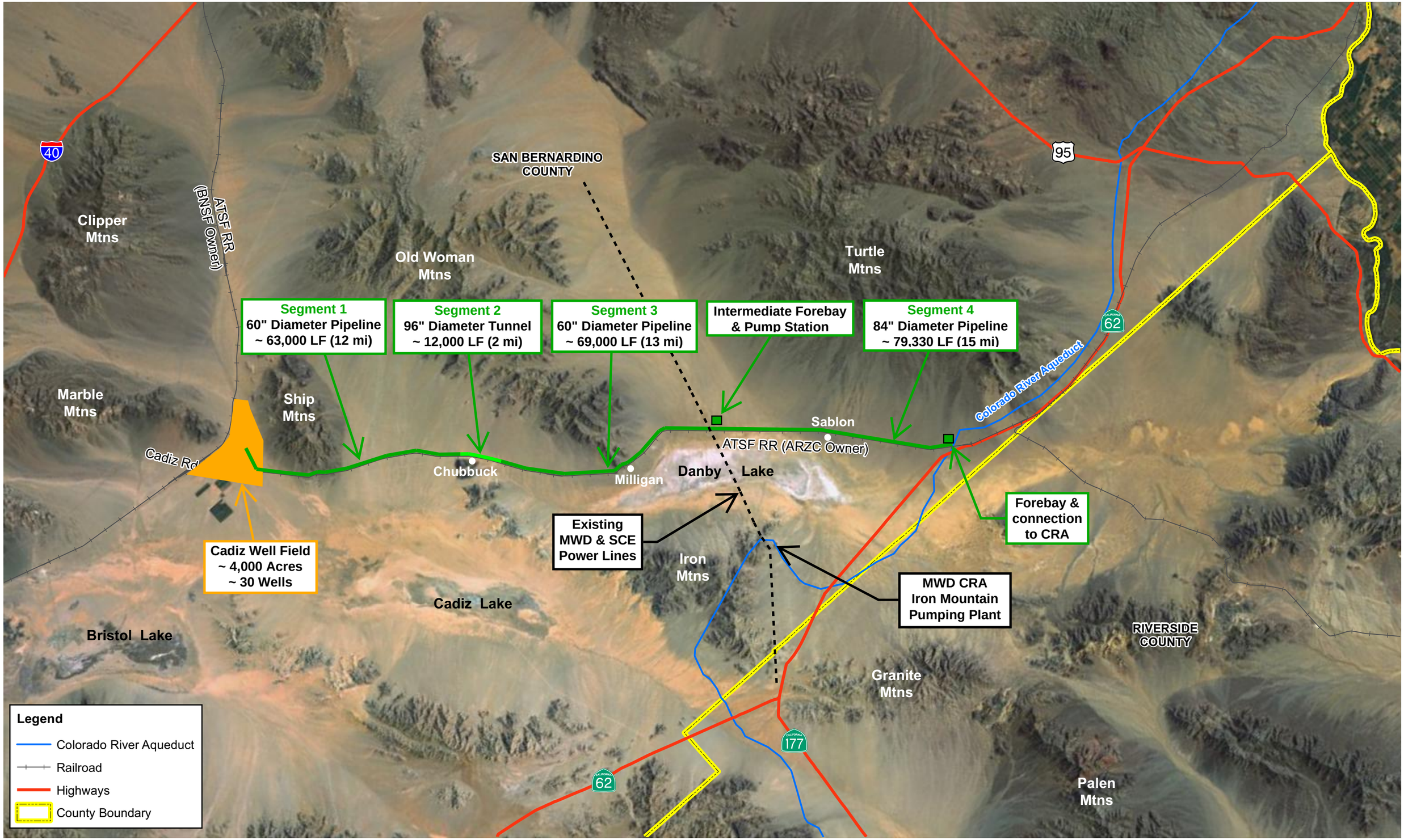
Supply of electric power from SCE at the well field and IPS is questionable. The ability to tie into 230kV SCE power line (which is the only major power line in the area) and construct a substation near the IPS is dubious and subjects Cadiz to unknowns regarding costs, design, and construction schedules. For this reason, it is recommended that gas engine driven pumps be considered for the IPS, especially since the equivalent cost of operation is cheaper than the cost of electrical pumping. At the well field, if the existing SCE power line could be realistically upgraded to supply the well field needs, this would be the most cost effective approach and does not subject Cadiz to any major risks. *It is suggested that Cadiz submit a formal application for service at the well field which will get SCE started and they will determine any cost or schedule implications for a new or modified service. A single line diagram for a proposed project would need to be prepared and submitted with other information for the application, which RBF is capable of doing for Cadiz.*

If the electrical power line upgrade turns out to be impractical, then the Solar® gas turbine generator is a viable option, which is ideally suited for 24/7 operation. The cost to produce power is cheaper than purchased power and all maintenance needs would be provided by the manufacturer. Cadiz would remain in control of design and construction of the facilities, making this a strong option. The only major risk associated with gas turbine power production is the cost of natural gas, and gas pricing is expected to remain stable into the near future, since additional economical sources of gas have come on line over the last few years. It would take virtually doubling of gas prices to make it more expensive than electricity, and even if this occurred, electricity costs would certainly go up as natural gas is used for a significant portion of utility electrical production.

Power generation options like hydro power and solar power are feasible options for this project, but do not boast substantial benefits. Each power generation option would require a connection point to a power source which unfortunately would not exist if the gas engine option at the IPS were utilized. A power line would need to be constructed along the railway alignment to deliver

the power back to the well field. As demonstrated in Table 11, additional up front capitol is required to install the hydro turbines and power generation at the only viable location (upstream of the IPS), yet does not develop any major cost saving benefits.

Solar power generation is highly capital intensive and realistically never pays back. Therefore, a small unit (less than 100 kW) could be considered for the well field area. It would connect to the well field power grid and supply some power as a demonstration of a good faith green effort. Another factor to consider is even if a significant amount of solar power were installed, all the remaining electrical generation would have to be installed at its full capacity regardless, as it would have to be available when solar power was not producing.



mdata:Leigh\Cadiz.mxd 06/07/10 LT

0 2.5 5 10 Miles

Source: Parcel Ownership, San Bernardino County, 2005, ESRI

Cadiz Groundwater Conservation and Storage Project

Phase I - Conceptual Project Layout

Exhibit A

APPENDIX

Power Cost - Life Cycle Analysis Tables A - D

Table A
20-Year Life Cycle Power Cost Summary - All Electric Option

PROJECT: **CADIZ GROUNDWATER CONSERVATION AND STORAGE PROJECT**
DESCRIPTION: **20-YR LIFE CYCLE POWER COST ANALYSIS**
PREPARED BY: **RBF CONSULTING** NET DISCOUNT RATE: **3.0%**
ESTIMATE DATE: **OCT 2010** AMORTIZED PAYMENT: **20 Years**

Calendar Year	n	Capital Cost 2010 Dollars	Capital Cost Payments (A/P, %, 20)	Annual O&M Cost	Total Annual Costs	2010 Present Worth (P/A, %, n)	Acre-Feet Extracted Per Year	kWh Used Per Year	Avg Annual Present Worth $/AF	Equivalent Annual Cost $/AF	Equivalent Annual Cost $/kWh
2010	0	$ 14,050,000	$ 944,000	$ 5,877,000	$ 6,821,000	$ 6,820,000	50,000	52,800,000	$ 136	$ 136	$ 0.13
2011	1	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 6,620,000	50,000	52,800,000	$ 132	$ 136	$ 0.13
2012	2	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 6,430,000	50,000	52,800,000	$ 129	$ 136	$ 0.13
2013	3	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 6,240,000	50,000	52,800,000	$ 125	$ 136	$ 0.13
2014	4	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 6,060,000	50,000	52,800,000	$ 121	$ 136	$ 0.13
2015	5	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,880,000	50,000	52,800,000	$ 118	$ 136	$ 0.13
2016	6	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,710,000	50,000	52,800,000	$ 114	$ 136	$ 0.13
2017	7	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,550,000	50,000	52,800,000	$ 111	$ 136	$ 0.13
2018	8	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,380,000	50,000	52,800,000	$ 108	$ 136	$ 0.13
2019	9	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,230,000	50,000	52,800,000	$ 105	$ 136	$ 0.13
2020	10	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 5,080,000	50,000	52,800,000	$ 102	$ 136	$ 0.13
2021	11	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,930,000	50,000	52,800,000	$ 99	$ 136	$ 0.13
2022	12	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,780,000	50,000	52,800,000	$ 96	$ 136	$ 0.13
2023	13	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,640,000	50,000	52,800,000	$ 93	$ 136	$ 0.13
2024	14	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,510,000	50,000	52,800,000	$ 90	$ 136	$ 0.13
2025	15	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,380,000	50,000	52,800,000	$ 88	$ 136	$ 0.13
2026	16	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,250,000	50,000	52,800,000	$ 85	$ 136	$ 0.13
2027	17	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,130,000	50,000	52,800,000	$ 83	$ 136	$ 0.13
2028	18	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 4,010,000	50,000	52,800,000	$ 80	$ 136	$ 0.13
2029	19	$ -	$ 944,000	$ 5,877,000	$ 6,821,000	$ 3,890,000	50,000	52,800,000	$ 78	$ 136	$ 0.13
TOTALS		**$ 14,050,000**	**$ 18,900,000**	**$ 117,500,000**	**$ 136,400,000**	**$ 104,500,000**	**1,000,000**	**1,056,000,000**	**$ 105**	**$ 136**	**$ 0.13**

Table B
20-Year Life Cycle Power Cost Summary - Hybrid Option 1

PROJECT: **CADIZ GROUNDWATER CONSERVATION AND STORAGE PROJECT**
DESCRIPTION: **20-YR LIFE CYCLE POWER COST ANALYSIS**
PREPARED BY: **RBF CONSULTING**
ESTIMATE DATE: **OCT 2010**
NET DISCOUNT RATE: **3.0%**
AMORTIZED PAYMENT: **20 Years**

Calendar Year	n	Capital Cost 2010 Dollars	Capital Cost Payments (A/P, %, 20)	Annual O&M Cost	Total Annual Costs	2010 Present Worth (P/A, %, n)	Acre-Feet Extracted Per Year	Equivalent kWh Per Year	Avg Annual Present Worth $/AF	Equivalent Annual Cost $/AF	Equivalent Annual Cost $/kWh
2010	0	$ 12,050,000	$ 810,000	$ 4,461,000	$ 5,271,000	$ 5,270,000	50,000	52,800,000	$ 105	$ 105	$ 0.10
2011	1	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 5,120,000	50,000	52,800,000	$ 102	$ 105	$ 0.10
2012	2	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,970,000	50,000	52,800,000	$ 99	$ 105	$ 0.10
2013	3	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,820,000	50,000	52,800,000	$ 96	$ 105	$ 0.10
2014	4	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,680,000	50,000	52,800,000	$ 94	$ 105	$ 0.10
2015	5	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,550,000	50,000	52,800,000	$ 91	$ 105	$ 0.10
2016	6	$ -	$ 810,000	$ 4,878,500	$ 5,688,500	$ 4,760,000	50,000	52,800,000	$ 95	$ 114	$ 0.11
2017	7	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,290,000	50,000	52,800,000	$ 86	$ 105	$ 0.10
2018	8	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,160,000	50,000	52,800,000	$ 83	$ 105	$ 0.10
2019	9	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 4,040,000	50,000	52,800,000	$ 81	$ 105	$ 0.10
2020	10	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,920,000	50,000	52,800,000	$ 78	$ 105	$ 0.10
2021	11	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,810,000	50,000	52,800,000	$ 76	$ 105	$ 0.10
2022	12	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,700,000	50,000	52,800,000	$ 74	$ 105	$ 0.10
2023	13	$ -	$ 810,000	$ 5,086,000	$ 5,896,000	$ 4,010,000	50,000	52,800,000	$ 80	$ 118	$ 0.11
2024	14	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,480,000	50,000	52,800,000	$ 70	$ 105	$ 0.10
2025	15	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,380,000	50,000	52,800,000	$ 68	$ 105	$ 0.10
2026	16	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,280,000	50,000	52,800,000	$ 66	$ 105	$ 0.10
2027	17	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,190,000	50,000	52,800,000	$ 64	$ 105	$ 0.10
2028	18	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,100,000	50,000	52,800,000	$ 62	$ 105	$ 0.10
2029	19	$ -	$ 810,000	$ 4,461,000	$ 5,271,000	$ 3,010,000	50,000	52,800,000	$ 60	$ 105	$ 0.10
TOTALS		**$ 12,050,000**	**$ 16,200,000**	**$ 90,300,000**	**$ 106,500,000**	**$ 81,500,000**	**1,000,000**	**1,056,000,000**	**$ 82**	**$ 106**	**$ 0.10**

Table C
20-Year Life Cycle Powr Cost Summary - Hybrid Option 2

PROJECT: **CADIZ GROUNDWATER CONSERVATION AND STORAGE PROJECT**
DESCRIPTION: **20-YR LIFE CYCLE POWER COST ANALYSIS**
PREPARED BY: **RBF CONSULTING**
ESTIMATE DATE: **OCT 2010**
NET DISCOUNT RATE: **3.0%**
AMORTIZED PAYMENT: **20 Years**

Calendar Year	n	Capital Cost 2010 Dollars	Capital Cost Payments (A/P, %, 20)	Annual O&M Cost	Total Annual Costs	2010 Present Worth (P/A, %, n)	Acre-Feet Extracted Per Year	Equivalent kWh Per Year	Avg Annual Present Worth $/AF	Equivalent Annual Cost $/AF	Equivalent Annual Cost $/kWh
2010	0	$ 15,550,000	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,810,000	50,000	52,800,000	$ 76	$ 76	$ 0.07
2011	1	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,700,000	50,000	52,800,000	$ 74	$ 76	$ 0.07
2012	2	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,590,000	50,000	52,800,000	$ 72	$ 76	$ 0.07
2013	3	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,490,000	50,000	52,800,000	$ 70	$ 76	$ 0.07
2014	4	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,390,000	50,000	52,800,000	$ 68	$ 76	$ 0.07
2015	5	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,290,000	50,000	52,800,000	$ 66	$ 76	$ 0.07
2016	6	$ -	$ 1,045,000	$ 3,393,400	$ 4,438,400	$ 3,720,000	50,000	52,800,000	$ 74	$ 89	$ 0.08
2017	7	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,100,000	50,000	52,800,000	$ 62	$ 76	$ 0.07
2018	8	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 3,010,000	50,000	52,800,000	$ 60	$ 76	$ 0.07
2019	9	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,920,000	50,000	52,800,000	$ 58	$ 76	$ 0.07
2020	10	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,840,000	50,000	52,800,000	$ 57	$ 76	$ 0.07
2021	11	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,750,000	50,000	52,800,000	$ 55	$ 76	$ 0.07
2022	12	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,670,000	50,000	52,800,000	$ 53	$ 76	$ 0.07
2023	13	$ -	$ 1,045,000	$ 3,393,400	$ 4,438,400	$ 3,020,000	50,000	52,800,000	$ 60	$ 89	$ 0.08
2024	14	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,520,000	50,000	52,800,000	$ 50	$ 76	$ 0.07
2025	15	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,450,000	50,000	52,800,000	$ 49	$ 76	$ 0.07
2026	16	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,380,000	50,000	52,800,000	$ 48	$ 76	$ 0.07
2027	17	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,310,000	50,000	52,800,000	$ 46	$ 76	$ 0.07
2028	18	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,240,000	50,000	52,800,000	$ 45	$ 76	$ 0.07
2029	19	$ -	$ 1,045,000	$ 2,768,400	$ 3,813,400	$ 2,170,000	50,000	52,800,000	$ 43	$ 76	$ 0.07
TOTALS		**$ 15,550,000**	**$ 20,900,000**	**$ 56,600,000**	**$ 77,500,000**	**$ 59,400,000**	**1,000,000**	**1,056,000,000**	**$ 59**	**$ 78**	**$ 0.07**

Table D
20-Year Life Cycle Power Cost Summary - Hybrid Option 3

PROJECT: **CADIZ GROUNDWATER CONSERVATION AND STORAGE PROJECT**
DESCRIPTION: **20-YR LIFE CYCLE POWER COST ANALYSIS**
PREPARED BY: **RBF CONSULTING**
ESTIMATE DATE: **OCT 2010**
NET DISCOUNT RATE: **3.0%**
AMORTIZED PAYMENT: **20 Years**

Calendar Year	n	Capital Cost 2010 Dollars	Capital Cost Payments (A/P, %, 20)	Annual O&M Cost	Total Annual Costs	2010 Present Worth (P/A, %, n)	Acre-Feet Extracted Per Year	Equivalent kWh Per Year	Avg Annual Present Worth $/AF	Equivalent Annual Cost $/AF	Equivalent Annual Cost $/kWh
2010	0	$ 23,050,000	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,910,000	50,000	52,800,000	$ 78	$ 78	$ 0.07
2011	1	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,790,000	50,000	52,800,000	$ 76	$ 78	$ 0.07
2012	2	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,680,000	50,000	52,800,000	$ 74	$ 78	$ 0.07
2013	3	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,570,000	50,000	52,800,000	$ 71	$ 78	$ 0.07
2014	4	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,470,000	50,000	52,800,000	$ 69	$ 78	$ 0.07
2015	5	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,370,000	50,000	52,800,000	$ 67	$ 78	$ 0.07
2016	6	$ -	$ 1,549,000	$ 2,773,500	$ 4,322,500	$ 3,620,000	50,000	52,800,000	$ 72	$ 86	$ 0.08
2017	7	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,180,000	50,000	52,800,000	$ 64	$ 78	$ 0.07
2018	8	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 3,080,000	50,000	52,800,000	$ 62	$ 78	$ 0.07
2019	9	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,990,000	50,000	52,800,000	$ 60	$ 78	$ 0.07
2020	10	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,910,000	50,000	52,800,000	$ 58	$ 78	$ 0.07
2021	11	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,820,000	50,000	52,800,000	$ 56	$ 78	$ 0.07
2022	12	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,740,000	50,000	52,800,000	$ 55	$ 78	$ 0.07
2023	13	$ -	$ 1,549,000	$ 2,981,000	$ 4,530,000	$ 3,080,000	50,000	52,800,000	$ 62	$ 91	$ 0.09
2024	14	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,580,000	50,000	52,800,000	$ 52	$ 78	$ 0.07
2025	15	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,510,000	50,000	52,800,000	$ 50	$ 78	$ 0.07
2026	16	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,430,000	50,000	52,800,000	$ 49	$ 78	$ 0.07
2027	17	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,360,000	50,000	52,800,000	$ 47	$ 78	$ 0.07
2028	18	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,290,000	50,000	52,800,000	$ 46	$ 78	$ 0.07
2029	19	$ -	$ 1,549,000	$ 2,356,000	$ 3,905,000	$ 2,230,000	50,000	52,800,000	$ 45	$ 78	$ 0.07
TOTALS		**$ 23,050,000**	**$ 31,000,000**	**$ 48,200,000**	**$ 79,100,000**	**$ 60,600,000**	**1,000,000**	**1,056,000,000**	**$ 61**	**$ 79**	**$ 0.07**

9/9/2011 2:03:41 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Mitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Pipeline CRA.urb924

Project Name: CADIZ Pipeline CRA

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Mitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/2/2012-1/6/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/7/2012-1/7/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 1/9/2012-1/13/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/14/2012-1/14/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/16/2012-1/20/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/21/2012-1/21/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 1/23/2012-1/27/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/28/2012-1/28/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/30/2012-2/3/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/4/2012-2/4/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 2/6/2012-2/10/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/11/2012-2/11/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/13/2012-2/17/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/18/2012-2/18/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 2/20/2012-2/24/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/25/2012-2/25/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/27/2012-3/2/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/3/2012-3/3/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 3/5/2012-3/9/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/10/2012-3/10/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/12/2012-3/16/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/17/2012-3/17/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 3/19/2012-3/23/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/24/2012-3/24/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/26/2012-3/30/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/31/2012-3/31/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/2/2012-4/6/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/7/2012-4/7/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/9/2012-4/13/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/14/2012-4/14/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/16/2012-4/20/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/21/2012-4/21/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/23/2012-4/27/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/28/2012-4/28/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/30/2012-5/4/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/5/2012-5/5/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/7/2012-5/11/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/12/2012-5/12/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 5/14/2012-5/18/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/19/2012-5/19/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/21/2012-5/25/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/26/2012-5/26/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 5/28/2012-6/1/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/2/2012-6/2/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/4/2012-6/8/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/9/2012-6/9/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 6/11/2012-6/15/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/16/2012-6/16/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/18/2012-6/22/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/23/2012-6/23/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 6/25/2012-6/29/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/30/2012-6/30/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/2/2012-7/6/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/7/2012-7/7/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 7/9/2012-7/13/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/14/2012-7/14/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/16/2012-7/20/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/21/2012-7/21/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 7/23/2012-7/27/2012 Active Days: 5	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/28/2012-7/28/2012 Active Days: 1	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/30/2012-8/1/2012 Active Days: 3	13.97	87.54	65.11	0.01	0.07	3.56	3.62	0.02	3.27	3.29	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	84.59	64.03	0.01	0.05	3.44	3.49	0.02	3.17	3.19	13,624.51
Trenching Off Road Diesel	13.60	84.18	58.51	0.00	0.00	3.42	3.42	0.00	3.15	3.15	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

9/9/2011 2:03:42 PM

Time Slice 8/2/2012-8/3/2012 Active Days: 2	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/4/2012-8/4/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/6/2012-8/10/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/11/2012-8/11/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/13/2012-8/17/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/18/2012-8/18/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

Time Slice 8/20/2012-8/24/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/25/2012-8/25/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/27/2012-8/31/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/1/2012-9/1/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/3/2012-9/7/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/8/2012-9/8/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:42 PM

Time Slice 9/10/2012-9/14/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/15/2012-9/15/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/17/2012-9/21/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/22/2012-9/22/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/24/2012-9/28/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/29/2012-9/29/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

Time Slice 10/1/2012-10/5/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/6/2012-10/6/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/8/2012-10/12/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/13/2012-10/13/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/15/2012-10/19/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/20/2012-10/20/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:43 PM

Time Slice 10/22/2012-10/26/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/27/2012-10/27/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/29/2012-11/2/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/3/2012-11/3/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/5/2012-11/9/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/10/2012-11/10/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:43 PM

Time Slice 11/12/2012-11/16/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/17/2012-11/17/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/19/2012-11/23/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/24/2012-11/24/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/26/2012-11/30/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/1/2012-12/1/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:43 PM

Time Slice 12/3/2012-12/7/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/8/2012-12/8/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/10/2012-12/14/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 12/15/2012-12/15/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/17/2012-12/21/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/22/2012-12/22/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:43 PM

Time Slice 12/24/2012-12/28/2012 Active Days: 5	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/29/2012-12/29/2012 Active Days: 1	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/31/2012-12/31/2012 Active Days: 1	**20.27**	124.93	**273.30**	**0.36**	**1.98**	4.82	6.80	**0.71**	4.39	5.10	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	121.98	272.21	0.36	1.96	4.71	6.67	0.70	4.29	4.99	49,756.54
Building Off Road Diesel	12.39	79.59	54.56	0.00	0.00	2.79	2.79	0.00	2.57	2.57	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Construction Related Mitigation Measures

The following mitigation measures apply to Phase: Mass Grading 1/1/2012 - 12/31/2012 - truck trips

For Soil Stablizing Measures, the Apply soil stabilizers to inactive areas mitigation reduces emissions by:

PM10: 84% PM25: 84%

For Soil Stablizing Measures, the Replace ground cover in disturbed areas quickly mitigation reduces emissions by:

PM10: 5% PM25: 5%

For Soil Stablizing Measures, the Water exposed surfaces 2x daily watering mitigation reduces emissions by:

PM10: 55% PM25: 55%

For Soil Stablizing Measures, the Equipment loading/unloading mitigation reduces emissions by:

PM10: 69% PM25: 69%

The following mitigation measures apply to Phase: Trenching 1/1/2012 - 8/1/2012 - pipeline

For Tractors/Loaders/Backhoes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Air Compressors, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Bore/Drill Rigs, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Cranes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Dumpers/Tenders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Graders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Other Equipment, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Rubber Tired Dozers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Water Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

The following mitigation measures apply to Phase: Building Construction 8/2/2012 - 12/31/2012 - CRA tie in

For Cranes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Tractors/Loaders/Backhoes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Air Compressors, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Cement and Mortar Mixers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Dumpers/Tenders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Rubber Tired Dozers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Graders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Rubber Tired Loaders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Water Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 12/31/2012 - truck trips
Total Acres Disturbed: 0
Maximum Daily Acreage Disturbed: 0
Fugitive Dust Level of Detail: Default
20 lbs per acre-day
On Road Truck Travel (VMT): 120.04
Off-Road Equipment:

Phase: Trenching 1/1/2012 - 8/1/2012 - pipeline
Off-Road Equipment:
1 Air Compressors (106 hp) operating at a 0.48 load factor for 12 hours per day
1 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 12 hours per day
1 Cranes (399 hp) operating at a 0.43 load factor for 12 hours per day
2 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 12 hours per day
1 Graders (174 hp) operating at a 0.61 load factor for 12 hours per day
1 Other Equipment (190 hp) operating at a 0.62 load factor for 12 hours per day
1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 12 hours per day
8 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 12 hours per day
1 Water Trucks (189 hp) operating at a 0.5 load factor for 12 hours per day

Phase: Building Construction 8/2/2012 - 12/31/2012 - CRA tie in

Off-Road Equipment:

1 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day

2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day

1 Cranes (399 hp) operating at a 0.43 load factor for 7 hours per day

4 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day

3 Graders (174 hp) operating at a 0.61 load factor for 8 hours per day

3 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 8 hours per day

3 Rubber Tired Loaders (164 hp) operating at a 0.54 load factor for 8 hours per day

3 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day

2 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 2:03:22 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Unmitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Pipeline CRA.urb924

Project Name: CADIZ Pipeline CRA

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/2/2012-1/6/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/7/2012-1/7/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 1/9/2012-1/13/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/14/2012-1/14/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/16/2012-1/20/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/21/2012-1/21/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 1/23/2012-1/27/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/28/2012-1/28/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 1/30/2012-2/3/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/4/2012-2/4/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 2/6/2012-2/10/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/11/2012-2/11/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/13/2012-2/17/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/18/2012-2/18/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 2/20/2012-2/24/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/25/2012-2/25/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 2/27/2012-3/2/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/3/2012-3/3/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 3/5/2012-3/9/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/10/2012-3/10/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/12/2012-3/16/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/17/2012-3/17/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 3/19/2012-3/23/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/24/2012-3/24/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/26/2012-3/30/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 3/31/2012-3/31/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/2/2012-4/6/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/7/2012-4/7/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/9/2012-4/13/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/14/2012-4/14/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/16/2012-4/20/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/21/2012-4/21/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/23/2012-4/27/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 4/28/2012-4/28/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 4/30/2012-5/4/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/5/2012-5/5/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/7/2012-5/11/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/12/2012-5/12/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 5/14/2012-5/18/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/19/2012-5/19/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/21/2012-5/25/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 5/26/2012-5/26/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 5/28/2012-6/1/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/2/2012-6/2/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/4/2012-6/8/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/9/2012-6/9/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 6/11/2012-6/15/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/16/2012-6/16/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/18/2012-6/22/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/23/2012-6/23/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 6/25/2012-6/29/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 6/30/2012-6/30/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/2/2012-7/6/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/7/2012-7/7/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 7/9/2012-7/13/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/14/2012-7/14/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/16/2012-7/20/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/21/2012-7/21/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

Time Slice 7/23/2012-7/27/2012 Active Days: 5	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/28/2012-7/28/2012 Active Days: 1	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46
Time Slice 7/30/2012-8/1/2012 Active Days: 3	13.97	108.59	65.11	0.01	0.07	6.36	6.42	0.02	5.85	5.87	14,133.28
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trenching 01/01/2012-08/01/2012	13.75	105.64	64.03	0.01	0.05	6.24	6.29	0.02	5.74	5.76	13,624.51
Trenching Off Road Diesel	13.60	105.23	58.51	0.00	0.00	6.22	6.22	0.00	5.72	5.72	12,686.05
Trenching Worker Trips	0.15	0.41	5.51	0.01	0.05	0.02	0.07	0.02	0.02	0.04	938.46

9/9/2011 2:03:23 PM

Time Slice 8/2/2012-8/3/2012 Active Days: 2	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/4/2012-8/4/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/6/2012-8/10/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/11/2012-8/11/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/13/2012-8/17/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/18/2012-8/18/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 8/20/2012-8/24/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/25/2012-8/25/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 8/27/2012-8/31/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/1/2012-9/1/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/3/2012-9/7/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/8/2012-9/8/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 9/10/2012-9/14/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/15/2012-9/15/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/17/2012-9/21/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/22/2012-9/22/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 9/24/2012-9/28/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/29/2012-9/29/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 10/1/2012-10/5/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/6/2012-10/6/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/8/2012-10/12/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/13/2012-10/13/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/15/2012-10/19/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/20/2012-10/20/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 10/22/2012-10/26/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/27/2012-10/27/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 10/29/2012-11/2/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/3/2012-11/3/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/5/2012-11/9/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/10/2012-11/10/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 11/12/2012-11/16/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/17/2012-11/17/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/19/2012-11/23/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/24/2012-11/24/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 11/26/2012-11/30/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/1/2012-12/1/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 12/3/2012-12/7/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/8/2012-12/8/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/10/2012-12/14/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 12/15/2012-12/15/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/17/2012-12/21/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/22/2012-12/22/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43

9/9/2011 2:03:23 PM

Time Slice 12/24/2012-12/28/2012 Active Days: 5	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 12/29/2012-12/29/2012 Active Days: 1	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Time Slice 12/31/2012-12/31/2012 Active Days: 1	**20.27**	**144.83**	**273.30**	**0.36**	**1.98**	**7.10**	**9.08**	**0.71**	**6.49**	**7.20**	**50,265.31**
Building 08/02/2012-12/31/2012	20.04	141.88	272.21	0.36	1.96	6.99	8.95	0.70	6.38	7.09	49,756.54
Building Off Road Diesel	12.39	99.49	54.56	0.00	0.00	5.07	5.07	0.00	4.67	4.67	10,108.27
Building Vendor Trips	2.47	28.11	24.41	0.06	0.24	1.13	1.37	0.08	1.03	1.11	6,745.85
Building Worker Trips	5.18	14.28	193.24	0.29	1.72	0.79	2.52	0.62	0.69	1.31	32,902.43
Mass Grading 01/01/2012-12/31/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.77
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9/9/2011 2:03:23 PM

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 12/31/2012 - truck trips
Total Acres Disturbed: 0
Maximum Daily Acreage Disturbed: 0
Fugitive Dust Level of Detail: Default
20 lbs per acre-day
On Road Truck Travel (VMT): 120.04
Off-Road Equipment:

Phase: Trenching 1/1/2012 - 8/1/2012 - pipeline
Off-Road Equipment:
1 Air Compressors (106 hp) operating at a 0.48 load factor for 12 hours per day
1 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 12 hours per day
1 Cranes (399 hp) operating at a 0.43 load factor for 12 hours per day
2 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 12 hours per day
1 Graders (174 hp) operating at a 0.61 load factor for 12 hours per day
1 Other Equipment (190 hp) operating at a 0.62 load factor for 12 hours per day
1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 12 hours per day
8 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 12 hours per day
1 Water Trucks (189 hp) operating at a 0.5 load factor for 12 hours per day

Phase: Building Construction 8/2/2012 - 12/31/2012 - CRA tie in
Off-Road Equipment:
1 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day
2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day
1 Cranes (399 hp) operating at a 0.43 load factor for 7 hours per day
4 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day
3 Graders (174 hp) operating at a 0.61 load factor for 8 hours per day
3 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 8 hours per day
3 Rubber Tired Loaders (164 hp) operating at a 0.54 load factor for 8 hours per day
3 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day
2 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 2:04:04 PM

Urbemis 2007 Version 9.2.4

Summary Report for Annual Emissions (Tons/Year)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Pipeline CRA.urb924

Project Name: CADIZ Pipeline CRA

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (tons/year unmitigated)	2.59	19.27	23.69	0.02	0.13	1.04	1.17	0.05	0.95	1.00	4,547.21
2012 TOTALS (tons/year mitigated)	2.59	16.05	23.69	0.02	0.13	0.64	0.77	0.05	0.58	0.63	4,547.21
Percent Reduction	0.00	16.70	0.00	0.00	0.00	38.88	34.44	0.00	39.01	37.14	0.00

9/9/2011 2:01:43 PM

Urbemis 2007 Version 9.2.4

Summary Report for Summer Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Pipeline CRA.urb924

Project Name: CADIZ Pipeline CRA

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (lbs/day unmitigated)	20.27	144.83	273.30	0.36	1.98	7.10	9.08	0.71	6.49	7.20	50,265.31
2012 TOTALS (lbs/day mitigated)	20.27	124.93	273.30	0.36	1.98	4.82	6.80	0.71	4.39	5.10	50,265.31

9/9/2011 6:37:54 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Mitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Storage.urb924

Project Name: Cadiz Storage

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Mitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/2/2012-12/28/2012 Active Days: 260	**13.99**	93.08	**56.78**	**0.02**	22.74	3.02	25.76	4.76	2.77	7.53	**14,813.30**
Mass Grading 01/01/2012-12/30/2012	13.99	93.08	56.78	0.02	22.74	3.02	25.76	4.76	2.77	7.53	14,813.30
Mass Grading Dust	0.00	0.00	0.00	0.00	22.68	0.00	22.68	4.74	0.00	4.74	0.00
Mass Grading Off Road Diesel	13.43	87.84	49.32	0.00	0.00	2.81	2.81	0.00	2.58	2.58	13,223.50
Mass Grading On Road Diesel	0.38	4.92	1.81	0.01	0.03	0.19	0.22	0.01	0.17	0.18	847.68
Mass Grading Worker Trips	0.17	0.32	5.65	0.01	0.04	0.02	0.06	0.01	0.02	0.03	742.12

Construction Related Mitigation Measures

The following mitigation measures apply to Phase: Mass Grading 1/1/2012 - 12/30/2012 - Default Mass Site Grading/Excavation

For Soil Stablizing Measures, the Apply soil stabilizers to inactive areas mitigation reduces emissions by:

PM10: 84% PM25: 84%

For Soil Stablizing Measures, the Replace ground cover in disturbed areas quickly mitigation reduces emissions by:

PM10: 5% PM25: 5%

For Soil Stablizing Measures, the Water exposed surfaces 2x daily watering mitigation reduces emissions by:

PM10: 55% PM25: 55%

For Soil Stablizing Measures, the Equipment loading/unloading mitigation reduces emissions by:

PM10: 69% PM25: 69%

For Graders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Rubber Tired Dozers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Tractors/Loaders/Backhoes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Water Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Air Compressors, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Cement and Mortar Mixers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Cranes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Dumpers/Tenders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Other Equipment, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Off Highway Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 12/30/2012 - Default Mass Site Grading/Excavation
Total Acres Disturbed: 20
Maximum Daily Acreage Disturbed: 5
Fugitive Dust Level of Detail: Default
20 lbs per acre-day
On Road Truck Travel (VMT): 200
Off-Road Equipment:
2 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day
2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day
1 Cranes (399 hp) operating at a 0.43 load factor for 8 hours per day
4 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day
1 Graders (174 hp) operating at a 0.61 load factor for 6 hours per day
4 Off Highway Trucks (479 hp) operating at a 0.57 load factor for 8 hours per day
1 Other Equipment (190 hp) operating at a 0.62 load factor for 8 hours per day
2 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 6 hours per day
5 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day
2 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 6:37:15 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Unmitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Storage.urb924

Project Name: Cadiz Storage

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/2/2012-12/28/2012 Active Days: 260	**13.99**	**115.04**	**56.78**	**0.02**	**100.06**	**5.31**	**105.38**	**20.91**	**4.89**	**25.79**	**14,813.30**
Mass Grading 01/01/2012-12/30/2012	13.99	115.04	56.78	0.02	100.06	5.31	105.38	20.91	4.89	25.79	14,813.30
Mass Grading Dust	0.00	0.00	0.00	0.00	100.00	0.00	100.00	20.88	0.00	20.88	0.00
Mass Grading Off Road Diesel	13.43	109.80	49.32	0.00	0.00	5.10	5.10	0.00	4.70	4.70	13,223.50
Mass Grading On Road Diesel	0.38	4.92	1.81	0.01	0.03	0.19	0.22	0.01	0.17	0.18	847.68
Mass Grading Worker Trips	0.17	0.32	5.65	0.01	0.04	0.02	0.06	0.01	0.02	0.03	742.12

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 12/30/2012 - Default Mass Site Grading/Excavation

Total Acres Disturbed: 20

Maximum Daily Acreage Disturbed: 5

Fugitive Dust Level of Detail: Default

20 lbs per acre-day

On Road Truck Travel (VMT): 200

Off-Road Equipment:

2 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day

2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day

1 Cranes (399 hp) operating at a 0.43 load factor for 8 hours per day

4 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day

1 Graders (174 hp) operating at a 0.61 load factor for 6 hours per day

9/9/2011 6:37:15 PM

4 Off Highway Trucks (479 hp) operating at a 0.57 load factor for 8 hours per day

1 Other Equipment (190 hp) operating at a 0.62 load factor for 8 hours per day

2 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 6 hours per day

5 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day

2 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 6:38:56 PM

Urbemis 2007 Version 9.2.4

Summary Report for Annual Emissions (Tons/Year)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Storage.urb924

Project Name: Cadiz Storage

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (tons/year unmitigated)	1.82	14.96	7.38	0.00	13.01	0.69	13.70	2.72	0.64	3.35	1,925.73
2012 TOTALS (tons/year mitigated)	1.82	12.10	7.38	0.00	2.96	0.39	3.35	0.62	0.36	0.98	1,925.73
Percent Reduction	0.00	19.09	0.00	0.00	77.28	43.22	75.56	77.24	43.23	70.80	0.00

9/9/2011 6:35:35 PM

Urbemis 2007 Version 9.2.4

Summary Report for Summer Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Storage.urb924

Project Name: Cadiz Storage

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (lbs/day unmitigated)	13.99	115.04	56.78	0.02	100.06	5.31	105.38	20.91	4.89	25.79	14,813.30
2012 TOTALS (lbs/day mitigated)	13.99	93.08	56.78	0.02	22.74	3.02	25.76	4.76	2.77	7.53	14,813.30

9/9/2011 1:54:53 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Mitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Wells.urb924

Project Name: Cadiz Wells

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Mitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/1/2012-1/1/2012 Active Days: 1	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/2/2012-1/6/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9/9/2011 1:54:53 PM

Time Slice 1/7/2012-1/8/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/9/2012-1/13/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 1/14/2012-1/15/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:53 PM

Time Slice 1/16/2012-1/20/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 1/21/2012-1/22/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/23/2012-1/27/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 1/28/2012-1/29/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/30/2012-2/3/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/4/2012-2/5/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 2/6/2012-2/10/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/11/2012-2/12/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 2/13/2012-2/17/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 2/18/2012-2/19/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 2/20/2012-2/24/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/25/2012-2/26/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 2/27/2012-3/2/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/3/2012-3/4/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/5/2012-3/9/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 3/10/2012-3/11/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/12/2012-3/16/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/17/2012-3/18/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 3/19/2012-3/23/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/24/2012-3/25/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/26/2012-3/30/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 3/31/2012-4/1/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/2/2012-4/6/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/7/2012-4/8/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 4/9/2012-4/13/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/14/2012-4/15/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/16/2012-4/20/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 4/21/2012-4/22/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/23/2012-4/27/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/28/2012-4/29/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 4/30/2012-5/4/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/5/2012-5/6/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/7/2012-5/11/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 5/12/2012-5/13/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/14/2012-5/18/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/19/2012-5/20/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 5/21/2012-5/25/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/26/2012-5/27/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/28/2012-6/1/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 6/2/2012-6/3/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/4/2012-6/8/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/9/2012-6/10/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 6/11/2012-6/15/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/16/2012-6/17/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/18/2012-6/22/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 6/23/2012-6/24/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/25/2012-6/29/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/30/2012-7/1/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 7/2/2012-7/6/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/7/2012-7/8/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/9/2012-7/13/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 7/14/2012-7/15/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/16/2012-7/20/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/21/2012-7/22/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 7/23/2012-7/27/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/28/2012-7/29/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/30/2012-8/3/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/4/2012-8/5/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/6/2012-8/10/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/11/2012-8/12/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 8/13/2012-8/17/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/18/2012-8/19/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/20/2012-8/24/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/25/2012-8/26/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/27/2012-8/31/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/1/2012-9/2/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:54 PM

Time Slice 9/3/2012-9/7/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/8/2012-9/9/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 9/10/2012-9/14/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/15/2012-9/16/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 9/17/2012-9/21/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/22/2012-9/23/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 9/24/2012-9/28/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/29/2012-9/30/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/1/2012-10/5/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/6/2012-10/7/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/8/2012-10/12/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/13/2012-10/14/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:55 PM

Time Slice 10/15/2012-10/19/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/20/2012-10/21/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/22/2012-10/26/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/27/2012-10/28/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/29/2012-11/2/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/3/2012-11/4/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:55 PM

Time Slice 11/5/2012-11/9/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/10/2012-11/11/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 11/12/2012-11/16/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/17/2012-11/18/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 11/19/2012-11/23/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/24/2012-11/25/2012 Active Days: 2	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 11/26/2012-11/30/2012 Active Days: 5	**18.00**	123.21	**89.00**	**0.04**	**0.17**	3.59	3.76	**0.06**	3.30	3.36	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	120.26	87.92	0.03	0.15	3.48	3.63	0.05	3.19	3.25	30,599.77
Building Off Road Diesel	16.90	116.26	65.35	0.00	0.00	3.28	3.28	0.00	3.02	3.02	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Construction Related Mitigation Measures

The following mitigation measures apply to Phase: Mass Grading 1/1/2012 - 11/30/2012 - truck trips

For Soil Stablizing Measures, the Apply soil stabilizers to inactive areas mitigation reduces emissions by:

PM10: 84% PM25: 84%

For Soil Stablizing Measures, the Replace ground cover in disturbed areas quickly mitigation reduces emissions by:

PM10: 5% PM25: 5%

For Soil Stablizing Measures, the Water exposed surfaces 2x daily watering mitigation reduces emissions by:

PM10: 55% PM25: 55%

For Soil Stablizing Measures, the Equipment loading/unloading mitigation reduces emissions by:

PM10: 69% PM25: 69%

The following mitigation measures apply to Phase: Building Construction 1/1/2012 - 11/30/2012 - Default Building Construction

For Cranes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Tractors/Loaders/Backhoes, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 25% PM10: 45% PM25: 45%

For Air Compressors, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Bore/Drill Rigs, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Cement and Mortar Mixers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:

NOX: 20% PM10: 45% PM25: 45%

For Dumpers/Tenders, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 20% PM10: 45% PM25: 45%
For Rubber Tired Dozers, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 25% PM10: 45% PM25: 45%
For Water Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 25% PM10: 45% PM25: 45%
For Off Highway Trucks, the Use Aqueous Diesel Fuel mitigation reduces emissions by:
NOX: 25% PM10: 45% PM25: 45%

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 11/30/2012 - truck trips
Total Acres Disturbed: 0
Maximum Daily Acreage Disturbed: 0
Fugitive Dust Level of Detail: Default
20 lbs per acre-day
On Road Truck Travel (VMT): 119.92
Off-Road Equipment:

Phase: Building Construction 1/1/2012 - 11/30/2012 - Default Building Construction
Off-Road Equipment:
2 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day
4 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 24 hours per day
2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day
2 Cranes (399 hp) operating at a 0.43 load factor for 6 hours per day
2 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day
2 Off Highway Trucks (479 hp) operating at a 0.57 load factor for 8 hours per day
1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 8 hours per day
3 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 8 hours per day
1 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 1:54:36 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Unmitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Wells.urb924

Project Name: Cadiz Wells

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 1/1/2012-1/1/2012 Active Days: 1	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/2/2012-1/6/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9/9/2011 1:54:36 PM

Time Slice 1/7/2012-1/8/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/9/2012-1/13/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 1/14/2012-1/15/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:36 PM

Time Slice 1/16/2012-1/20/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 1/21/2012-1/22/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/23/2012-1/27/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 1/28/2012-1/29/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 1/30/2012-2/3/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/4/2012-2/5/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:36 PM

Time Slice 2/6/2012-2/10/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/11/2012-2/12/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 2/13/2012-2/17/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 2/18/2012-2/19/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 2/20/2012-2/24/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 2/25/2012-2/26/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 2/27/2012-3/2/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/3/2012-3/4/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/5/2012-3/9/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 3/10/2012-3/11/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/12/2012-3/16/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/17/2012-3/18/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 3/19/2012-3/23/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 3/24/2012-3/25/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 3/26/2012-3/30/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 3/31/2012-4/1/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/2/2012-4/6/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/7/2012-4/8/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 4/9/2012-4/13/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/14/2012-4/15/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/16/2012-4/20/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 4/21/2012-4/22/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 4/23/2012-4/27/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 4/28/2012-4/29/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 4/30/2012-5/4/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/5/2012-5/6/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/7/2012-5/11/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 5/12/2012-5/13/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/14/2012-5/18/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/19/2012-5/20/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 5/21/2012-5/25/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 5/26/2012-5/27/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 5/28/2012-6/1/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 6/2/2012-6/3/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/4/2012-6/8/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/9/2012-6/10/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 6/11/2012-6/15/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/16/2012-6/17/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/18/2012-6/22/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 6/23/2012-6/24/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 6/25/2012-6/29/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 6/30/2012-7/1/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 7/2/2012-7/6/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/7/2012-7/8/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/9/2012-7/13/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 7/14/2012-7/15/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/16/2012-7/20/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/21/2012-7/22/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 7/23/2012-7/27/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 7/28/2012-7/29/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 7/30/2012-8/3/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/4/2012-8/5/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/6/2012-8/10/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/11/2012-8/12/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 8/13/2012-8/17/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 8/18/2012-8/19/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/20/2012-8/24/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 8/25/2012-8/26/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 8/27/2012-8/31/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/1/2012-9/2/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 9/3/2012-9/7/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/8/2012-9/9/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 9/10/2012-9/14/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 9/15/2012-9/16/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 9/17/2012-9/21/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/22/2012-9/23/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:37 PM

Time Slice 9/24/2012-9/28/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 9/29/2012-9/30/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/1/2012-10/5/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/6/2012-10/7/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/8/2012-10/12/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/13/2012-10/14/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 10/15/2012-10/19/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 10/20/2012-10/21/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/22/2012-10/26/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 10/27/2012-10/28/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 10/29/2012-11/2/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/3/2012-11/4/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

9/9/2011 1:54:38 PM

Time Slice 11/5/2012-11/9/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/10/2012-11/11/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 11/12/2012-11/16/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Time Slice 11/17/2012-11/18/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Time Slice 11/19/2012-11/23/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time Slice 11/24/2012-11/25/2012 Active Days: 2	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43

Time Slice 11/26/2012-11/30/2012 Active Days: 5	**18.00**	**155.37**	**89.00**	**0.04**	**0.17**	**6.28**	**6.44**	**0.06**	**5.77**	**5.83**	**31,108.03**
Building 01/01/2012-11/30/2012	17.77	152.42	87.92	0.03	0.15	6.17	6.32	0.05	5.67	5.72	30,599.77
Building Off Road Diesel	16.90	148.43	65.35	0.00	0.00	5.97	5.97	0.00	5.49	5.49	27,283.47
Building Vendor Trips	0.25	2.85	2.52	0.01	0.02	0.11	0.14	0.01	0.10	0.11	681.87
Building Worker Trips	0.61	1.15	20.04	0.03	0.13	0.08	0.21	0.05	0.07	0.11	2,634.43
Mass Grading 01/01/2012-11/30/2012	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.23	2.95	1.09	0.00	0.02	0.11	0.13	0.01	0.10	0.11	508.26
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Phase Assumptions

Phase: Mass Grading 1/1/2012 - 11/30/2012 - truck trips

Total Acres Disturbed: 0

Maximum Daily Acreage Disturbed: 0

Fugitive Dust Level of Detail: Default

20 lbs per acre-day

On Road Truck Travel (VMT): 119.92

Off-Road Equipment:

Phase: Building Construction 1/1/2012 - 11/30/2012 - Default Building Construction

Off-Road Equipment:

2 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day

4 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 24 hours per day

2 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 8 hours per day

2 Cranes (399 hp) operating at a 0.43 load factor for 6 hours per day

2 Dumpers/Tenders (16 hp) operating at a 0.38 load factor for 8 hours per day

2 Off Highway Trucks (479 hp) operating at a 0.57 load factor for 8 hours per day

1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 8 hours per day

3 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 8 hours per day

1 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

9/9/2011 1:55:16 PM

Urbemis 2007 Version 9.2.4

Summary Report for Annual Emissions (Tons/Year)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Wells.urb924

Project Name: Cadiz Wells

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (tons/year unmitigated)	3.00	25.88	14.86	0.01	0.03	1.05	1.07	0.01	0.96	0.97	5,186.45
2012 TOTALS (tons/year mitigated)	3.00	20.50	14.86	0.01	0.03	0.60	0.62	0.01	0.55	0.56	5,186.45
Percent Reduction	0.00	20.81	0.00	0.00	0.00	43.01	41.92	0.00	43.06	42.63	0.00

9/9/2011 1:53:16 PM

Urbemis 2007 Version 9.2.4

Summary Report for Summer Emissions (Pounds/Day)

File Name: C:\Documents and Settings\dsa\Application Data\Urbemis\Version9a\Projects\Cadiz Wells.urb924

Project Name: Cadiz Wells

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2012 TOTALS (lbs/day unmitigated)	18.00	155.37	89.00	0.04	0.17	6.28	6.44	0.06	5.77	5.83	31,108.03
2012 TOTALS (lbs/day mitigated)	18.00	123.21	89.00	0.04	0.17	3.59	3.76	0.06	3.30	3.36	31,108.03

HydroBio
Advanced Remote Sensing

Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California

August 30, 2011

Executive Summary

This investigation characterizes soil chemistry and structure on the Bristol Playa and the immediate margins to evaluate the relationship between groundwater and surface soils. Cadiz Playa is interpreted in relation to Bristol Playa because it is highly similar. The study seeks to assess whether the playa surfaces could become a significant source of dust like certain other playas in the Mojave Desert, such as the Owens and Franklin Playas. The study concludes that the soil and water chemistry of both Cadiz and Bristol Playas have very low quantities of the sodium salts of carbonate, bicarbonate and sulfate that are known to cause severe fugitive dust storms from Owens and Franklin Playas.

Bristol Playa does produce fugitive dust from erosion by sand grains driven by high wind across the playa surface. In this process, the quantity of sand available on the playa margin is responsible for the magnitude of the dust release. The available sand appears to have diminished over time and this is hypothesized to be due to the action of a mix of weedy species that have grown increasingly dominant over the past 50 years. Hence, the severity of Bristol Playa fugitive dust is hypothesized to be diminishing with time. Changes in groundwater level will likely have no impact upon this relationship.

Cadiz Playa appears to be the sink for the sand blown from the region of the Bristol Playa directly upwind to the northwest. This sand tends to be stabilized by the growth of Russian thistle (tumbleweed). Cadiz has the same chemistry but due to the copious sand dunes around the shore, particularly in the north to northeast regions, large amounts of sand are available to erode the playa surface. Dust storms from Cadiz Playa will likely not diminish in the future regardless of the depth to water beneath the playa.

Section		Page
1.	Introduction and Purpose	1
2.	Physical Setting	1
3.	Mojave Desert Playas Known to Release Significant Dust	5
4.	Field Data from the Bristol Playa	7
5.	The Bristol Playa and its Chemistry	8
6.	The Bristol Playa and its Hydrology and Sedimentology	9
7.	Satellite Data, Salt Efflorescence and Dust Release	10
8.	Sand Balance for the Bristol Playa	11
9.	Cadiz Playa and Its Relationship to Sand and Dust	14
10.	Conclusions	14
11.	Literature Cited	15
	Appendix A: Salt Chemistry, Salt Species, and Glossary of Terms	17
	Appendix B: Field Trip Photographs and Notes	19
	Appendix C: Observation of Satellite Images	27

1220 Cerro Gordo Rd., Santa Fe, NM 87501; HydroBio Contact Dr. David P. Groeneveld

1. Introduction and Purpose

Desiccation of arid land saline water bodies has led to severe air quality problems and threats to human health and welfare at sites like the Aral Sea (Micklin, 1988) in Central Asia and the Owens Lake, in eastern California (Saint-Amand et al. 1986). The purpose of this investigation is to evaluate whether changes in water table levels below Bristol and Cadiz Playas could result in an increase in the generation of dust above existing conditions.

The analyses presented here were performed after field investigations on November 9, 2010, and on August 23, 2011. During both trips observations of both playa surfaces were made, vegetation and sand deposits were identified, soil samples were obtained and observations were made of features that indicated the nature of windborne fugitive dust releases from the Playas and the surrounding area. An air tour over Bristol and Cadiz Playas and surrounding region was made prior to the investigation on the ground for observations of the physiography, indications of hydrology and wind erosion effects and to obtain photographs for documentation and interpretation. An additional field trip was accomplished on August 23, 2011 for the purpose of gathering samples from the Cadiz Playa for confirmation that the playa chemistry is equivalent to Bristol Playa.

The Cadiz Groundwater Conservation, Recovery, and Storage Project (Project) proposes the adaptive management of groundwater in the Cadiz Valley as part of a groundwater project for southern California public water supply (CH2M Hill). The major focus of this investigation was to evaluate mechanisms for dust release and the role played by hydrology within the Bristol Playa region that lies adjacent and downgradient of Fenner Gap, the location contemplated for Project production wells (CH2MHill, 2010). This research agenda included evaluating the hydrology of the playa and its relationship to air quality. A minor focus is the evaluation of these same aspects for the Cadiz Playa that is located southeast of Bristol playa, and separated from it by a low alluvial divide that rises 52 feet above the lowest part of Bristol Playa and 104 feet above the Cadiz Playa (Bassett et al. 1959). Although the literature focuses on Bristol Playa the same processes are occurring on the Cadiz Playa. Likewise, this analysis focuses primarily on Bristol Playa also because of its proximity to the Fenner Gap, Cadiz Playa is then compared to Bristol Playa.

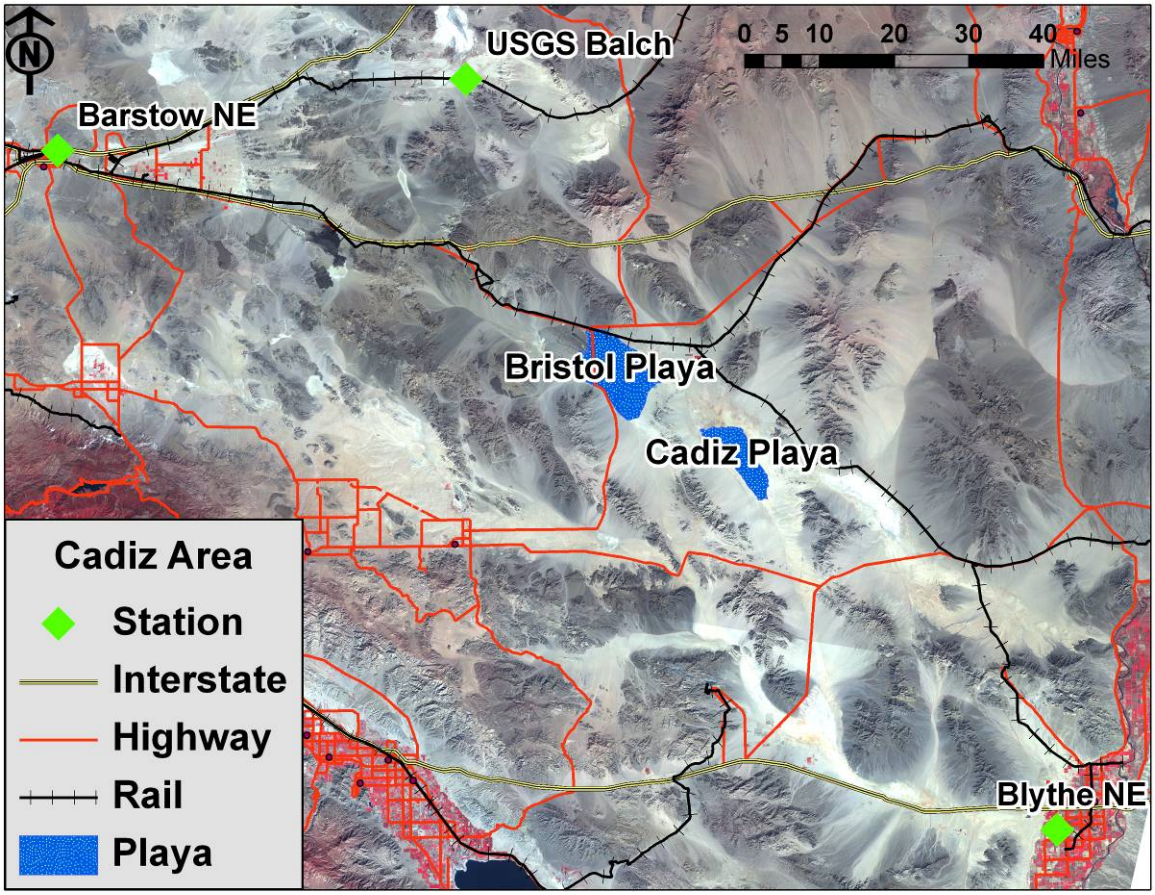
2. Physical Setting

The Bristol Playa lies in Cadiz Valley, California (Figure 1). The biome here is Mojave Desert, characterized by low scrubby vegetation cover and intense aridity. Vegetation on and around the Playa is dominated by two native shrub species, creosote bush and two saltbush species, four wing saltbush and cattle saltbush. The saltbushes occupy salinized zones next to the Playa and intergrade with creosote bush that tends to occupy non salt-affected soils farther away from the Playa margin. Appendix A defines terms used in this report. Note that Lake and Playa are used here interchangeably (“Lake” on some figures), however, both Bristol and Cadiz are more properly termed playas because there is no geologic record that they were ever inundated (Rosen, 1991;Handford, 1982).

The long-term annual average precipitation at Mitchell Caverns, located at an altitude of 4,350 feet in the Providence Mountains approximately 40 miles north of Bristol Playa, is 10.47 inches measured from 1948 to 2004). Amboy, located along the north shore of Bristol Playa, is represented by two stations, Amboy – Saltus Number 1, with an elevation of 624 feet and a long-term annual average precipitation of 3.28 inches (from 1967 through 1988) and Amboy – Saltus Number 2, with an elevation of 595 feet and long-term annual average precipitation of 2.71 inches (1972 through 1992). Over millennia, Bristol and Cadiz Playas have acquired economically viable deposits of evaporite minerals that are currently being mined (Gale, 1915; Handford, 1982).

Rainfall in the surrounding area increases proportionately to elevation (Figure 2; derived by annualizing the data presented by CH2MHill [2010]). Consequentially, large rainstorms may generate runoff that flows down the alluvial fans to deliver water to the Playa and surrounding area. Distributaries of these drainages are evident on the Playa with sparse vegetation of saltbush growing out for a kilometer or more onto the Bristol Playa away from the ecotonal boundary of shrubs around the lake margin.

Figure 1. Location Map showing the two important playas in the Cadiz Valley and locations of three weather stations used in selection of satellite data for analysis of blowing dust and salt on the playa surface.



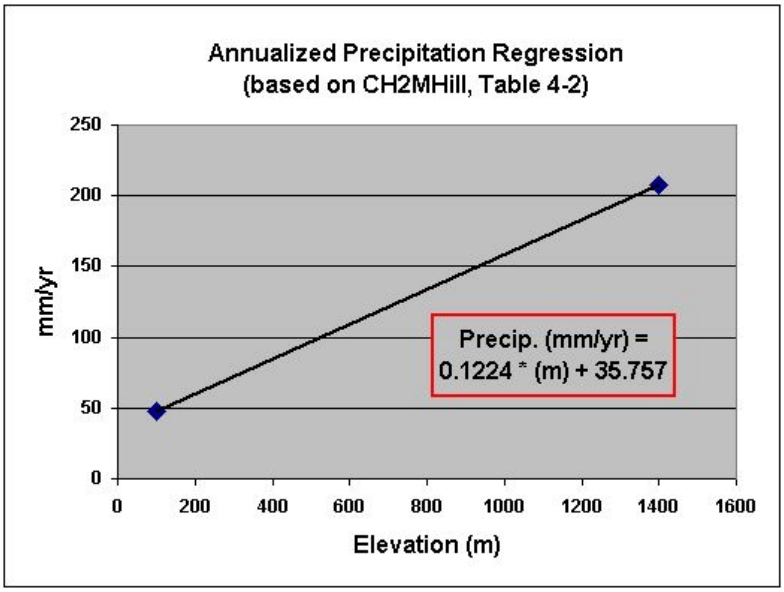


Figure 2. Annualized curve of precipitation with elevation based upon data in CH2MHill (2010) Table 4-2.

The hydrology of Bristol and Cadiz Playas is directly related to the watershed catchment and the rainfall that is received. Figure 3 provides a map of average annual rainfall within the watershed that feeds both playas. The majority of the catchment, especially the highest elevations, is located above the Fenner Wash to the north. The fans and drainages from Fenner Wash provide occasional short-term surface flows that deliver water to each of the Playas.

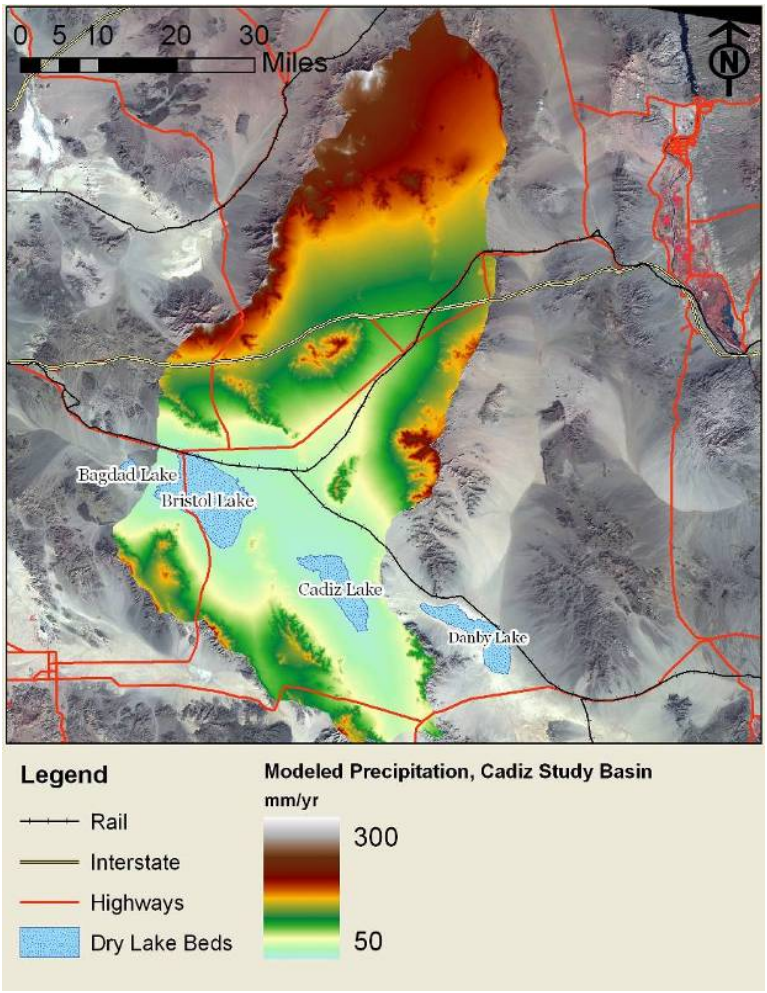


Figure 3. A map of annual average precipitation calculated from digital elevation model data and the relationship shown in Figure 2.

The northwest to southeast trending valley floor is roughly aligned with the direction of the highest winds as determined from the USGS Balch weather station located approximately 40 to 50 miles northwest of the Bristol Playa (Figure 1). Figure 4 was generated for winds of nine meters per second (about 20 miles per hour) because winds of this magnitude are expected to produce copious fugitive dust from dust sources. It shows that winds from the southeast through southwest are only a small fraction of the winds from the west. Note, however, that the USGS Balch station is located in a windgap that is generally aligned west-to-east that induces a forcing influence on the direction of westerly winds. Likewise, the northwest-southeast topographic trend of the Cadiz Valley likely influences a forcing upon the direction of winds of sufficient velocity to move particles. This is aptly illustrated by visible traces of cinder movement from the basalt flow northwest of the Bristol Playa (Figure 5).

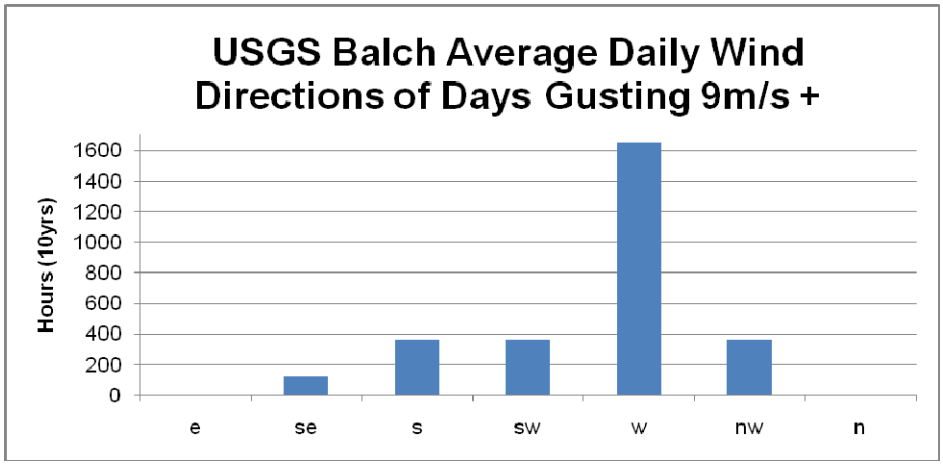


Figure 4. Wind directions in hours totaled for the 10-year record for the USGS Balch weather stations. Each directional pie slice is 45 degrees; e.g., west is from 247.5° to 292.5°.

Figure 5. Indication of prevailing direction of high winds shown by wind-drift cinders from Amboy Cinder Cone and surrounding features. (Image courtesy of Google Earth)

That significant and potentially disruptive sand movement has occurred historically in the region adjacent to the Bristol Playa is illustrated by the athel trees that were planted for dune control along the Atchison-Topeka and Santa Fe Railroad grade that passes from east to west (Figure 1). Athel trees were planted where problems with sand were encountered by the railroads through the Mojave Desert that were emplaced specifically for sand control (Trainweb, undated). The overview from the air and while driving along two miles of the railroad track to access the Bristol Playa indicated that drifting sand is not a concern in recent decades since no recent deposits of sand were noted in this area. Hence, the athel trees appear to be superfluous today, indicating that conditions may have changed from the time when they were planted.

3. Mojave Desert Playas Known to Release Significant Dust

Owens Lake is a well understood source of windborne fugitive dust—formerly identified as the largest single source of dust in the United States (Great Basin Unified Air Pollution Control District [GBUAPCD, undated]). The air quality problems at Owens Lake are known to result from salt chemistry interaction with the clay-to-sand lakebed substrate, thus implicating salts as the driving factor for the fugitive dust problem.

Owens Lake has been the terminus for the Owens River during the past several thousand years with evaporation concentrating the salts received from regional runoff (Gale 1915, Jayco and Bacon 2008). The dominant cation is sodium and the dominant anions, listed in order of solubility are carbonate-bicarbonate, sulfate and chloride, with about 10% of other elements (Saint-Amand et al. 1987).

Owens Lake salt chemistry and efflorescence have been identified as the causal factor for extreme levels of windborne dust through a temperature-controlled process that occurs during the winter (Saint-Amand et al. 1986, 1987). Below a temperature of 65°F, thenardite, an anhydrous form of Na_2SO_4 hydrates to form mirabilite.

The addition of ten molecules of water causes mirabilite to occupy about 4.1 times the volume of thenardite, fracturing soil crusts and separating particles. During warm sunny winter days when temperatures often exceed 65°F, the mirabilite loses the water from its crystal structure to form amorphous thenadardite that is light, fluffy and prone to wind erosion (Saint-Amand 1987). At 50°F, the same process converts the decahydrate carbonate salts thermonatrite that occupy 4.8 times the volume to natron when it dehydrates. This disrupts the surface crust in the same manner. Appendix A provides the chemical equilibria for these reactions and identifies the ions that make up these salts.

The loss of water molecules from natron due to evaporation on clear warm winter days at >50°F creates fluffy, easily-lofted surface salts as amorphous trona. Together with the affects of amorphous thenardite, the damaged crust enables a wind of only 15 mph (and possibly less) to ablate carbonate- and sulfate-rich dust from the lakebed surface (Saint-Amand 1987). This temperature controlled hydration/desiccation of Owens Lake salts is the key aspect for creating the single largest source of respirable dust in the United States (GBUAPCD, 2008). High winds in combination with temperature-induced salt

metamorphosis have released an estimated 80,000 metric tons of particles in single storms from the untreated lakebed (Gill and Gillette, 1991). The air quality problems at Owens Lake have prompted large-scale, highly expensive efforts to control the dust releases (GBUAPCD, undated).

Owens Lake represents an interesting case in air quality that is very different from other playas in the Mojave Desert owing to the fact that desiccation was caused by diversion of its surface water supply rather than climate influence, and so represents only a one hundred year period of desiccation. This compares to the likely continuous desiccation of the Bristol Playa, hypothesized to have been dry since its inception thousands of years ago (Handford, 1982; Rosen, 1991).

Studies of playas in the Mojave Desert indicate a strong relationship between saline hydrology, capillary transport and salt chemistry. Reynolds et al. (2007) found that playa surfaces are dynamic with depth to water, rainfall and rates of evaporation—these factors influence dust release along with salt chemistry. Dry playas with deep groundwater give rise to little or no dust if undisturbed.

Franklin, Soda, and West Playas have surface sediments that give rise to significant dust. Reynolds et al. (2007) focused mainly upon Franklin Playa that has halite, trona, thenardite, and burkeite surface evaporites deposited from groundwater capillarity and evaporation. These salts are the same species as found on the Owens Lake Playa and are formed from carbonate, bicarbonate and sulfate that give rise to windborne dust. In these systems the release of windborne dust was primarily related to the formation of fluffy efflorescence, likely the same effect of temperature controlled salt crystal metamorphosis found by Saint-Amand et al. (1986) at Owens Lake. Salts occur in very high concentrations in the Owens Lakebed surface up to 70% by weight, dominated by carbonate, bicarbonate, and sulfate ions (GBUAPCD, 2010).

Halite (sodium chloride, table salt) is not implicated in the literature as fostering surface release of windborne dust and appears to be protective of the surface since it forms hardened crystals. Groeneveld et al. (2010) found that ultra-thin crusts of halite seal playa surfaces to render them resistant to desiccation. Where this occurs, the underlying playa substrate tends to remain moist. In an active capillary environment dominated by salt species, this condition may be transitory. Breit et al. (2009) found that salts accumulated through capillary rise in the near surface (0 to 20 centimeters) on the Franklin Playa were depleted in chloride and enriched in carbonate in relation to deeper positions. Hence, even if chloride is present with sodium carbonate and sulfate, these other salt species may dominate the process for creation of loose fluffy surfaces to induce windborne dust.

Because of calcium chloride's lack of hydration (though this salt has hygroscopic properties that may pull water from air close to water vapor saturation), this salt has the same properties for tacking and sealing loose surfaces as sodium chloride. These properties were confirmed in the laboratory using diluted solutions of saturated calcium chloride (obtained from the Tetra Chemicals mine on the Bristol Playa) on loose clay and silt surfaces as discussed below.

4. Field Data from Bristol Playa and Cadiz Playas.

The Bristol Playa was investigated on the ground on November 9, 2010, and the Cadiz Playa was visited on August 23, 2011as described in Appendix B. Aerial overflight was also conducted in the morning before exploration on the ground. Two samples from Bristol Playa were collected and analyzed for dominant salt ion content in preparation for this report. Samples were also collected from the Cadiz Playa to confirm that the salt chemistry is the same as on the Bristol Playa. These samples are being processed at the time of this report and a confirmation letter for their chemistry will be attached.

Conclusions derived from the field inspections are as follows:

(1) The release of dust from both Bristol and Cadiz Playas and margins is the result of the physical process of windblown saltation of sand particles that debride the surface.

(2) Sand grains are rare on the bare Playas, but may be blown across in high winds. There are aeolian deposits of medium sand that are trapped in near shore features of both Bristol and Cadiz Playas. Small patches of the Bristol Playa showed obvious signs of recent wind erosion activity from saltating sand grains (Point 8, Appendix B).

(3) The majority of the wind erosion is taking place within the shrub-occupied coppice mounds around the outer margin of the Bristol Playa. Erosion of these features provides the sand to debride the surface. The margins of the Bristol Playa appear to be deflating, overall.

(4) The Bristol lakeshore can be divided into saltation and accumulation zones. The source zones provide the eroded particles that are carried in high winds. Much of this material is deposited into an accumulation zone within the gentle alluvial divide between Bristol Playa and Cadiz Playa to the southeast.

(5) Judging by the easily lofted particles, the accumulation zone southeast of the Bristol Playa can be a significant source of blowing dust. Weak crusting following rain may offer temporary protection of the surface: however, high winds with saltating sand grains can destroy this crust and render the surface highly emissive.

(6) No evidence was found for dust releases as affected by groundwater capillarity such as at Owens and Franklin Playas. Such patches are indicators of sodium sulfate- and carbonate-dominated groundwater chemistry. This chemistry is lacking on both the Cadiz and Bristol Playas, as discussed below.

(7) While the Bristol shore appears to have been deflated, much of this sand appears to be trapped within dune fields at the north to northeast margin of the Cadiz Playa. This sand is a reservoir that may impact the Cadiz Playa by releasing sand.

Observations of Satellite imagery in Section 7 support the conclusions in 4, through 7, above. Figure 6 shows a rough interpretation of “source” and “accumulation” areas noted during the field work and during interpretation of Satellite data in Section 7.

5. The Bristol Playa and its Chemistry

Both Bristol and Cadiz Playas have histories of solute mining activities. At present, two companies are collecting and marketing both solid sodium chloride and liquid calcium chloride that drains in a natural mix with small amounts of other minor ionic constituents. The calcium chloride is concentrated from native brine that drains from a series of trenches that generally flow by gravity. Evaporative concentration causes sodium chloride to precipitate, leaving a nearly pure solution of calcium chloride (bulk density of around 1.35). Gale (1951) reported the chemical constituents in brine that was collected from a 50 foot deep test hole in the Bristol Playa (Table 1) showing that chloride was the dominant anion and calcium and sodium were the dominant cations with extremely low concentrations of bicarbonate and sulfate.

Table 1. Ionic constituents in Bristol Playa brine reported by Gale (1951). The ionic species sum to 100 percent.

Cations	Ca^{++}	calcium	25.30%
	Na^{+}	sodium	23.60%
	Mg^{++}	magnesium	1.10%
Anions	Cl^{-}	chloride	49.95%
	HCO_3^{-}	bicarbonate	0.05%
	SO_4^{--}	sulfate	0.04%

Rosen (1991) reported similar results to Table 1 stating that chemical analyses of shallow groundwater from beneath Bristol Playa show sodium, calcium, and chloride dominate the ions in solution while these ions plus small amounts of magnesium and potassium increase toward the Playa center.

In conclusion, the Bristol lacks the chemistry that has been implicated in the release of dust from other playas in the Mojave Desert. Instead, the presence of sodium and calcium chloride likely induces surface crusting that is resistant to abrasion and will aid in reducing windborne dust.

The two surface soil samples (top ¾ inch) from the Bristol Playa were analyzed by IAS Laboratories in Phoenix, Arizona (Table 2). These results show that the samples are high in sodium and chloride with sulfate in small quantities that increased from the Playa edge.

Table 2. Test results in weight percent from two near surface soil samples taken from Bristol Playa. The other soil constituents (making 100%) were silica minerals.

	Ca	Na	Cl	SO_4	CO_3	HCO_3
Point 4	0.55	9.25	8.1	0.96	ND	0.0092
Point 5	0.42	2.95	1.91	1.15	ND	0.012

There was a significant difference in the sodium chloride between the Sample Points 4 and 5. At Sample Point 5, weak patterns of drainage pans were present that may indicate that the sodium chloride has been removed by runon and runoff processes. Although sodium sulfate has been implicated in dust releases for other playas, this ion is in restricted supply within the two samples, especially from Point 4, relative to chloride. At Point 5, however, the sulfate is in relatively high concentration relative to chloride but it must be remembered that where sodium sulfate is implicated in dusty conditions, it is in very high concentrations (>10%, of the weight of the sample). This is the case for the Owens Lake system where salts of sodium carbonate, bicarbonate and sulfate may exceed 50% (GUBAPCD, 2010). In both samples from Points 4 and 5, much of the sulfate is likely loosely bound with calcium to create gypsum or anhydrite (up to 36 to 57% of the sample fraction if in ionic balance with Ca).

The samples from Bristol Playa lack the ionic chemistry that has been found to be conducive to fugitive dust released from playas in the Mojave Desert—heavy dominance by sulfate, carbonate and bicarbonate ions. The presence of ions that demonstrably create resistant crusts, sodium chloride, supports that the dust that is released from the Bristol Playa and its margins is not directly influenced by groundwater hydrology.

Confirmation of the chemistry of the Cadiz Playa, hypothesized to be equivalent to Bristol Playa, i.e., dominated by Ca, Na and Cl is pending at the time of this report and are being analyzed at IAS Laboratories as were the Bristol Playa samples.

6. The Bristol Playa and its Hydrology and Sedimentology

Handford (1982) described the sedimentology and genesis of the evaporite of Bristol Playa. The system contains a bull's eye pattern of halite in the center of Playa surrounded by interbedded sediments, gypsum, anhydrite and halite. Sediments have been deposited by sheetflow and suspension settling from ponded floodwater. Both Rosen (1991) and Handford (1982) noted that Bristol Playa probably was generated in an environment that remained dry during the majority of its many thousand year genesis.

The intermittent supply of sediment that is delivered to the Bristol Playa with storm runoff is an important factor for air quality, because the particles provide the transfer of erosive energy when propelled by the wind. The balance of the sediments on the Playa is a central control for windborne dust through a process in which the particles are (1) being deposited by runon from the adjacent alluival fans, (2) being reworked by wind, or (3) being exported from the Bristol Playa to the southeast toward the margin of Cadiz Playa. These processes are described in the next few sections.

7. Satellite Data: Salt Efflorescence and Dust Release

Images for observation of either the effect of recent rain or dust release from Bristol Playa were selected from the Landsat TM and Aster archives maintained by the USGS.

This analysis was prompted because no records of dust release are known to have been kept for the Cadiz-Bristol Playa area, nor of the surface condition of the Playa itself. The concept was to (1) be able to observe dust storms in progress to determine the dust source areas, and (2) determine whether surface salt efflorescence is present that has been implicated on strongly groundwater-coupled playas such as Owens (Saint-Amand et al., 1987) and Franklin Playas (Reynolds et al., 2007). Such salt efflorescence can be expected to follow rainy weather during the cooler season when the process of capillary supply is steady under a somewhat reduced evaporative driving force in cooler weather with higher relative humidity.

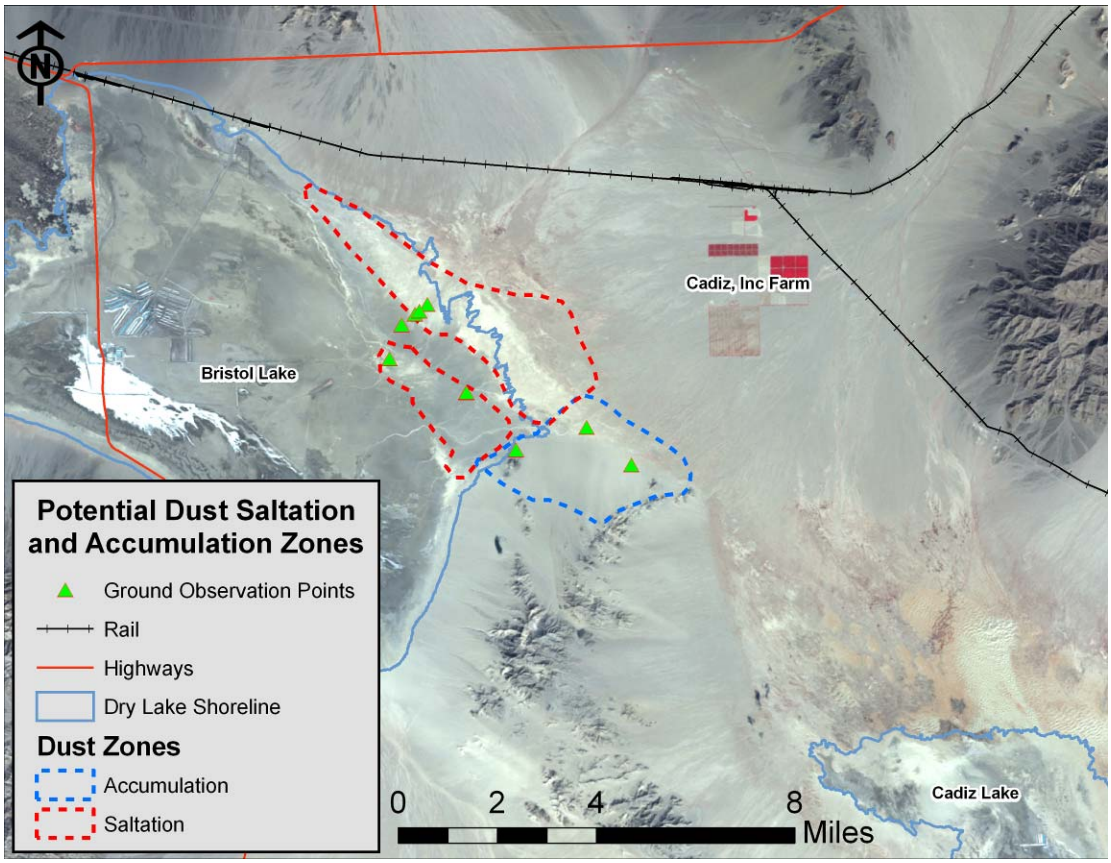
The period of this investigation was 2000 to present because the weather data to evaluate regional wind movement and rain were available, particularly from the USGS Balch station that was brought online in 2000. Nineteen satellite images were evaluated with eight chosen to evaluate possible dust storms during the satellite overpass hour when the measured wind at the USGS Balch Station were 12 miles per hour or greater. Thirteen images were selected for overpasses that fell within about two weeks of rainy periods that deposited at least one inch of rain as an average of the surrounding stations. This was the entire suite of cloud-free images corresponding to these conditions during the period of USGS Balch Station operation, except for one image from 1997 that occurred after a large rainstorm occurred in Barstow. One of the selected images served a dual purpose for both dust and rain effects. Wind and rain were averaged from records for the three weather stations whose locations are shown on Figure 1 to provide a regional perspective. The results from the evaluation of satellite data are presented in Appendix C.

Of the eight images analyzed for blowing dust, three contained visible traces of actual dust releases, an incidence of 38%. One hypothesis for why high magnitude wind did not cause higher incidence of blowing dust is that the winds near Bristol Playa were low. However, sustained high winds in the Mojave Desert are driven by frontal passage that affects the entire region as indicated by the averages of winds and rain from the three weather stations. Thus, even if high winds are present, special circumstances may be required to develop severe dust storms, likely including the breakdown of the weak crusting in re-deposited material that was evident during field work (Appendix B).

In two of the three dust images contained in Appendix C, the high levels of dust release were from the zone found to have deposited accumulations of fine textured soils. These deposits are shown on Figure 6 that was mapped from observations in the field and on satellite data. The boundaries on Figure 6 are only approximate. The saltation zone that extends into the Bristol Playa likely generates much less fugitive dust than the larger area mapped to the north, because the source of supply for saltating sand grains is from the opposite (northwestern) margin of the lake or from sand that was carried onto the Playa by wadis during storms that generated significant runon.

The Cadiz Playa showed extreme levels of dust blowing on one image, 11-25-2002 (Potential Dust Scene 2, Appendix C), with the dust occurring on the north half of the playa in the region where dunes were located upwind. This contrasts with the southern half of the playa which remained clear, underscoring the importance of sand erosion of the lakebed surface.

Figure 6. An interpretation of areas of saltation source and deposition. Boundaries are approximate. The dune field north of Cadiz Playa is also an accumulation but mostly of sand within dunes. The reddish color is from the growth of Russian thistle that tends to stabilize the sand within the dune field.



8. Sand Balance for the Bristol Playa

A number of observations lead to two hypotheses discussed below concerning the sand balance in the Cadiz Valley around Bristol Playa. These observations are:

- Coppice mound shapes around the northern Playa margin trend toward tall, narrow and oriented with their axes northwest to southeast, parallel to the dominant high magnitude wind direction. This is an indicator that the coppice mound shapes are ventifacts, eroded around there bases by saltating sand.
- Coppice mounds may not be undergoing replacement. Significant numbers of coppice mounds appear to be capped by dead shrubs and hence will not remain since coppice mounding requires the interaction of sand movement and new shrub growth. During field work, several young saltbush were observed; however, these were not accumulating their own sand reserves and stood on tap roots raised nearly a foot above the exposed Playa surface—thus suggesting that the surface on which they germinated, likely sand, was now gone. Although shrubs die of old age, about 20 to 40 years for a saltbush, the continued presence of shrubs is dependent upon recruitment. In this playa margin habitat, recruitment and

replacement of the older shrubs, in turn, depends upon collection of sand to form a coppice mound.

- Much of the Playa surface and its margins appear to be deflating. Erosional evidence (Point 8, Appendix B) was found that supported this interpretation.
- Handford (1982) described sediments derived from runon as being reworked by the wind to form barcan dunes around the Bristol Playa margins. These dunes are lacking today.
- In addition to dunes around the margin of the Bristol Playa, Handford (1982) also included a photograph of a barcan dune on the Bristol Playa. No such dunes exist today on the playa.
- The Achison, Topeka and Santa Fe Railroad planted athel trees along their railroad grade and siding adjacent to Bristol Playa. Such planting protects the tracks from dune formation and blowing sand (Trainweb, undated). In another locale prone to significant drifting sand, the Union Pacific railroad grade that passes the Kelso Dunes was also planted with athel trees. Today, there is no evidence of sand movement in the form of accumulation in the athel trees in Cadiz Valley.

The sand balance has apparently changed in the Cadiz Valley, especially around the Bristol Playa. This may derive from growth of weedy species that became naturalized during the past century. Two hypotheses are discussed as follows:

Hypothesis 1: Reduction in sand supply.

The Mojave Desert receives pulses of rain that are likely tied to the El Nino Southern Oscillation (ENSO). The wet pulses lasting a year to multiple years within this cycle enable runoff to potentially supply the new wave of sediments, including sand grains that play a dominant role in saltation and fugitive dust releases erosion. The precipitation analysis by CH2M Hill noted a trend of relatively dry conditions prior to the mid-1970s followed by relatively wet conditions since the mid-1970s (CH2MHill, 2010). The wet periods also foster the growth of introduced weeds, all germinating in the fall or early winter and growing through the winter including Mediterranean grass, Sahara mustard, filaree, red chess, and cheatgrass (Brooks, 2009). The weeds may form relatively intense ground cover, well above original cover of native species: this can hold sediments in place rather than allowing surface creep or entrainment. Thus, the supply of sand is now restricted due to the weedy species in the overlying catchment.

Hypothesis 2: Net export of sand due to lack of “backwash”.

To a certain extent, saltating sand was a resource that sloshed back and forth with winds, predominantly from the northwest but also from southeast through south that can push the sand back to the northwest. Now, however, another weedy species, Russian thistle (also known as tumbleweed) has colonized the dunes in the region surrounding Cadiz Playa. Thus, any sand that is moved toward the Cadiz Playa with the prevailing direction of the high winds (to the southeast), is trapped by the Russian thistle. Russian thistle provides active wind trapping

capability both when it is alive and also after it has died and tumbled, generally filling dune interspaces (Figures 7 and 8).

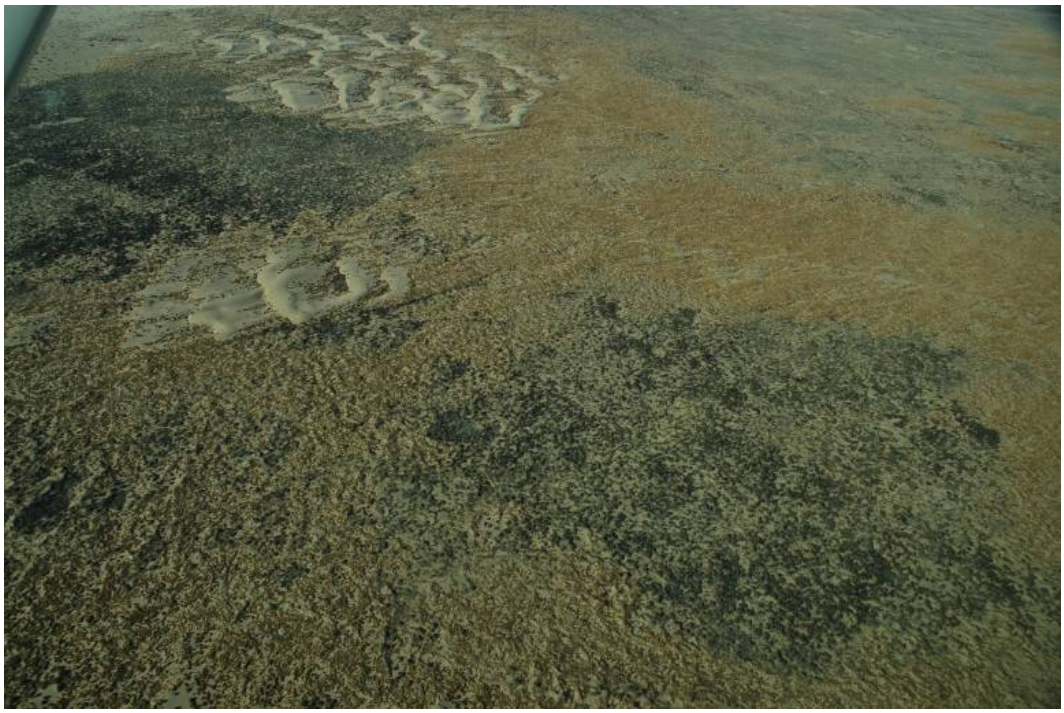


Figure 7. Photo 51 from the aerial overflight taken of a dune field near the NW corner of the Cadiz Playa 1500' above ground. The orange color is Russian thistle that grew during 2010. The dark color is patches of older weathered dead Russian thistle crowns that grew in situ or were tumbled in with the wind.

Figure 8. Photo 57 of the aerial overflight taken of the region to the northeast of Cadiz Playa. The orange coloration is the Russian thistle crop from 2010.

9. The Cadiz Playa Hydrology, Sedimentology, Sand and Dust

Formed in the same environment as Bristol Playa, Cadiz Playa has analogous hydrology and sedimentology, however, the surrounding catchments are much smaller and at lower elevation. Inflow of surface water is therefore potentially much less than on Bristol Playa. Surface flows delivered down Fenner wash apparently do not make it to the Cadiz Playa but are stopped within the sand dunes, ponding and promoting heavy Russian thistle growth leaving visible traces on the satellite imagery in Appendix C.

The Cadiz Playa was visited on the ground on August 23, 2011 to collect soil samples to confirm that the chemistry is equivalent to Bristol (dominated by Ca, Na, and Cl). The results from these samples are pending at the time of this report but are not expected to show that the Cadiz chemistry is dissimilar from Bristol. As can be clearly seen in Figure 8 the vegetation around the margin is not coupled with groundwater because the margin shows vegetation cover that is about the same as the regions upslope and away from the playa margin. By contrast, groundwater coupled vegetation is more verdant and lush compared to the surrounding desert vegetation—a condition lacking around the entire shore of the Cadiz Playa.

The Cadiz Playa region has become a sink for sand that has moved with prevailing high winds from the Bristol Playa region. For that reason, there is plenty of sand available to debride the surface during high winds. The majority of this sand is located in the north through northeast portions of the playa and theses zones apparently give rise to significant dust that erodes the surface of the playa (as seen in the 11-25-2002 (Potential Dust Scene 2, Appendix C).

10. Conclusions

- The chemistry of the Bristol Playa is low in carbonate, bicarbonate and sulfate ions that are implicated in other playas that produce major dust storms (such as Owens and Franklin Playas).
- Instead, this playa contains chemistry that has been noted to induce surface stability (Ca, Na and Cl). Cadiz Playa appears to have the same chemistry.
- Wind erosion from the Bristol Playa and immediate margins is driven by the supply of sand-sized particles that can saltate and debride the surface.
- Wetting by rainfall heals disturbances of the crust if erosion by sand grains has occurred.
- The cause of windborne dust from Bristol Playa is mechanical abrasion from saltating sand grains. This appears to be the case for Cadiz Playa as well.
- The Bristol Playa system has likely experienced a decrease in blowing dust during recent decades due to decreasing sand available for saltation and mechanical abrasion. The mechanism for this is hypothesized to be due to weedy species in the rainfall catchment above (decreasing sediment supply) and net export of sand to the region of the Cadiz Playa where it is stabilized by Russian thistle and cannot be blown back toward Bristol Playa.
- Cadiz Playa experiences the same processes.

11. Literature Cited

Brooks, M.L. 2009. Spatial and temporal distribution of nonnative plants in upland areas of the Mojave Desert. Pages 101-124, In Webb, R.H., Fenstermaker, L.F., and Heaton, JS, Hughson, D.L., McDonald, E.V., and Miller, D.M. (eds.) 2009. Mojave Desert: ecosystem processes and sustainability. University of Nevada Press, Reno, NV.

Bassett, A.M., Kupfer, D.H. and Barstow, F.C. 1959. Core logs from Bristol, Cadiz, and Danby Dry Lakes, San Bernardino County, California. USGS Bulletin 1045-D.

CSIL. 2005. California Spatial Information Library Cadiz Area Digital Orthophoto Quads. <http://www.atlas.ca.gov/download.html#/casil/imageryBaseMapsLandCover/imagery/cir_doqs_2005>. Acquisition Date: Summer 2005. Downloaded Nov 8, 2010.

CH2MHill. 2010. Cadiz groundwater conservation and storage project. Report prepared for Cadiz, Inc. by CH2MHill, Los Angeles California Office. July, 2010.
Gale, H.S., 1915. Salines in the Owens, Searles and Panamint Basins, southeastern California. U.S. Geological Survey Bulletin 580:251-323.

Gale, H.S., 1915. Salines in the Owens, Searles and Panamint Basins, southeastern California. U.S. Geological Survey Bulletin 580:251-323.

Gill, T. E. and Gillette, D. L. 1991, "Owens Lake: A Natural Laboratory for Aridification, Playa Desiccation and Desert Dust", *Geological Society of America Abstracts Programs* **23**: 462.

GBUAPCD. undated. Great Basin Unified Air Pollution Control District website description of Owens Lake and the dust control program. Available at http://www.gbuapcd.org/owenslake/index.htm (last accessed 29 November 2010).

GBUAPCD. 2010. Soils data compiled by Great Basin Unified Air Pollution Control District for the region around the Owens Lakebed (on file). Received December 6, 2010.

Groeneveld, D.P., Huntington, J.L. and Barz, D.D., 2010. Floating brine crusts, reduction of evaporation and possible replacement of fresh water to control dust from Owens Lake bed, California. *Journal of Hydrology* **392**:211-218.

Handford, C. R., 1982. Sedimentology and evaporite genesis in a Holocene continental-sabkha playa basin—Bristol Dry Lake, California. *Sedimentology* **29**:219-253.

Jayko, A.S. and Bacon, S.N., 2008. Late Quaternary MIS 6-8 shoreline features of pluvial Owens Lake, Owens Valley, eastern California, *in* Reheis, M.C., Hershler, R., and Miller, D.M., eds., Late Cenozoic Drainage History of the Southwestern Great Basin and Lower Colorado River Region: Geologic and Biotic Perspectives: *Geological Society of America Special Paper* **439**:185-206.

Reynolds, R.L., Yount, J.C., Reheis, M., Goldstein, H., Chavez Jr., P. Fulton, R., Whitney, J. Fuller, C., and Forester, R.M. 2007. Dust emissions from wet and dry playas in the Mojave Desert, USA. *Earth Surface Processes and Landforms* **32**:1811-1827.

Rosen, M.R. 1991. Sedimentologic and geochemical constraints on the evolution of Bristo Dry Lake Basin, California, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* **84**:229-257.

Trainweb. Undated. Amtrak Desert Wind Route Guide. Available at: http://www.trainweb.com/routes/route_35/rg_35old.htm. (Accessed 19 December 2010).

Saint-Amand, P., Mathews, L.A., Gaines, C., and Reinking, R. 1986. Dust storms from Owens and Mono Valleys, California. U.S. Naval Weapons Center, China Lake, California. Publication NWC-TP6731. 79pp.

Saint-Amand, P., Gaines, C., and Saint-Amand, D. 1987. Owens Lake, an ionic soap operas staged on a natric playa. Centennial field Guide Volume 1. Cordilleran Section of the Geological Society of America. 145-150. Available at http://www.gsajournals.org/perlserv/?request=get-specialpub-toc&isbn=0-8137-5401-1 (last accessed 29 November 2010).

Appendix A. Salt Chemistry, Salt Species, and Glossary of Terms.

Temperature controlled reactions resulting in windborne dust-prone surfaces:

$$\underline{Na_2SO_4 \cdot 10H_2O} \quad \leftrightharpoons \quad \underline{Na_2SO_4} + 10\ H_2O$$
Mirabilite ← 65°F → Thenardite

$$\underline{Na_2CO_3 \cdot 10H_2O} \quad \leftrightharpoons \quad \underline{Na_2CO_3 \cdot H_2O} + 9H_2O$$
Natron ← 50°F → Thermonatrite

$$\underline{Na_2CO_3 \cdot 10H_2O} + Na^+ + H^+ + CO_3^{=} \quad \leftrightharpoons \quad \underline{Na_3H(CO_3)_2 \cdot 2H_2O} + 8\ H_2O$$
Natron ← 50°F → Trona

Other salt species discussed in this report:

Halite: NaCl
Burkeite: (a complex salt of sulfate and carbonate): $Na_6(SO_4)_2(CO_3)$
Gypsum: $CaSO_4 \cdot 2\ H_2O$
Anhydrite: $CaSO_4$

Ecologic and Geomorphic Terms used in this report:

Aeolian: wind blown; moved by the wind.

Barcan dunes: a crescent shaped wind blown deposit of sand that moves with the prevailing wind. The steep face of a barcan dune is on the lee side.

Biome: region defined by similar climate and geography. Example: Mojave Desert

Coppice mound: dune-like mound of aeolian soil collected around single or multiple shrubs generally requiring decades to establish.

Debrided: a process whereby the surface is removed by wearing, used in this report to describe the wearing away of the surface by action of saltating sindblown sand grains.

Deflation: process whereby a soil surface is lowered through windborne loss of material.

Desert pavement: collection of larger particles that were too large and heavy to be moved by the wind, hence forming an armor to protect the surface from further blowing.

Fluffy surface: dry, easily wind-lofted salts supplied by capillarity and exemplary of playa environments on the Owens Lakebed and Franklin Playas.

Ecotone: transition from one type of environment to another e.g., the unvegetated Bristol Playa and the vegetated margins. Ecotones can occur abruptly or gradually.

Efflorescence: process involving upward capillarity of soil water that strands loose deposits salt crystals at the soil surface.

Phreatophyte: species that obtain a portion of their water supply from groundwater. Creosote bush and cattle saltbush ares not phreatophytes. Four-wing saltbush is a facultative phreatophyte, meaning it can benefit from but generally does not require shallow groundwater.

Playa: a fine texture-dominated flat pan often called a dry lake.

Puffy surface: (general term given specific meaning in this work); the gently heaved surface common on the Bristol Playa.

Saltation: (from Latin for jump) process whereby the wind imparts energy to a sand grain that then flies in an arc to strike the soil, impart energy to additional sand particles and erode and release fugitive dust. During a wind storm the process of saltation causes a cascading effect tending to increase as more particles are saltated.

Sand: any particle between 0.63mm and 2mm in size. Sand is the principle agent for wind erosion and comes in three recognized fractions: Coarse sand: 0.63 to 2mm, Medium sand: 0.2 to 0.63mm, and Fine sand: 0.063 to 0.2 mm.

Sorting: a process that is Aeolian or alluvial that selects for certain grain sizes. For example, dune sand is often of about the same grain size and is therefore, highly sorted.

Ventifact: an object such as a wood, rock or coppice mound that has been carved by the action of wind and entrained sand.

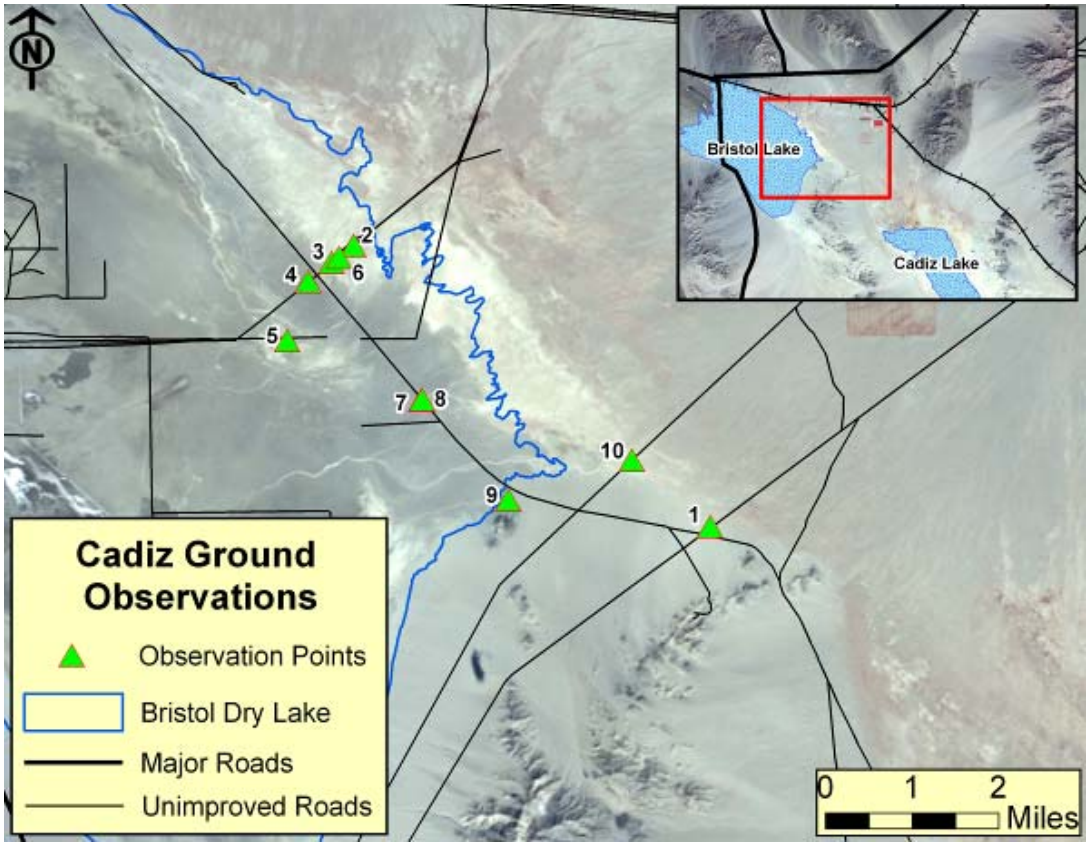
Wadi: dry wash that receives discharge from large rain events (often called flash floods).

Appendix B. Field Trip Photographs and Notes

An initial field trip was conducted on 11-9-2010 by vehicle with stops in areas of interest. A shovel was used to turn the soil to examine conditions in the top 20 cm. Notes were taken at each location. Two samples were taken at two locations, Points 4 and 5 (Figure B-1).

A second field trip was conducted to Cadiz Playa on 8-23-2011. Photos are included from that visit as Figures

Figure B-1. Points of interest visited during the ground portion of the field trip.



From field visit and comparison of the 10 points described below, it was apparent that:

(1) Shrub-occupied coppice mounds around the Bristol Playa are the source of sand that debrides the surface by saltation. The shrubby zone around the lake is generally the source area for saltating particles.

(2) The bare lakebed is not emissive unless debrided by windblown saltating sand grains. This mechanism is not directly related to the water table.

(3) Accumulation areas southeast of the Bristol Playa in the alluvial gap between it and Cadiz Playa can be a major source of dust. Weak surface crusting induced by rains can cause this zone to be protected for a while, suggesting that it takes a period of high winds to break down the crusting so that the surface becomes blowable. Once

this crust is removed, any high wind will likely create a large dust release, a condition that will last until reset by additional rainfall.

The field visit was conducted after a 20-day period of relatively warm and dry weather following rain events that totaled over an inch measured at the USGS Balch Station, 40 to 50 miles northwest of the Bristol Playa (Figure 1). Weather measured at USGS Balch is provided in Table B-1. Figure B-2 is a Landsat 5 scene from 10-30-2010.

Figure B-2. Image of the Bristol Playa and surrounding area 10 days before the field visit.

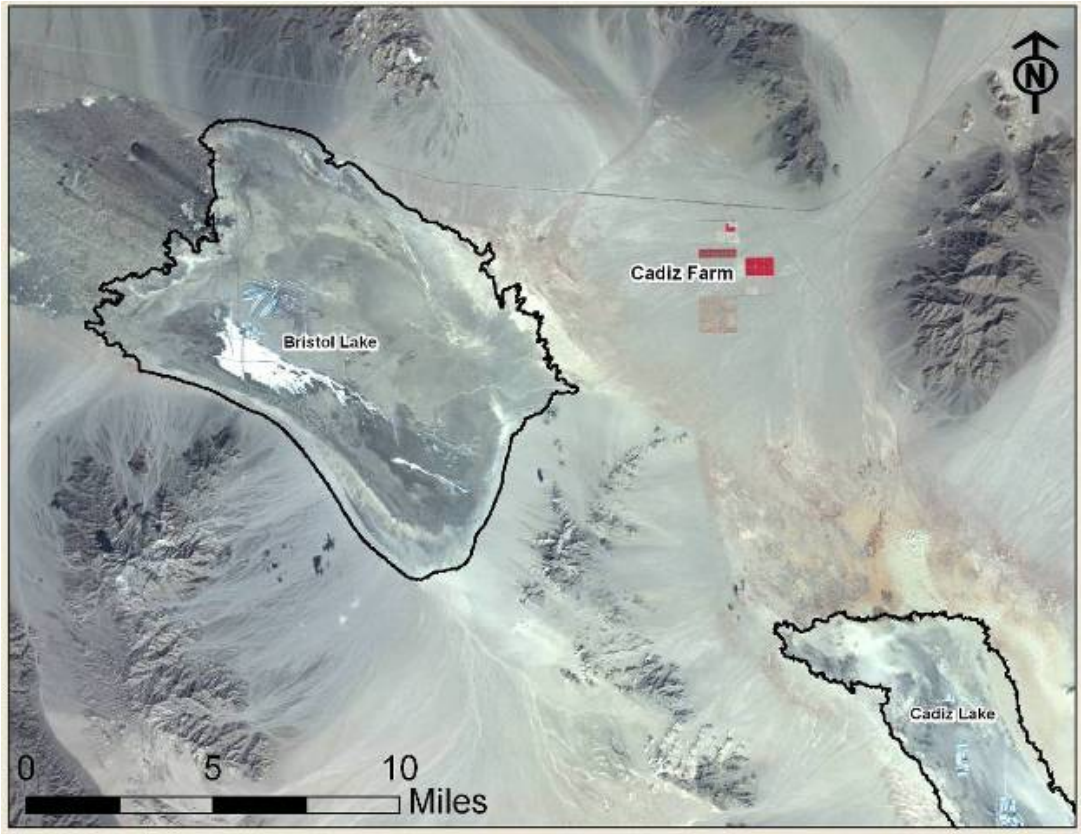


Table B-1. Weather measured at USGS Balch prior to field visit.

Date	Avg. T (°F)	Avg.Wind (mph)	Rain (in.)	LandsatTM Overpass	Date	Avg. T (°F)	Avg.Wind (mph)	Rain (in.)	LandsatTM Overpass
10/09/10	68	4	0		10/25/10	62	6.7	0	
10/10/10	72	3.5	0		10/26/10	56	3.7	0	
10/11/10	74	3.3	0		10/27/10	52	3	0	
10/12/10	76	3.7	0		10/28/10	54	3	0	
10/13/10	73	3.2	0		10/29/10	60	2.7	0.02	
10/14/10	73	3.2	0	X	10/30/10	59	9.1	0	X
10/15/10	79	4.3	0		10/31/10	56	3.4	0	
10/16/10	76	6.4	0		11/01/10	66	2.7	0	
10/17/10	71	4.1	0		11/02/10	64	3	0	
10/18/10	65	3.6	0.07		11/03/10	67	3.5	0	
10/19/10	64	2.7	0.59		11/04/10	66	3.7	0	
10/20/10	59	3.7	0.38		11/05/10	66	2.6	0	
10/21/10	62	6.6	0		11/06/10	66	4.6	0	
10/22/10	62	8.9	0		11/07/10	59	5.7	0	
10/23/10	63	10.9	0		11/08/10	54	11.1	0	
10/24/10	65	13.4	0		11/09/10	48	3.3	0	

Point 1. Downwind (SE) of the Bristol Playa. This is an area of strong Aeolian deposition where features suggestive of historic coppice mounds in the foreground have been buried. The material is very loose and high in silt content and was covered by larger, sorted, sand and gravel particles showing an incipient desert pavement. Shovels of dry soil thrown into the air generated significant dust. The surface horizons are lightly armored to about 2 cm deep by easily frangible crusting likely resulting from the one inch of rain that fell almost 3 weeks before. Remnants of weedy annual vegetation are visible.

Point 2. Coppice mounds formed at the base of a saltbush. Patches of coarse sand and some gravel have been sorted by high winds. Small dunes partially armored by this desert pavement are visible toward the left of the photo.

Point 3. At the ecotone between the unvegetated playa and the shrub vegetation higher upgradient. Note the coppiced shrub mounds in the background. The soil was puffy, pushed up by crystal pressure from below. The coppice mounds appeared to be undergoing active erosion as indicated by aspect (very tall) indicating erosion around their bases. No loose sand was visible.

Point 4. Puffy lakebed sediments on the playa beyond the shrub ecotone. The surface here resembled Points 3 and 5 with granular material below a 2cm thick crust that was moist with very slight salt efflorescence at the surface. A soil sample from this location was very high in Na (9.25%), and Cl (8.1%) with relatively low SO_4 (0.96%)—other constituents are silica minerals. No loose sand was visible.

Point 5. Puffy soils further out onto the barren Playa. The soil sample taken from the surface here was highest in Na (2.95% and Cl (1.91%) but also contained comparative levels of SO_4 (1.15%). Some medium fine sand was visible.

Point 6. This site was located after backtracking from Points 3, 4, and 5 to view more of the shrub vegetation in the ecotone region. This location is notable because of the apparent deflation to a buried clayey horizon that has characteristics of the surfaces at Points 3, 4 and 5. Coarse sand grains winnowed by high winds are visible on the surface. Note the dead shrub in the left foreground.

Point 7. Obvious deflation around a coppice mound. This location is in a wadi drained from the adjacent Playa margin about 500 m away. The coppiced saltbush in the foreground has been debrided around the base indicating a maximum saltation height of about 30 cm.

Point 8. Located about 50 m to the southwest of Point 7 and on the edge of the wadi. Obvious surface erosion features are present. This same pattern can be seen around the shovel shown at Point 7. The substrate is mostly silt and clay, so any erosion such as can be seen here generates fugitive dust.

Point 9. Volcanic hills located on the downwind margin of the Bristol Playa. The light colored deposits are highly sorted medium sand deposited by wind action. The inset shows these features at a distance.

Point 10. Accumulation area located northwest of and similar to the depositional area at Point 1. Beneath a weak crust extending about 1 cm deep, the soil was loose, silty and easily lofted. Note the loss of numerous coppice mounds in the foreground through background.

Point 11. Cadiz Playa from a location between the saltworks visible on the Appendix C Potential Dust Scenes 2. Landsat TM5 Image 11/25/2002. This surface is analogous to Bristol Playa at Points 4, 5 and 7.

Point 12. Cadiz Playa to the south of the southernmost salt works. The surface of this site is analogous to Point 11 and the mentioned Bristol Playa Points. This site was where Cadiz Playa sample 2 was obtained.

Appendix C. Observation of Satellite images

Nineteen Landsat TM satellite images were chosen for evaluation of the surface conditions on the Playa and Playa margins chosen for the period 2000 to present. This period was chosen because it coincides with wind and rainfall data available from the USGS Balch station. Two factors were of interest in this investigation (1) images of blowing dust and (2) images of the lakebed to determine whether efflorescence was occurring. To evaluate blowing dust, images were selected from days that had 12 mph average windspeed in the hour of the satellite overpass measured at the USGS Balch Station. To evaluate efflorescence and ponding effects, images were chosen following precipitation periods of one inch or more within two weeks. Eighteen images represent the entire suite of Landsat TM and Aster satellite images that occurred during the wind and rainfall conditions desired within the 10-year window.

Evidence for blowing dust was considered to be a plume that occluded or softened the ground features that it overlay. Evidence of efflorescence was taken to be a generally whitening of the surface. Table D-1 lists the images chosen to evaluate the presence of either blowing or efflorescence.

Potential days for examination of blowing dust and wetting effects were selected using data acquired from the USGS Balch, CIMIS Barstow, and CIMIS Blythe NE weather stations located within 40, 70, and 75 miles, respectively of the Bristol Dry Lake (Figure 1). To account for spatial variability of rain, data were combined and averaged between the stations. Average daily wind speeds were identified for the hour of the overpass and matched with corresponding LandSat TM5 overpass dates of the Cadiz Basin area. We estimated minimum threshold wind speed values based on previous work on emissive dry lakes and documented dust blowing dates on the Cadiz and Bristol Dry Lakes. A threshold average daily wind speed value of 12 mph was set and matched with LandSat overpass dates. All selected satellite scenes were downloaded and analyzed in false color for the occurrence of dust emission. Due to the 16-day temporal resolution of the imagery and the hourly variability in dust storms, few scenes captured active dust emissions.

The potential efflorescence scenes were selected in a similar manner by combining precipitation data from surrounding weather stations. Precipitation data from the same USGS Balch and CIMIS stations were used to identify wet periods prior to a LandSat TM5 overpass. Both large single-day, and small multiple-day storms were selected and matched with a following LandSat TM5 overpass date. Due to the generally low rainfall of the region, threshold values were informal, and scenes were selected if at least an inch of rain fell within the region during the two weeks leading up to a LandSat TM5 overpass. One exception to this scheme was from 11-12-2003 that was selected because 0.63 inch fell during that day. An image was also include from 10-10-1997 (prior to operation of Balch) because a large amount of rainfall had occurred regionally in immediate past (9.09 inches in Barstow and 0.68 inches in Blythe on 9-25-97)

Of the eight scenes chosen for analysis of blowing dust, three 3 were positive and of these, one (11-25-2002) showed very small amounts of dust released from the Bristol

Playa despite evidence of significant wind movement (25.6 mph measured at USGS Balch during the overpass, and sever dust that was released from the Cadiz Playa due to movement of the sand across the playa that was stored in the dunes. The role of sand in creating dust from the playa is confirmed with this image because the southern half of the playa, lacking upwind sand deposits is clear of dust.

Table D-1. Images evaluated for blowing dust or rain effects on the playa. Images coded for evaluating windborne dust are coded buff, rain as blue and for the co-occurrence of both, as red. average wind during the hour of the overpasses measured at USGS Balch and 2-week antecedent rain and are listed for each image. The October 30, 2010 scene was used to evaluate both potential dust and efflorescence.

2001	Condition	2002	Condition	2003	Condition	2004	Condition	2005	Condition
3/11	1.01 in.	4/15	18.2 mph	2/25	1.19 in.	8/26	1.43 in.	2/11	1.13 in.
3/27	1.1 in.	9/22	3.99 in.	4/14	1.05 in.				
11/22	13.5 mph	11/25	25.6 mph	11/12	0.63 in.				

2006	Condition	2007	Condition	2008	Condition	2009	Condition	2010	Condition
2/23	1.13 in.	4/12	23.5 mph	3/14	17.9 mph	4/2	1.1 in.	10/30	14.5 mph
				3/30	13.5 mph	10/27	19.2 mph		1.05 in.

The two scenes that show significant dust release from Bristol Playa are from 4-12-2007 and 10-27-2009. In both scenes, the highest magnitude dust released was from an area of accumulation (observed during the field trip as Points 1 and 10—Appendix B). The image from 4-12-2007 is clearer than the 10-27-2009 image because it lacks high clouds and it shows a much more severe dust storm in progress (and the 10-27-2009 image is generally supportive of the same areas viewed on 4-12-2007). The dust being released from the accumulation areas can be seen to emanate directly from the ground source, while the plumes that are visible over the Playa, itself, are raised above the Playa, indicating that this is not the source of the visible plume. Examination of the small water droplet cloud sitting over the Bristol Playa in this scene can be used to gage the height of the dust plume, itself creating a shadow. The length of the shadow of the dust plumes approaches, but is less than the height of the cloud, thus, the dust plumes are lifted significantly off of the Playa below but not as high as the cloud.

From the examination of dust releases and the wind speeds measured at the USGS Balch Station, the threshold velocity for dust entrainment appears to be around 20 mph. This is an imperfect comparison because of few days recording blowing dust and the 50-mile distance of the USGS Balch Station. Still, most strong continuous winds in the Mojave Desert tend to be the product of regional-scale phenomena driven by frontal passage.

The images chosen to examine whether or not salt efflorescence occurs show that this mechanism for creation of fugitive dust is extremely limited. Only one of the images, 4-02-2009, showed the surface becoming light in a pattern suggestive of salt efflorescence. Efflorescence is important because in the systems that are prone to dustiness, pervasive whitish salt efflorescence is a common feature, particularly following rainy weather when upward capillarity can carry the salts back to the surface where they are stranded as the

water molecules evaporate. Hence, if the 4-02-2009 image is indicative, this incidence is only 1in 12, or 8% (including the 10-10-1997 image). Counting this image as efflorescent, however, is not correct in comparison to Owens Lake where salt efflorescence during the winter can generate a snow white salt crust on multiple square-mile areas of the lakebed.

From examination of the satellite imagery, it can be concluded that:

(1) Significant dust releases occur from areas of accumulation identified during the field visit. The accumulation is from particles debrided off of the Playa and its margins by saltating sand grains. Areas of accumulation exist in a zone to the southeast of where the dust is initially generated. Dunes are zones of accumulation on the north through northeast margin of the Cadiz Playa.

(2) High winds (of 20 mph or greater) alone may be insufficient to cause the release of dust. This may be the result of weak surface crusting that has occurred due to recent rains a condition that can be broken down under high winds and the energies imparted by saltating sand grains.

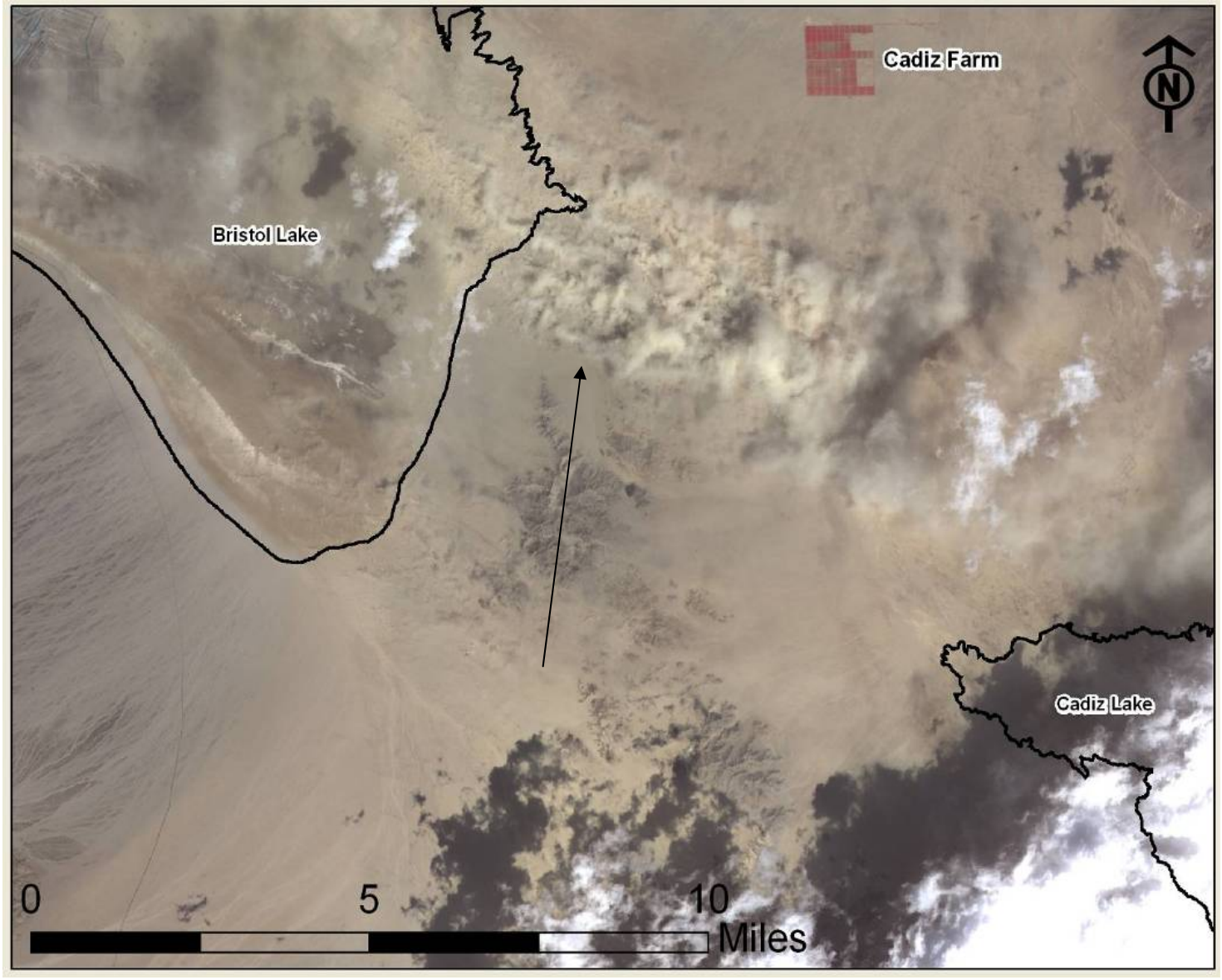
(3) both Bristol and Cadiz Playas are non-emissive unless sand is provided for saltation that debrides the surface where it tracks across with the wind.

(5) Significant rainfall appears to create only small amounts of surface ponding on the Bristol Playa. This suggests that the Playa absorbs rainfall and runon rather than causing long-term ponding. Cadiz

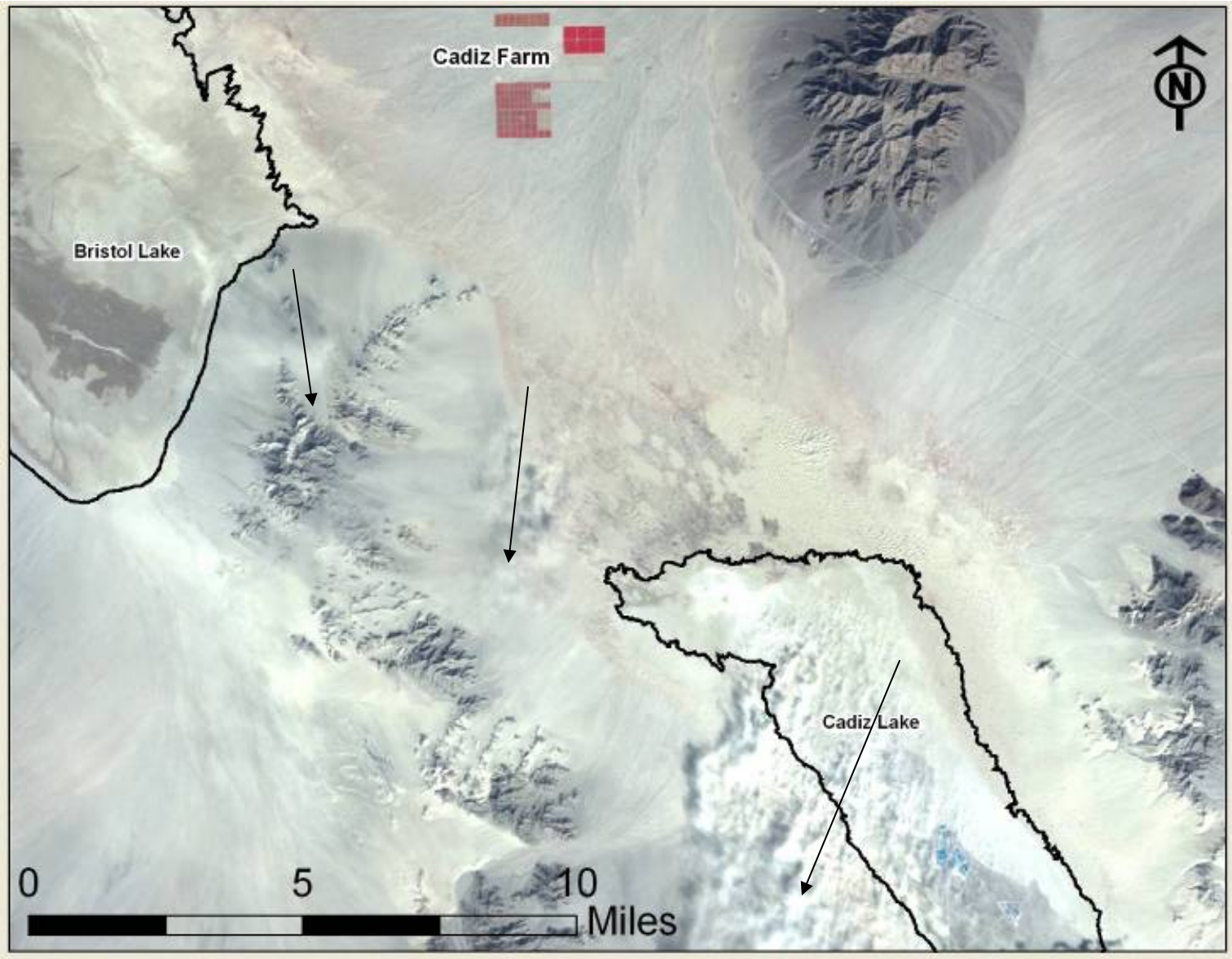
(6) Playa is much drier than Bristol Playa and has little evidence of runon from the surrounding catchments. Flooding from Fenner Wash is trapped in the dunes and does not reach the Cadiz Playa.

(y) Little to no rain-capillarity-evaporation-driven salt efflorescence appears to be part of the dust release cycle from either playa. Hence, the dust from these playas is solely a factor of the energy imparted upon the surface by wind velocity through the action of saltating sandgrains. The majority of the dust released is, therefore, silica minerals rather than salts.

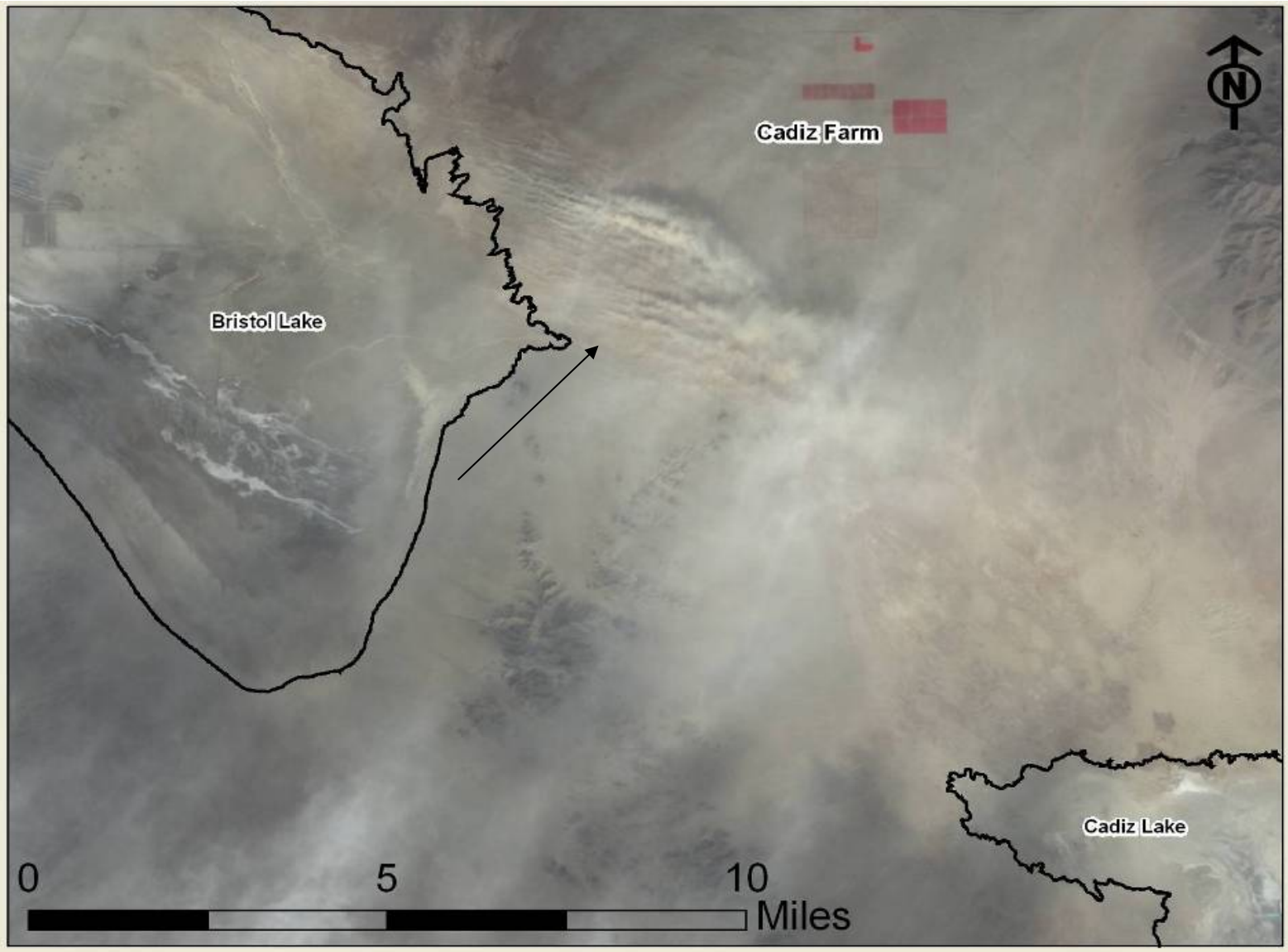
Potential Dust Scenes 1. Aster Image: 4/12/2007. Average windspeed during the hour of the overpass was 23.5 mph (at USGS Balch). Arrow shows dust plumes. Note the color difference for clouds of dust particles (buff colored) and those of water droplets (white or grayish).



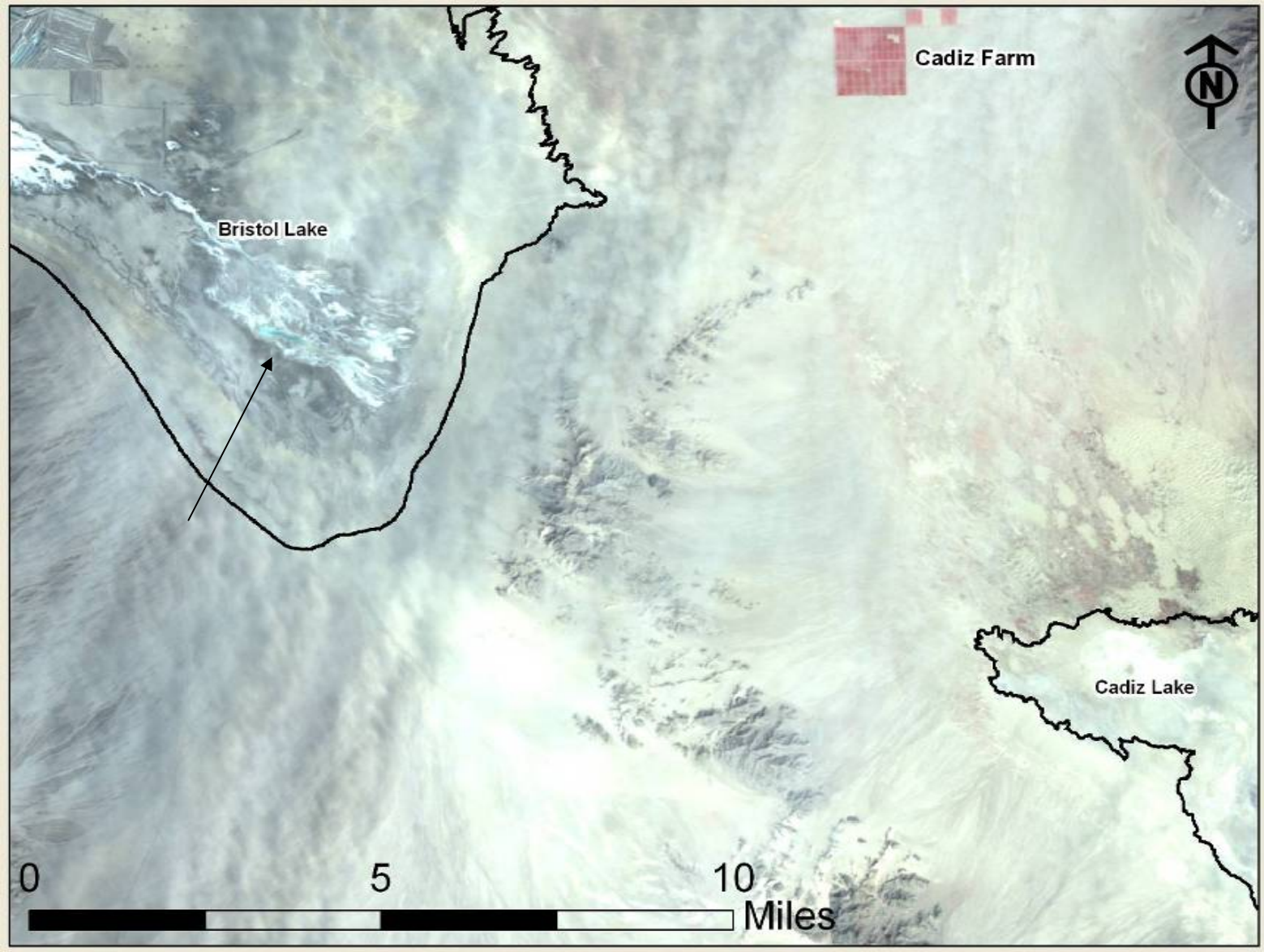
Potential Dust Scenes 2. Landsat TM5 Image: 11/25/2002. Average wind speed during the hour of the overpass was 25.65 mph (at USGS Balch). Arrows show dust plumes and their apparent direction of travel. The wind is apparently from north as can be seen in the dust leaving the Cadiz playa. The north half of Cadiz playa may be impacted by the huge reservoir of sand on the north and northeast margin.



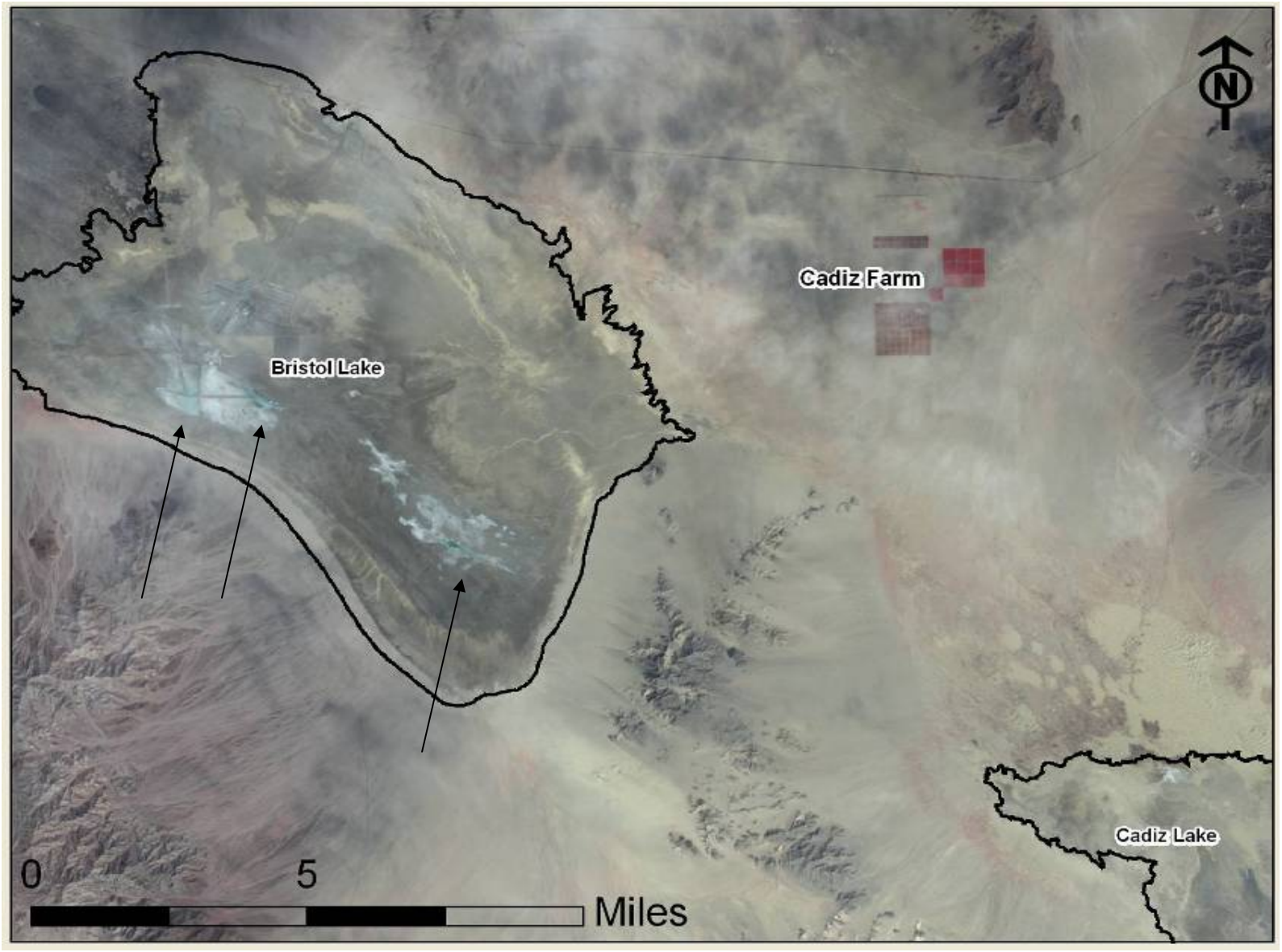
Potential Dust scenes 3. Landsat TM5 image: 10/27/2009. Average wind speed during the hour of the overpass was 19.2 mph (at USGS Balch). A high level cloud crosses the middle of this scene from SW to NE. The arrow indicates dust released from the accumulation area (Figure 6) The long tendrils of dust cloud are indicative of stripes of saltating particles.



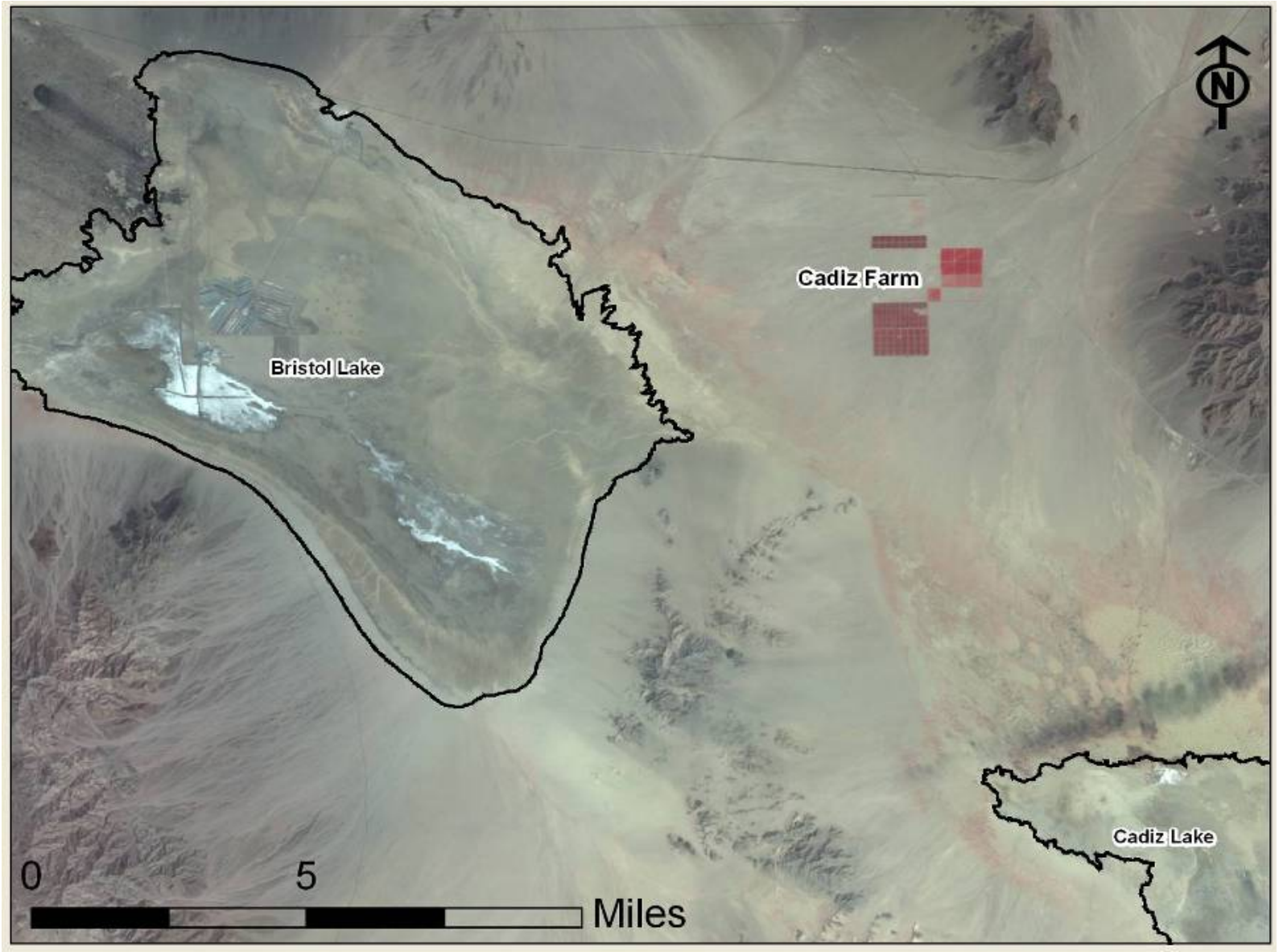
Potential Efflorescence Scenes 1. Landsat TM5 Image: 10/10/1997. 9"rain in previous 2 weeks at Barstow and 0.68 inches at Blythe (see Figure 1). Arrow shows surface ponding. Significant thin water droplet clouds are present in this image



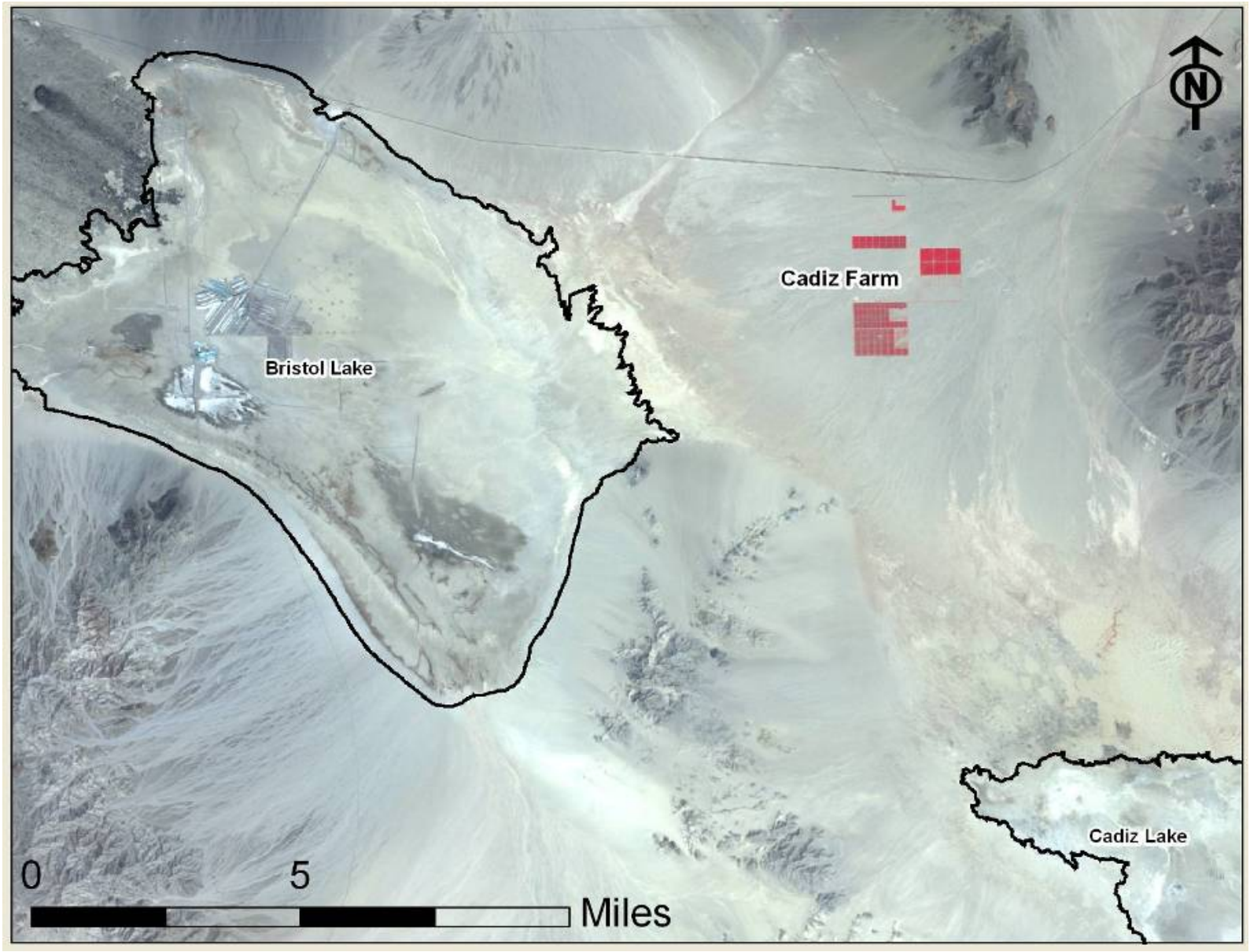
Potential Efflorescence Scenes 2. Landsat TM5 Image: 3/11/2001. 1.4" rain in previous week (average of all three stations shown on Figure 1). Restricted areas of turquoise on the Playa are ponded surface water (arrows). Clouds (thin) and shadows are present in this image.



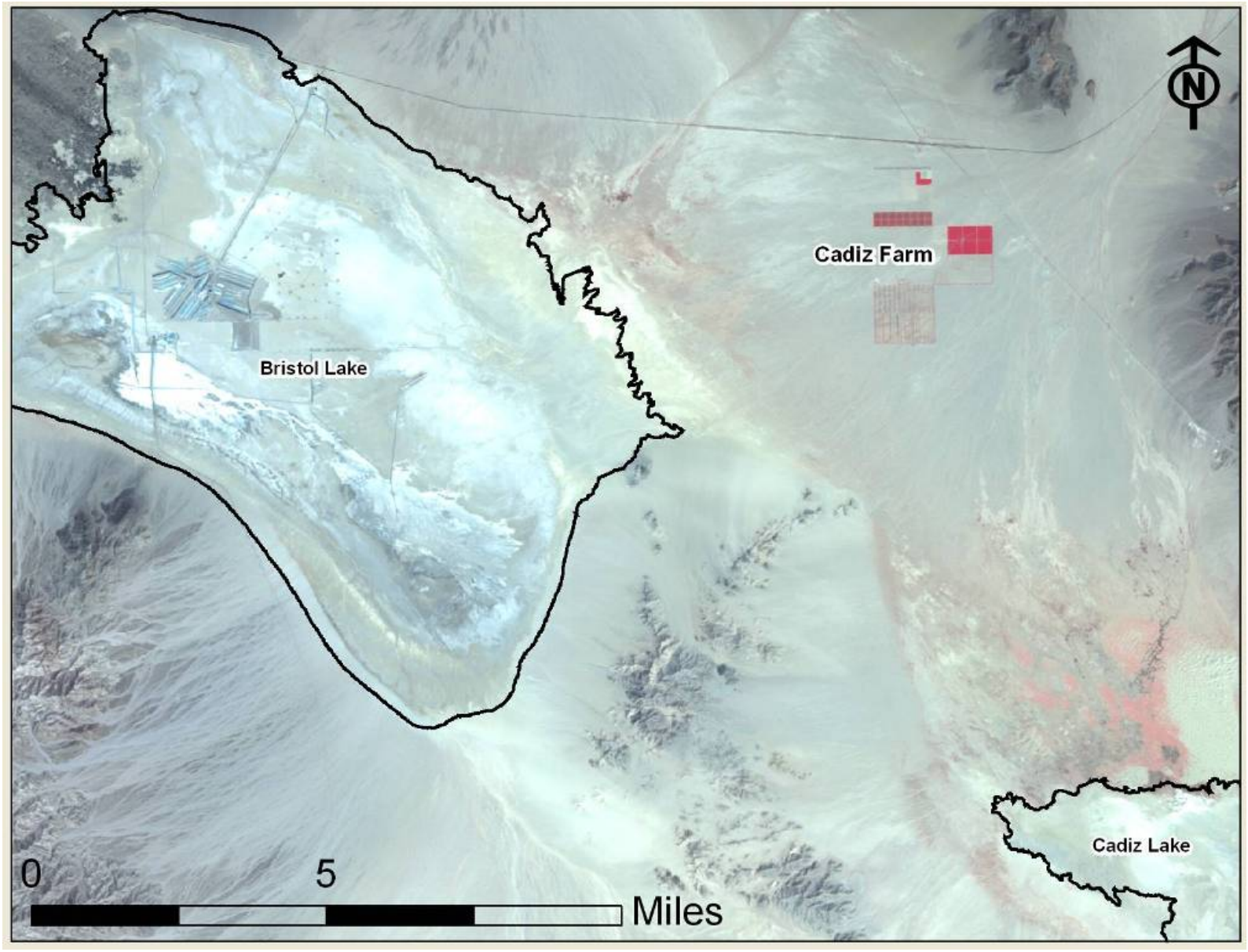
Potential Efflorescence Scenes 3. Landsat TM5 Image: 3/27/2001. Ponding is gone in this scene taken 16 days after Scene 2.



Potential Efflorescence Scenes 4. Landsat TM5: 8/26/2004. 1.4" rain in previous week (average of all three stations shown on Figure 1). Turquoise indicates surface ponding.



Potential Efflorescence Scenes 5. Landsat TM5: 4/2/2009. Possible Efflorescence. Little rain was recorded at surrounding Met stations (Figure 1). The bright red adjacent to the Cadiz Playa is a vigorous cover of Russian thistle.



HydroBio
Advanced Remote Sensing

Memorandum, September 8, 2011
To: Tom Barnes, ESA
From: David P. Groeneveld, Ph.D.

RE: Results from Soil Samples Acquired from Cadiz Playa

Attached are the results for two soil samples obtained from Cadiz Playa. The purpose for this sampling was to determine the chemistry of this playa in comparison to the Bristol Playa and with relationship to the potential for Cadiz Playa to become a dust source if the water table were to decline. Sample 1 was taken near the north end of the Tetra Chemical workings and Sample 2 was taken from the region of the south end of these workings.

The results show a playa soil that is dominated by sodium calcium cations and chloride ions. Sulfate is present at higher concentrations than at the Bristol Playa. Carbonate and bicarbonate are present at very low concentrations. The relative concentration and species of salts confirms that dust releases such as occur at Owens Lake will not occur from Cadiz Playa.

As described in other reporting, dust that arises from either Bristol or Cadiz is due to the energy imparted by saltating sand grains and this process will not be affected if depth to water changes within the region.

IAS Laboratories
2515 East University Drive
Phoenix, Arizona 85034
(602) 273-7248
Fax (602) 275-3836

Date: September 8, 2011

Submitted by: HydroBio

Report To: Scott Murray

Report #: 6641368

Date Received: September 1, 2011

SOIL ANALYSIS

		*	*	*	**	***	***
Sender ID	**Lab ID**	**Ca %**	**Na %**	**SO4 %**	**Cl %**	**Carbonate %**	**Bicarbonate %**
Cadiz 1	950	0.77	8.38	1.25	3.27	0.044	0.39
Cadiz 2	951	1.16	4.34	1.00	1.09	ND	0.017

* Sample dissolved in DI water on a 5:1 ratio and analyzed on ICP.
**Probe analysis
***Methods of Analysis for Soils, Plants and Waters. Chapman and Pratt, 1961. p22.

ND means None Detected

Operational Mobile Source Emissions

	Grams/mile				
YEAR	**ROG**	**CO**	**NOx**	**CO_2**	**PM_{10}**
2012	0.241	3.638	2.475	581	0.085

Assumed average speed of vehicles type to be 55 mph to and from the project site.

Paved Road	
Entrained PM lbs/VMT	
PM_{10}	**$PM_{2.5}$**
0.0031	0.0002

EMISSIONS CALCULATION FOR ON-ROAD VEHICLES DURING OPERATIONS

Emissions = Vehicle Type x Emission Factor x Miles/Trip x Trips/Day

Miles/day
60

	Emission Factors					
	ROG	**CO**	**NOx**	**CO_2**	**PM_{10}**	**$PM_{2.5}$**
2012 emissions (grams/mile)	0.241	3.638	2.475	581	0.085	0.084
2012 emissions (pounds/mile)	5.31E-04	8.02E-03	5.46E-03	1.28E+00	1.87E-04	1.86E-04
Mobile Source Emissions (lbs/day)	0.03	0.48	0.33	76.85	0.01	0.01
Mobile Source Emissions (tons/yr)	0.006	0.088	0.060	12.721	0.002	0.002

Dust

	PM_{10}	**$PM_{2.5}$**
lbs/day	0.19	0.01
tons/year	0.03	0.002

Provided by applicant: Less than 3 trips per day, 20 miles each ~ 60 miles/day

Construction GHG Emissions amortized over 30 years

	Tons from URBEMIS	Metric Tons	Amortized metric tons
Pipe	4547.21	4125.16	137.51
Wells	5186.45	4705.07	156.84
Storage	1925.73	1746.99	58.23
Total	**11659.39**	**10577.23**	**352.57**
Worker Trips		1703	57
Total		**12280**	**409**

Construction Worker Mobile Emissions Year 2012

	Grams/mile				
YEAR	**ROG**	**CO**	**NOx**	**CO_2**	**PM_{10}**
2012	0.241	3.638	2.475	581	0.085

Assumed average speed of vehicles type to be 55 mph to and from the project site.

Paved Road	
Entrained PM lbs/VMT	
PM_{10}	**$PM_{2.5}$**
0.0031	0.0002

EMISSIONS CALCULATION FOR ON-ROAD VEHICLES DURING CONSTRUCTION ACTIVITIES

Emissions = Vehicle Type x Emission Factor x Miles/Trip x Trips/Day

Miles/day
8029

	Emission Factors					
	ROG	**CO**	**NOx**	**CO_2**	**PM_{10}**	**$PM_{2.5}$**
2012 emissions (grams/mile)	0.241	3.638	2.475	581	0.085	0.084
2012 emissions (pounds/mile)	5.31E-04	8.02E-03	5.46E-03	1.28E+00	1.87E-04	1.86E-04
Mobile Source Emissions (lbs/day)	4.27	64.40	43.81	10284.13	1.50	1.49
Mobile Source Emissions (tons/yr)	0.779	11.752	7.995	1702.306	0.275	0.272

Dust

	PM_{10}	**$PM_{2.5}$**
lbs/day	24.99	1.42
tons/year	4.56	0.260

From Project Description Worker Trips

	Well	**Pipeline**	**Storage**	**CRA**
Mobilization Daily	100	2500	1000	1000
Commute once a week	6000	10000	4000	4000
Commute divided by 7	857.14	1428.57	571.43	571.43
Total daily miles	957	3929	1571	1571

8029 Total project trips

Basic Info and Equations from Another CTG (Combustion-Turbine Generator) Analysis
(http://www.energy.ca.gov/sitingcases/elsegundo_amendment/documents/owner/Appendices/3.1-A1_Air_Emission_Data.pdf)

Standard Conditions Assumed: 29.92 inches Hg and 68 degrees Fahrenheit
Emission Factor (lb/MMBTU) = (ppmvd)*(MW)*(1/SMV)*(20.9/5.9)*(Fd)*(1/1E6)
where,
controlled ppmvd = controlled concentration corrected to 15% O2
MW = molecular weight (lb/lb-mol)
SMV = specific molar volume at 68 degrees Fahrenheit = 385.3 dscf/lb-mol
Fd = dry oxygen F-factor for natural gas = 8,710 dscf/MMBTU at 68 degrees Fahrenheit

Emission Factors for CO, NOx, and VOC incorporate SCAQMD BACT Guidelines for Gas Turbines
(Pollutant Conc. Controlled from BACT Guidelines, Part D: BACT Guidelines for Non-Major Polluting Facilities)

Pollutant	Pollutant Conc. Controlled (ppmvd)	Molecular Weight (lbs/lb-mole)	Specific Molar Volume (dscf/lb-mole)	Dry Fuel Factor (dscf/MMBTu)	Emission Factor Controlled (lb/MMBTu)
CO	6.0	28	385.3	8710	0.0135
NOx	2.5	46	385.3	8710	0.0092
VOC	2.0	16	385.3	8710	0.0026

Emission Factors for PM10 and CO2 are from AP-42 since there are no BACT Guidelines for Gas Turbines
(AP-42 Chapter 3, Section 3.1: Stationary Gas Turbines)

Pollutant	Emission Factor Uncontrolled (lb/MMBTu)
PM10	0.0066
CO2	110

Calculations for Project Emissions from natural gas used by the project

Project Name: Cadiz

Pump station operations requires		22,000,000	kWh/year	
Wellfield operations requires		30,800,000	kWh/year	
Total operations requires		52,800,000	kWh/year	
For natural gas use pump station requires		73,333,333	kWh/year	Factoring 30% efficiency
For natural gas use wellfield requires		77,000,000	kWh/year	Factoring 40% efficiency
Total operations with NG requires		**150,333,333**	kWh/year	
1	kWh equals	3,412	BTU	
Pump station		250,213,333,333	BTU	
Wellfield		262,724,000,000	BTU	
Operations requires		512,937,333,333	BTU/year	
1	MMBTU equals	1,000,000	BTU	
Operations requires		512,937.33	MMBTU/year	
Operations requires		1,405.31	MMBTU/day	

Pollutant	**Emission Factor**	**Emission per day**	**Emission per year**	**lbs/day**	**lbs/day**
	lb/MMBTU	**lbs/day**	**tons/year**	**Pump Station**	**Wellfield**
CO	0.013	18.91	3.450	9.22	9.68
NOx	0.009	12.94	2.362	6.31	6.63
VOC	0.003	3.60	0.657	1.76	1.84
PM_{10}	0.007	9.28	1.693	4.52	4.75

Conversion Factors

1	ton equals	2,000	lbs
1	g equals	0.001	kg
1	kg equals	0.001	metric tons
54.01	kg CO_2/MMBTU equals	0.054	metric tons/MMBTU
0.1	g N_2O/MMBTU equals	0.0000001	metric tons/MMBTU
1	g CH_4/MMBTU equals	0.000001	metric tons/MMBTU

Gases	Emission Factor	GHGs	CO_2 equivalent	CO_2 Equivalent
	metric tons/MMBTU	metric tons/year	factor	Emissions (metric tons)
CO_2	0.054	27703.75	1	27703.75
nitrous oxide (N_2O)	0.0000001	0.05	296	15.18
Methane (CH_4)	0.000001	0.51	23	11.80
			Total GHG	**27731**

Source: U.S. Energy Information Administration, *Voluntary Reporting of Greenhouse Gases Program*
http://www.eia.doe.gov/oiaf/1605/coefficients.html

Calculations for Project Emissions from natural gas used by the project

Project Name: Cadiz

Pump station operations requires		22,000,000	kWh/year	
Wellfield operations requires		50,700,000	kWh/year	
Total operations requires		72,700,000	kWh/year	
For natural gas use pump station requires		73,333,333	kWh/year	Factoring 30% efficiency
For natural gas use wellfield requires		126,750,000	kWh/year	Factoring 40% efficiency
Total operations with NG requires		**200,083,333**	kWh/year	
1	kWh equals	3,412	BTU	
Pump station		250,213,333,333	BTU	
Wellfield		432,471,000,000	BTU	
Operations requires		682,684,333,333	BTU/year	
1	MMBTU equals	1,000,000	BTU	
Operations requires		682,684.33	MMBTU/year	
Operations requires		1,870.37	MMBTU/day	

Pollutant	Emission Factor lb/MMBTU	Emission per day lbs/day	Emission per year tons/year	lbs/day Pump Station	lbs/day Wellfield
CO	0.013	25.16	4.592	9.22	15.94
NOx	0.009	17.22	3.143	6.31	10.91
VOC	0.003	4.79	0.875	1.76	3.04
PM_{10}	0.007	12.34	2.253	4.52	7.82

Conversion Factors

1	ton equals	2,000	lbs
1	g equals	0.001	kg
1	kg equals	0.001	metric tons
54.01	kg CO_2/MMBTU equals	0.054	metric tons/MMBTU
0.1	g N_2O/MMBTU equals	0.0000001	metric tons/MMBTU
1	g CH_4/MMBTU equals	0.000001	metric tons/MMBTU

Gases	Emission Factor	GHGs	CO_2 equivalent	CO_2 Equivalent
	metric tons/MMBTU	metric tons/year	factor	Emissions (metric tons)
CO_2	0.054	36871.78	1	36871.78
nitrous oxide (N_2O)	0.0000001	0.07	296	20.21
Methane (CH_4)	0.000001	0.68	23	15.70
			Total GHG	**36908**

Source: U.S. Energy Information Administration, *Voluntary Reporting of Greenhouse Gases Program*
http://www.eia.doe.gov/oiaf/1605/coefficients.html

Greenhouse Gas (GHG) Emissions Calculations

Project Name: cadiz

Indirect Greenhouse Gas (GHG) Emissions from Project use of Electricity (Power Plant Emissions)

	Pump	30,800,000
	Well 100 AFY	22,000,000
Estimated Project Annual Electrical Use		**52,800,000** kWh (kilowatt hours)/year
		52,800 MWh (megawatt hours)/year

Indirect GHG gases	Emission Factor lb/MWh	Annual Project Electricity MWh	Annual GHGs metric tons	CO_2 Equivalent Factor	Annual CO_2 Equivalent Emissions (metric tons)
Carbon Dioxide (CO2)	641.26	52,800	15,358	1	15,358
Nitrous Oxide (N2O)	0.0037	52,800	0.1	296	26
Methane (CH4)	0.0067	52,800	0.2	23	4
		Total Indirect GHG Emissions from Project Electricity Use=			**15,388**

Total Annual Greenhouse Gas (GHG) Emission from Project Operations -- All Sources (CO2 equivalent Metric Tons)

Electrical Use	**15388**
Total=	**15,388**

Notes and References:

Total Emissions from Indirect Electricity Use
Formula and Emission Factor from The California Climate Action Regiustry Report Protocol
Reporting Entity-wide Greenhouse Gas Emissions 2008
Pg. 33 (CCARRP) gives Equations

Pg. 36 (CCARRP - April 2008 update) gives CO2 output emission rate (lbs/mWh)
878.71 (lbs/mWh)

Pg. 36 (CCARRP) gives CO2 equivalency factors

Pg. 36 (CCARRP) gives Methane and Nitrous Oxide electricity emission factors (lbs/mWh)
Methane - 0.0067 (lbs/mWh)
Nitrous Oxide - 0.0037 (lbs/mWh)

lbs/metric ton = 2204.62
Southern California Edison emission rate 641.26 from ARB local gov operations protocol 2008

Greenhouse Gas (GHG) Emissions Calculations

Project Name: cadiz

Indirect Greenhouse Gas (GHG) Emissions from Project use of Electricity (Power Plant Emissions)

Pump	50,700,000	
Well 100 AFY	22,000,000	
Estimated Project Annual Electrical Use	**72,700,000**	kWh (kilowatt hours)/year
	72,700	MWh (megawatt hours)/year

Indirect GHG gases	Emission Factor lb/MWh	Annual Project Electricity MWh	Annual GHGs metric tons	CO_2 Equivalent Factor	Annual CO_2 Equivalent Emissions (metric tons)
Carbon Dioxide (CO2)	641.26	72,700	21,146	1	21,146
Nitrous Oxide (N2O)	0.0037	72,700	0.1	296	36
Methane (CH4)	0.0067	72,700	0.2	23	5
		Total Indirect GHG Emissions from Project Electricity Use=			**21,188**

Total Annual Greenhouse Gas (GHG) Emission from Project Operations -- All Sources (CO2 equivalent Metric Tons)

Electrical Use	**21188**
Total=	**21,188**

Notes and References:

Total Emissions from Indirect Electricity Use
Formula and Emission Factor from The California Climate Action Regiustry Report Protocol
Reporting Entity-wide Greenhouse Gas Emissions 2008
Pg. 33 (CCARRP) gives Equations

Pg. 36 (CCARRP - April 2008 update) gives CO2 output emission rate (lbs/mWh)
878.71 (lbs/mWh)

Pg. 36 (CCARRP) gives CO2 equivalency factors

Pg. 36 (CCARRP) gives Methane and Nitrous Oxide electricity emission factors (lbs/mWh)
Methane - 0.0067 (lbs/mWh)
Nitrous Oxide - 0.0037 (lbs/mWh)

lbs/metric ton = 2204.62
Southern California Edison emission rate 641.26 from ARB local gov operations protocol 2008

Focused Survey for Desert Tortoise,
Habitat Evaluation for Burrowing Owl, and
General Biological Resource Assessment for the
Cadiz Valley Water Conservation, Recovery, and Storage Project,
San Bernardino County, California

Job#: 10-030

Prepared by:

Circle Mountain Biological Consultants, Inc.
P.O. Box 3197
Wrightwood, California 92397
PH: (760) 249-4948
FAX: (760) 249-4948
Email: circlemtn@yahoo.com
Contacts: Ed LaRue, Sharon Dougherty

Prepared for:

Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, California 92688
PH: (949) 459-6400

I hereby certify that the statements furnished herein, including attached exhibits, present the data and information required for this biological evaluation, and that the facts, statements, and information presented are true and correct to the best of my knowledge and belief. Field work conducted for this assessment was performed by me or under my direct supervision. I certify that I have not signed a nondisclosure or consultant confidentiality agreement with the project applicant or applicant's representative and that I have no financial interest in the project.

_____

Circle Mountain Biological Consultants, Inc.
Author and Field Investigator: Edward L. LaRue, Jr.

November 2011

Executive Summary

For **tortoises**, CMBC found 4 scat, 3 carcasses, and 1 burrow along the northern portion of the water conveyance pipeline within the Arizona & California Railroad Company (ARZC) right-of-way (ROW). All evidence of living tortoises was found between the north end of the ARZC ROW and Old Woman Mountains, with three carcasses found to the south. Tortoises may be absent or occur in very low densities south of Old Woman Mountains and are not common anywhere along the ARZC ROW, apparently occurring in low densities along northern reaches.

In the proposed wellfield area, evidence of *living* tortoises was restricted to Sections 17 and 18, with carcasses found in Sections 8 and 35. The carcass found in Section 35 appears to have died in the early 1940's and was the only tortoise sign found in the central and western portions of the proposed wellfield area. CMBC concludes that tortoises are most likely to be encountered in the eastern portion of the wellfield area (particularly Section 17 and 18, and perhaps Section 8) and least likely to be encountered elsewhere. Though not detected at the conceptual spreading basin area, habitats there are among the least impacted and most suitable, and tortoise(s) may occur there in the future, if not already.

None of the following **special status plant species** reported from the area would be significantly affected by Project development: White bear poppy, crucifixion thorn, las animas colubrina, Alverson's foxtail cactus, Howe's hedgehog cactus, Little San Bernardino Mountains linanthus, spear-leaf matela, Robison's monardella, short-joint beavertail cactus, white-margined beardtongue, Stephen's beardtongue, lobed ground-cherry, Orocopia sage, and Rusby's desert-mallow.

There is some unknown potential for the following plant species to occur, as they would not have been detected during CMBC's September-October 2010 surveys: small-flowered androstephium, Borrego milk-vetch, ribbed cryptantha, winged cryptantha, Utah vine milkweed, and slender cottonheads.

The following species are known to occur on or adjacent to the Project site and may therefore be adversely affected at unknown levels by Project development: Harwood's milk-vetch, barrel cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree.

For **washes**, CMBC has prepared a separate report and jurisdictional delineation for the +/- 70 washes crossing the ARZC ROW and others, particularly Schulyler Wash, in the proposed wellfield and conceptual spreading basin areas.

None of the following **special status bird species** reported from the area would be significantly affected by Project development: Northern harrier, sharp-shinned hawk, Swainson's hawk, ferruginous hawk, golden eagle, merlin, or long-eared owl. These species may incidentally occur in the area and occasionally forage there but none of them would nest in the Project area, so no significant impacts are anticipated. The status of western snowy plover and mountain plover within the Project area remain unknown.

Bird species encountered during CMBC's 2010 survey included: 8 burrowing owls and 32 burrows with owl sign; 6 Cooper's hawk locations; 11 prairie falcon locations; 2 LeConte's thrashers; and 20 loggerhead shrike locations plus 93 sites where diagnostic shrike pellets were found.

Insufficient information is available to determine if Project development would affect the following **special status mammal species**: California leaf-nosed bat, Arizona myotis, cave myotis, spotted bat, Townsend's big-eared bat, pocket free-tailed bat, big free-tailed bat, western mastiff bat, fringed myotis, and southern grasshopper mouse. The status of grasshopper mouse remains unknown in the Project area.

For pallid bats, the surveys were sufficient to detect more than 160 individual bats at 22 of the 70 trestles inspected. This is considered a regionally significant resource for the species.

American badgers, though not observed, appear to occur throughout all Project areas. No primary burrow systems were observed, though evidence of their foraging is ubiquitous.

Impacts are discussed and mitigation measures recommended for each of these biological resources.

Table of Contents

Executive Summary i

1.0. Introduction 1

1.1. Purpose and Need for Study 1
1.2. Project Location 1
1.3. Project Description 4

2.0. Methods 5

2.1. Agency Consultation 5
2.2. Literature Review 6
2.3. Field Survey 6

3.0. Results 13

3.1. Common Biological Resources 13
3.1.1. Common Flora 14
3.1.2. Common Fauna 15

3.2. Uncommon Biological Resources 16
3.2.1. Regional Land Management for Desert Tortoise 16
3.2.2. Desert Tortoise Survey Findings 18
3.2.3. Desert Tortoise Literature Findings 20
3.2.4. Observable Human Disturbances 21
3.2.5. Other Special Status Species 24

3.3. Other Protected Biological Resources 40

4.0. Conclusions and Recommendations 40

4.1. Impacts to the Desert Tortoise and Proposed Mitigation 40
4.2. Impacts to Other Biological Resources and Proposed Mitigation 43

5.0. Literature Cited 48

List of Appendices

Appendix A. Plant Species 51
Appendix B. Animal Species 56
Appendix C. Locations of Desert Tortoise Sign 61
Appendix D. Locations of Burrowing Owl Sign and Burrows 63
Appendix E. Locations of Other Special Status Bird Species 88
Appendix F. Locations of Pallid Bats and Sign 90
Appendix G. Photographic Exhibits along Pipeline 91
Appendix H. Photographic Exhibits within Wellfield Area 99
Appendix I. Photographic Exhibits of Miscellaneous Biological Resources 114

List of Figures

Figure 1. Vicinity Map 2
Figure 2. Site Map 3
Figure 3. Regional Land Ownership 6
Figure 4. Transect Locations along the Proposed Pipeline Alignment 8
Figure 5. Variable Transect Coverage at Wellfield Areas 9
Figure 6. Dates and Hours of Surveys along the Proposed Pipeline Alignment 11
Figure 7. Dates and Hours of Surveys within Wellfield Areas & Spreading Basin 12
Figure 8. Plant Communities and Substrates along Pipeline Alignment 13
Figure 9. Location of Pipeline ROW Relative to Chemehuevi DWMA 17
Figure 10. Section Numbers Corresponding to Wellfield Areas 22
Figure 11. Special Status Species in CDFG CNDDB (2010a) 25
Figures C1-C2. Desert Tortoise Sign along Pipeline & Wellfield Areas 61
Figures D1-D10. Burrowing Owl Sign along Pipeline Alignment 63
Figures D11-D25. Burrowing Owl Sign for Wellfield Areas & Spreading Basin 73
Figures E1-E2. Other Special Status Bird Species 88
Figures F1. Locations of Pallid Bats and Sign 90

Focused Survey for Desert Tortoise,
Habitat Evaluation for Burrowing Owl, and
General Biological Resource Assessment for the
Cadiz Valley Water Conservation, Recovery, and Storage Project,
San Bernardino County, California

1.0. Introduction

1.1. Purpose and Need for Study. Circle Mountain Biological Consultants, Inc. (CMBC) was contacted by ESA Southern California Water Group (ESA) on behalf of Santa Margarita Water District (SMWD) to perform a focused survey for desert tortoise (*Gopherus agassizii*), habitat assessment for burrowing owl (*Athene cunicularia*), and a general biological resource assessment on the Cadiz Valley Water Conservation, Recovery, and Storage Project (Project) site located in San Bernardino County, California (see **Figures 1** and **2**). Given the location of the Project in an unincorporated portion of the County, this report has been prepared according to County of San Bernardino's *Report Protocol for Biological Assessment Reports* (County of San Bernardino 2006).

As the California Environmental Quality Act (CEQA) Lead Agency, Santa Margarita Water District (SMWD) is required to determine if site development will result in any adverse impacts to rare biological resources. The information will also be useful to federal and State regulatory agencies, including U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG), respectively, when they are asked to assess impacts associated with proposed development.

Results of CMBC's focused tortoise survey, burrowing owl habitat assessments, and general biological resource assessment are intended to provide sufficient baseline information to these and other pertinent agencies to determine if impacts will occur and to identify mitigation measures, if any, to offset those impacts.

1.2. Project Location. The Project area is located at the confluence of the Fenner Valley and Orange Blossom Watersheds which span nearly 1,300 square miles and contain an estimated total volume of groundwater in storage of more than 20 million acre feet. The Project area is underlain by an aquifer system composed of saturated alluvial materials, limeston-carbonates, and granitic rocks with a depth to groundwater of consistently more than 180 feet below ground surface (bgs) and raching over 400 feet bgs in many areas.

Figure 1. Cadiz Project: Vicinity Map

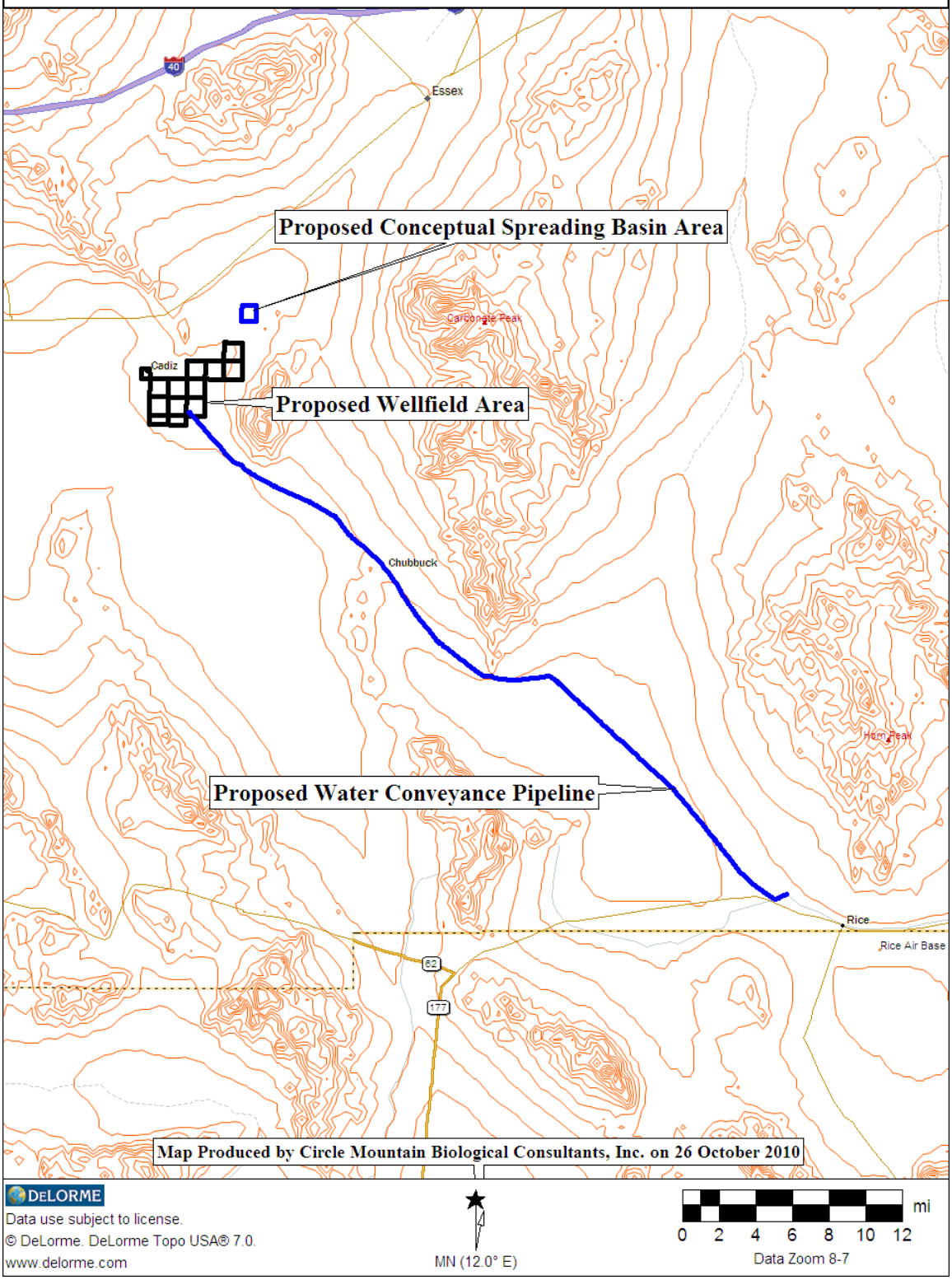
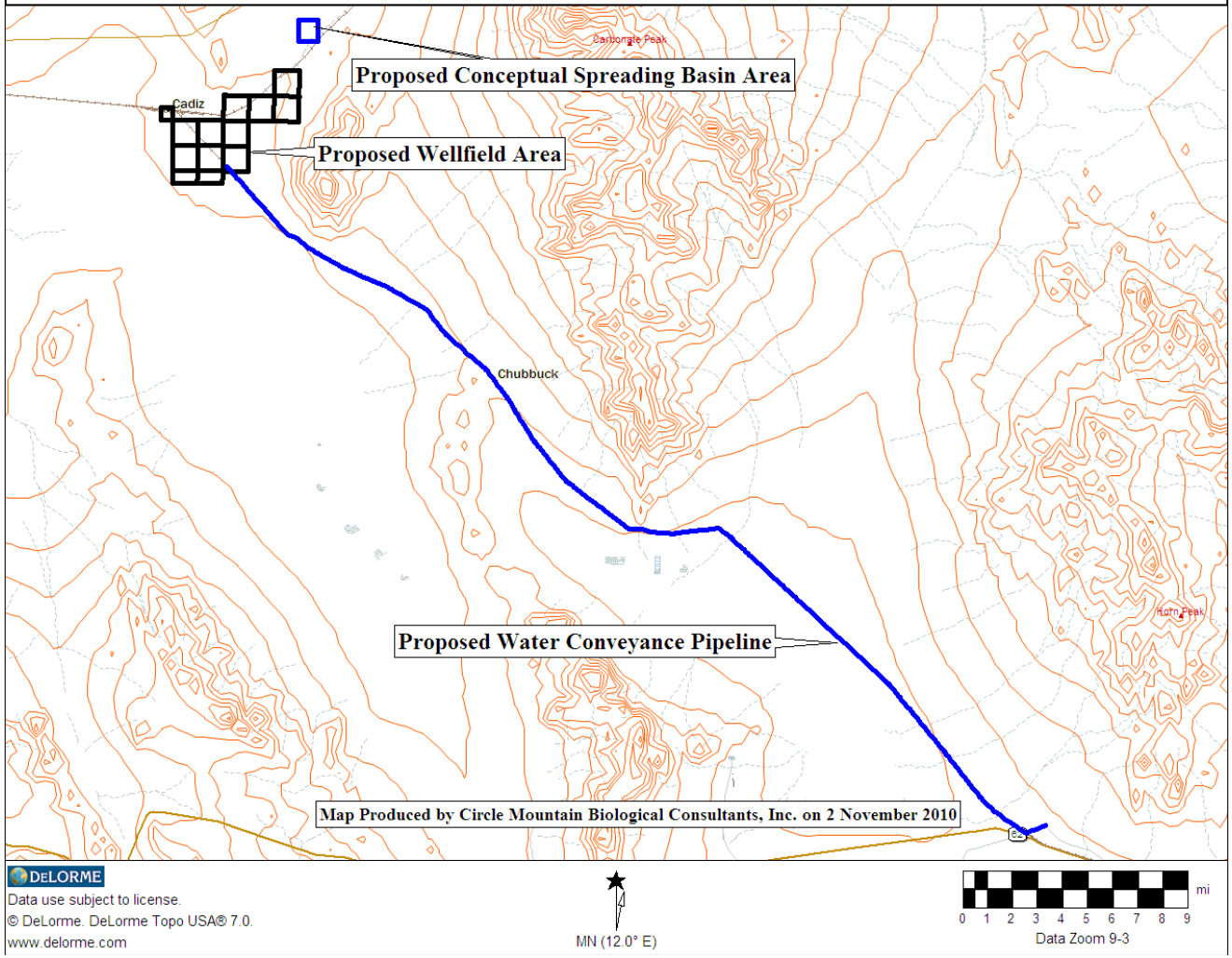


Figure 2. Cadiz Project: Site Map



1.3. Project Description. The Project proposes active management of the groundwater basin underlying Cadiz Inc. property in the Cadiz and Fenner Valleys located in the eastern Mojave Desert, San Bernardino County, California. The purpose of the Project is to enhance dry-year water supply reliability, water supply opportunities, and delivery flexibility for SMWD and other participating water providers.

The proposed Project would be executed in two phases: the first phase of the Project is the Conservation and Recovery Component, and the second phase is the Imported Water Storage Component. In the first phase, the Conservation and Recovery Component would be constructed to capture and conserve the average annual natural recharge in the Fenner and northern Bristol Valleys that would otherwise discharge to the Bristol and Cadiz Dry Lakes. Facilities that would be constructed under the first phase include a Project wellfield, water conveyance facilities (pipeline), tie-in to the Colorado River Aqueduct (CRA), access roads, and power supply and distribution facilities.

The second phase, referred to as the Imported Water Storage Component, would use the established hydraulic control for the importation, storage and recovery of imported developed water made available from the CRA. Facilities that would be constructed under the second phase include a Project wellfield expansion, extension of the water conveyance facilities, CRA diversion structure and pump station, access roads, expansion of the power supply and distribution facilities, and spreading basins. Because the Imported Water Storage Component would be implemented at a later date, it will be evaluated in the EIR on a programmatic basis. Prior to implementing the Imported Water Storage Component, it will undergo appropriate further environmental review consistent with CEQA.

Additional, extensive project description information will be included in Chapter 3 of the Draft Environmental Impact Report (Draft EIR) being prepared by ESA.

2.0. Methods

This study and technical report are provided as baseline data to support the CEQA analysis that will be included in the Draft EIR.

2.1. Agency Consultation. CMBC contacted CDFG Wildlife Biologist, Jim Sheridan,[1] to inquire about appropriate survey protocol. Mr. Sheridan provided limited input on desert tortoise surveys, referring CMBC to the 2010 survey protocol (U.S. Fish and Wildlife Service 2010). Mr. Sheridan did agree with the current approach for burrowing owl, which was to assess habitats now and eventually perform focused spring surveys for breeding burrowing owls.

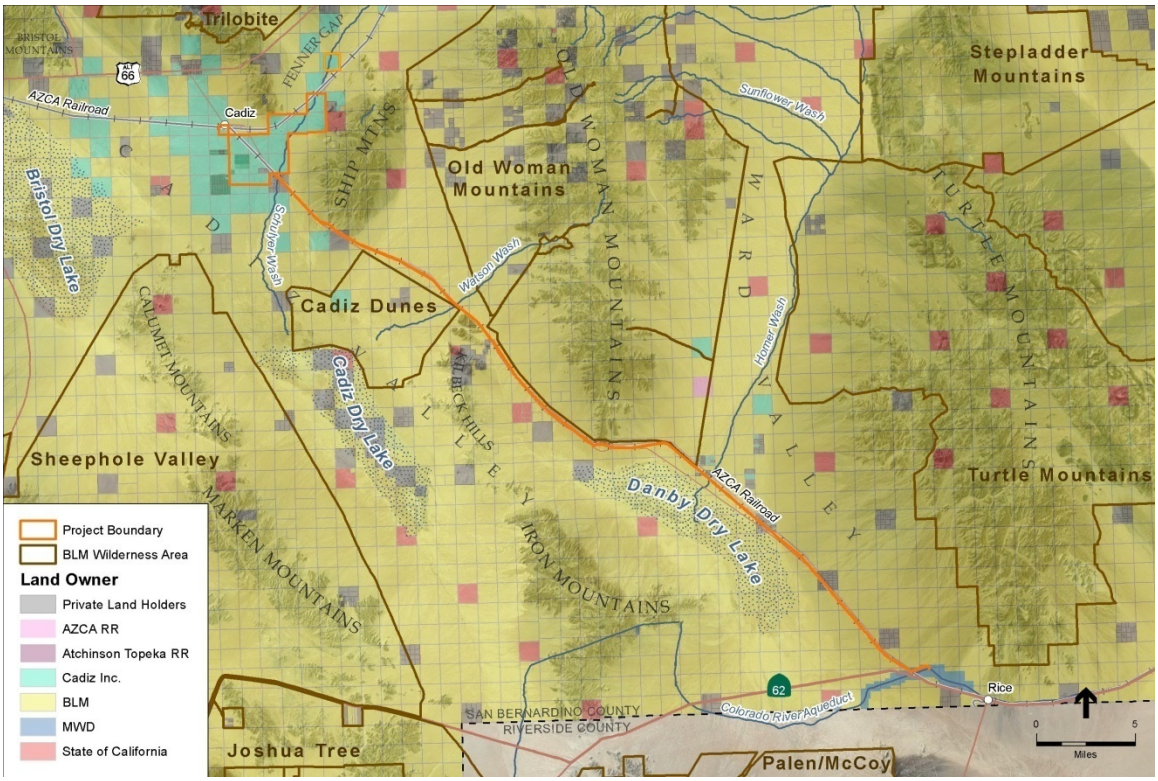
USFWS Wildlife Biologist Judy Hohman[2] was also contacted to obtain information regarding survey methodologies. Ms. Hohman recommended that the various project components (including staging areas, haul routes, etc.) be evaluated together as one project in order to address the need of a well defined action area.

It was determined that the action area will include direct impact areas associated with the well sites throughout the wellfield areas, the interconnecting pipes between the well sites, the water conveyance pipeline, and ancillary facilities located in these areas, indirect impacts are more difficult to assess. At a maximum, the action area could include the 11 square miles encompassing the wellfield areas and the 390-acre± conceptual spreading basin area; at the minimum, the action area would include the direct impact area plus a minimal buffer adjacent to the constructed facilities. In reality, the action area is somewhere in between. Field survey methodologies used for this study were distributed throughout the maximum action area so that potenital impacts to biological resources could be evaluated in the Draft EIR.

Although the region is mostly comprised of public lands managed by the Bureau of Land Management (BLM) (**Figure 3**), no public lands will be direcly impacted by this project. Construction of the water conveyance pipeline, wellfield, spreading basins and associated pipelines, and other project facilities would occur on private property and rights-of-way. As such, there is no BLM involvement and BLM biologists were not contacted prior to surveys. BLM Wildlife Biologist, Dr. Larry LaPre was contacted via email on 3 November 2010 concerning cattle grazing in the region with his response on 4 November 2010.

[1] Personal correspondence with Jim Sheridan, CDFG Bermuda Dunes Office, on 27 Septem ber 2010.
[2] Personal correspondence with Judy Hohman, USFWS, on 14 September 2010, 26 and 27 October 2010.

Figure 3. Regional Land Ownership



2.2. Literature Review. CMBC consulted materials included in our library to determine the nearest desert tortoise locations and other special status plant and animal species that have been reported from the vicinity of the subject property. Of particular relevance was CMBC's 1999 focused tortoise surveys of the then-proposed Cadiz pipeline, which shared the same ROW between the community of Cadiz and Chubbuck as the current pipeline alignment where it then turned southwest through the Kilbeck Hills, unlike the current pipeline alignment, which stays within the ARZC ROW. ESA provided CMBC with an updated review of the California Natural Diversity Data Base (CDFG CNDDB 2010b) for the following USGS-designated 7.5' quadrangles: Arica Mountains, Cadiz Summit, Cadiz Lake Northwest, Cadiz Lake Northeast, Chubbuck, Milligan, East of Milligan, Danby Lake, and Sablon. These and other materials used in the completion of this report are listed in Section 5.0, below.

2.3. Field Survey. For **desert tortoises**, the survey protocol first identified by the USFWS (1992) and recently revised (USFWS 2010) for their detection recommends that transects be surveyed at 30-foot intervals throughout the project impact area. If neither tortoises nor sign are encountered during *action area* surveys and the project, or any portion of project, is ≤ 0.8 km^2 (200 acres) or linear, three additional 30-foot (9 meters) belt transects at 655-foot (200 meters), 1,310-foot (400 meters), and 1,970-foot (600 meters) intervals parallel to and/or encircling the project perimeter should be surveyed.

The proposed water conveyance pipeline would be situated within the 200-foot wide ARZC ROW between the community of Cadiz to the north and Highway 62 to the south (Figures 1 and 2). Since it is too soon to know which side of the rail line would be used, *both* sides were surveyed out to 100 feet. This entailed survey of three transects, spaced at 30-foot intervals on both sides of the the railroad tracks. Since tortoise sign was found (see **Table 1**) within 100 feet on either side of the northern 25 miles of the proposed pipeline (**Figure C1** in Appendix C), zone of influence transects were surveyed at 655-, 1,310-, and 1,970-foot intervals on both sides of the southern 20 miles as depicted on the next page, in **Figure 4**. The ¾-mile stretch of the underground CRA between the southern terminus of the ROW and east to where the CRA surfaces was surveyed along 6 transects spaced at 30-foot intervals.

For wellfield areas, following suggested protocol methodologies would have resulted in the grid pattern shown in the lower half of **Figure 5** on page 11. Although it would have provided even coverage, much of the area would not have been surveyed. So that better coverage would be provided and to implement methodologies consistent with burrowing owl surveys described below, CMBC opted to programmatically survey each of the 10 640-acre sections, the 2 320-acre half-sections, the 160-acre parcel, and the 390-acre conceptual spreading basin area along transects spaced at 100-foot intervals. A 410-acre area encompassing the conceptual spreading basins was actually surveyed. As shown in Figure 6, this resulted in surveys of 54 linear miles within each square mile rather than 42 linear miles that would have been covered following the standard protocol.

Given that a Draft EIR is being prepared to address the Conservation and Recovery Component at a project level and the Imported Water Storage Component at a programmatic level, and that there will be ample opportunities to perform more detailed surveys later, this methodology was judged to be more appropriate for current surveys of the action area than would have been provided by implementing the suggested protocol.

Figure 4. Transect Locations Along the Proposed Pipeline Alignment

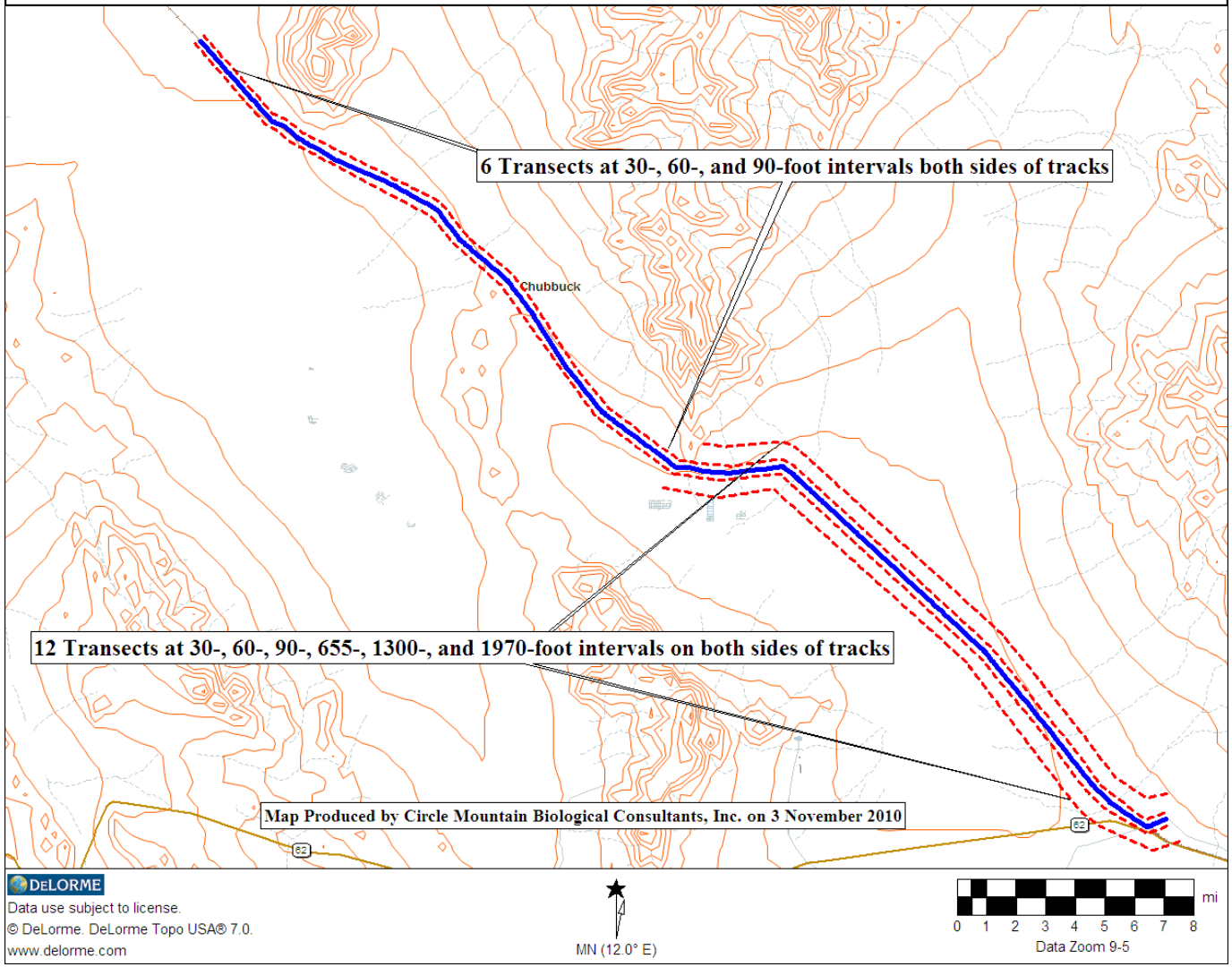
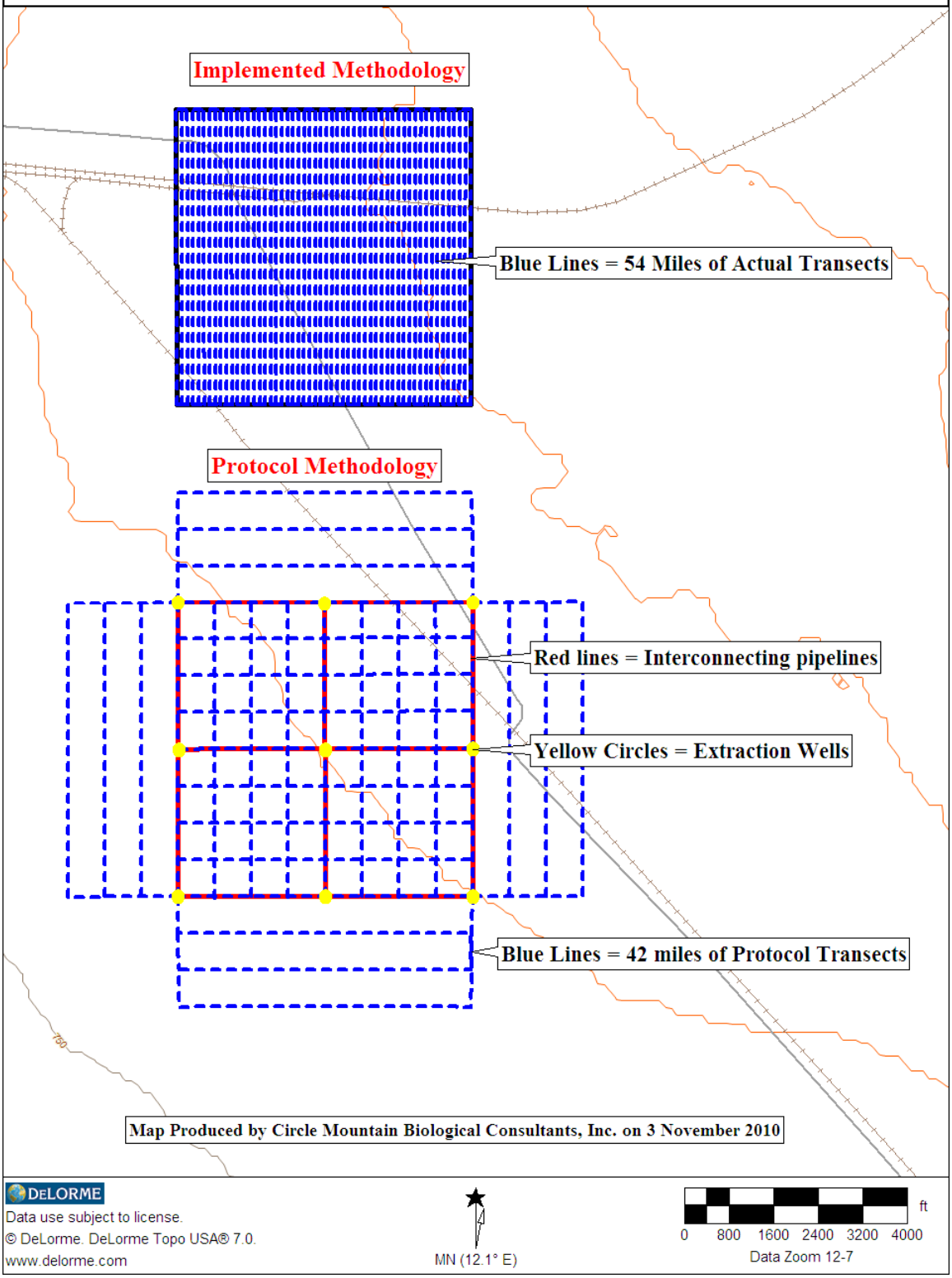


Figure 5. Variable Transect Coverages at Wellfield Areas



For **burrowing owl**, the CDFG (1995) survey protocol recommends transects be surveyed at 100-foot (30-meter) intervals throughout a given site with five transects spaced at 100-foot intervals surveyed in adjacent areas in potential habitat (i.e., excluding areas substantially developed for commercial, residential, industrial, etc. purposes). The transect interval used for this study was ideal for detecting burrowing owls.

Importantly, this methodology is considered a formal *Phase I and Phase II habitat assessment* for presence of burrowing owls, which can be conducted any time of the year. Field surveys revealed four types of burrows that may be occupied by burrowing owls: larger rodent colonies (Exhibits I11 an I12 in Appendix I), inactive kit fox dens (Exhibit I10), badger digs (Exhibit I7-I8), and single-entrance burrows created by an unknown source (ambiguous burrows likely created by badger or kit fox) (Exhibit I9). When found, each burrow was visually inspected for owl sign and coordinates were taken, which allowed us to map all burrows, including those with obvious owl sign (see **Figures D1-D25** in Appendix D).

For surveys within the ARZC ROW, for a total of 284 hours, between 20 and 28 September 2010, Ed LaRue of CMBC and subcontractors, Patricia Seamount, Michael Gallagher, Mike Radakovich, Bill Donnan, Shawn Gonzales, and Gary Thornbrugh, surveyed the ARZC ROW and adjacent areas as depicted below in **Figure 6**. The same surveyors, with the addition of Sharon Dougherty on 29 September 2010, spent a total of approximately 472 hours between 29 September and 17 October 2010 surveying transects throughout the 11 square miles encompassing the wellfield areas, the 160-acre parcel to the northwest, and the 410-acre conceptual spreading basin area as depicted in **Figure 7**.

As transects were surveyed in the wellfield areas, LaRue kept tallies of observable human disturbances encountered on each of the transects he surveyed within each 640-acre wellfield section and the conceptual spreading basin area. The results of this method provide *encounter rates* for observable human disturbances. For example, two roads observed on each of 20 transects would yield a tally of 40 roads (i.e., two roads encountered 20 times). Habitat quality, adjacent land uses, and this disturbance information are discussed below in Section 3.2 relative to the potential occurrence of desert tortoise and other special status species on and adjacent to the Project site.

All plant and animal species identified during the surveys were recorded in field notes and are listed in Appendices A and B, respectively. Biologists used various hand-held, global positioning system (GPS) units to survey straight transects and record Universal Transverse Mercador (UTM) coordinates (North American Datum – NAD 83) for property boundaries, rare species locations, burrow locations, and other pertinent information. A digital camera was used to take representative photographs (Appendices G, H, I), with locations and directions of exhibits shown in corresponding appendices.

Figure 6. Dates and Hours of Survey Along the Proposed Pipeline Alignment

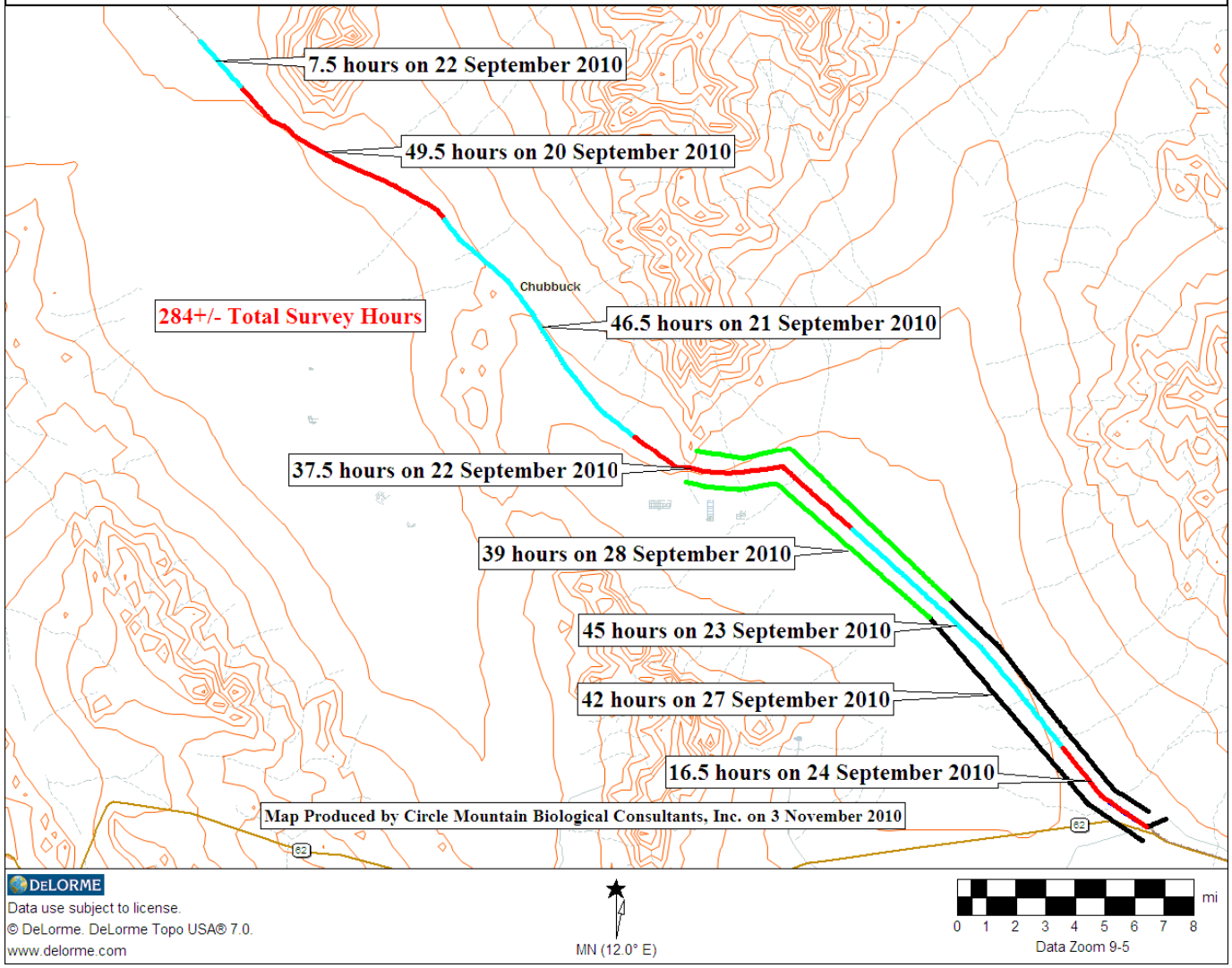
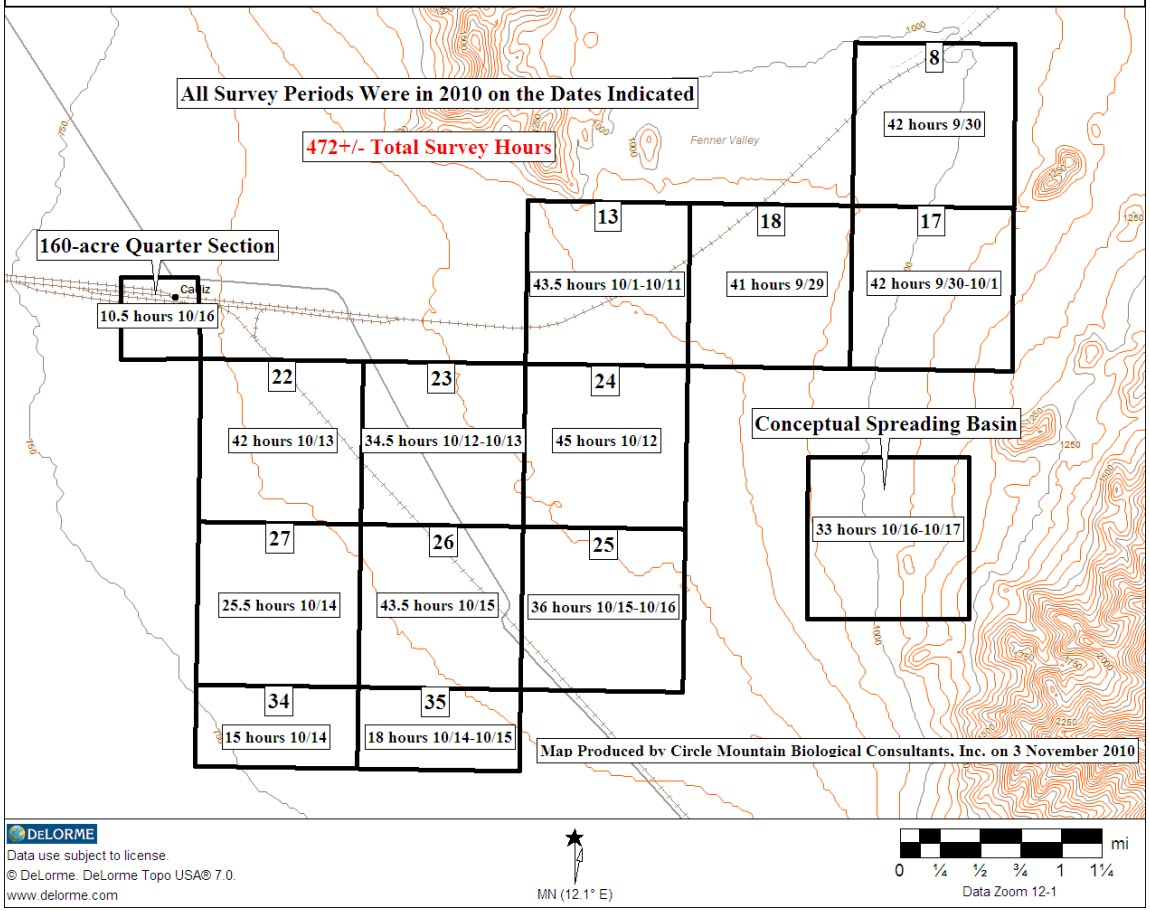


Figure 7. Dates and Hours of Survey Within Wellfield & Conceptual Spreading Basin Areas



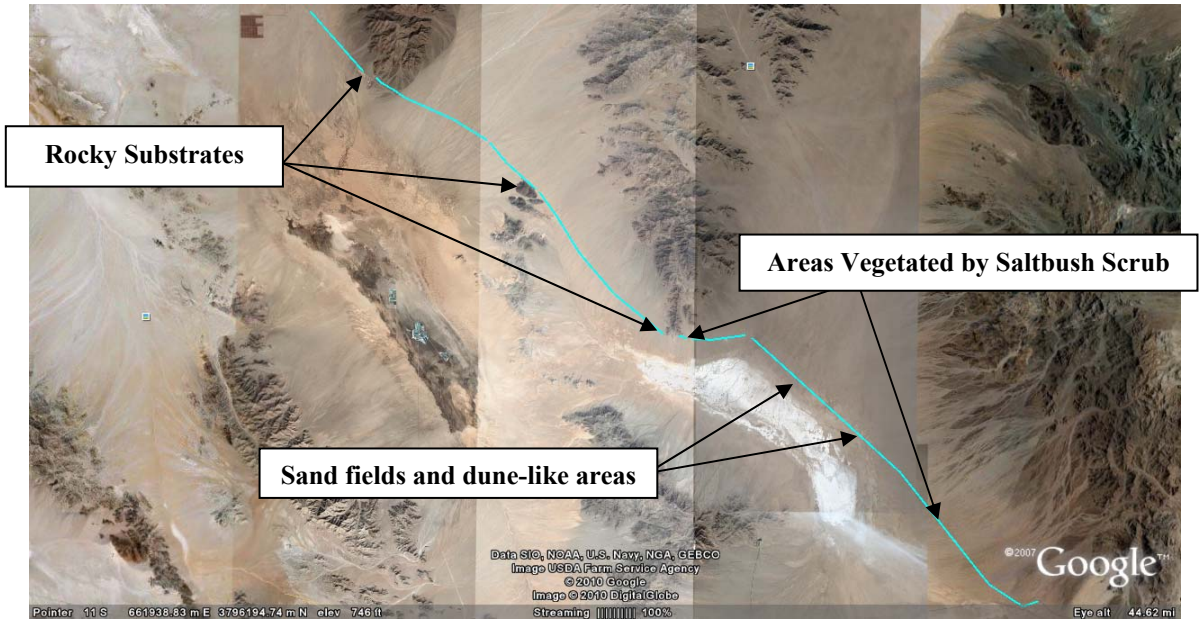
Although the conceptual spreading basin is located a mile north of Section 8 (see Figures 1 and 2 for actual location), it is repositioned in Figure 7 and several others to facilitate reporting.

3.0. Results

3.1. Common Biological Resources. The common plant and animal species identified during the survey are influenced by multiple factors such as elevation, topography, soil substrates, and adjacent land uses. Based on DeLorme Topo USA® 7.0 software, elevations along the pipeline ROW range from approximately 830 feet (253 meters) at the north end down to 640 feet (195 meters) east of Danby Lake back up to 950 feet (290 meters) where the pipeline terminates at the CRA. The wellfield areas range from 750 feet (229 meters) at the southwest corner of Section 34 up to 1,150 feet (351 meters) at the southeast corner of Section 17. The elevation near the center of the conceptual spreading basin is approximately 1,080 feet (329 meters). These variable elevations likely contribute to the presence of tortoise sign to the north and south of the water conveyance pipeline ROW and the apparent absence of living tortoise sign (e.g., burrows, carcass, scat, etc.) south of Old Woman Mountain, particularly in the vicinity of Danby Lake.

Although the wellfield areas are mostly uniformly vegetated by creosote bush scrub, variable elevations have influenced the plant communities occurring along the 44-mile long ARZC ROW, as depicted below in **Figure 8**. The northern and southern reaches of the pipeline are vegetated by creosote bush scrub while the lower elevation areas east of Danby Lake are vegetated by saltbush scrub communities. The rocky substrates associated with Ship Mountains to the north, Kilbeck Hills to the north, and Old Woman Mountains near the center provide substrates where cactus species and several other perennial plants are completely confined or relatively more common. Prevailing winds from the west associated with Danby Lake have created sandfields where Mojave fringe-toed lizards were observed and are likely restricted.

Figure 8. Plant Communities and Substrates along Pipeline Alignment



A separate jurisdictional waters analysis has been completed as an independent report that provides extensive details of drainages and washes in the project area. In summary, there are approximately 70 washes and drainages crossing the pipeline alignment. All of these streams flow east-to-west, and in many places have created washes and washlets along the eastern side of the ARCZ railroad. This flow of water impeded by the existing rail line has resulted in a zone of more frequent perennial plants (Exhibit I19 in Appendix I), including wash-adapted species described in Section 3.1.1., below. Most of these washes are associated with trestles beneath the train tracks (Exhibits I19, I20, and I21), which serve as focal points for many common and several sensitive animal species. A dozen washes also cross the wellfield areas, with Schulyler Wash comprising a regional resource that crosses the conceptual spreading basin area and 7 of the 11 square miles encompassing the wellfield.

3.1.1. *Common Flora*. The 106 plant species identified during the survey are listed in Appendix A. Common species in upland areas, which are vegetated by creosote bush scrub throughout the wellfield areas, the northern portions of the pipeline alignment north of Old Woman Mountains, and southern reaches of the pipeline alignment south of Danby Lake include creosote bush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), cheesebush (*Hymenoclea salsola*), desert tea (*Ephedra californica*), honeysweet (*Tidestromia oblongifolia*), white rhatany (*Krameria grayi*), and big galleta (*Pleuraphis rigida*).

There are three places where substrates along the ARZC ROW are influenced by the proximity of mountainous areas, which in turn support several plant species that are entirely restricted to those areas or nearly so. The two main influences are Ship Mountains to the north and Old Woman Mountains near the center, with Kilbeck Hills in the vicinity of Chubbuck having somewhat less influence. The three cactus species – barrel cactus (*Ferocactus cylindraceus*), silver cholla (*Opuntia echinocarpa*), and beavertail cactus (*Opuntia basilaris*) – are more common in these areas than elsewhere. These species are also present in the wellfield areas, with the addition of pencil cholla (*Opuntia ramosissima*), which was not observed within the ARZC ROW.

There is a 10-mile± stretch of the pipeline alignment located east of Danby Lake, south of Old Woman Mountains that is comprised of saltbush scrub. Soils are more alkaline, elevations are relatively low, and prevailing winds from the west have resulted in sand fields and dune-like areas. Dominant plants in the saltbush scrub community, several of which are not found elsewhere in the Project area, include four-winged saltbush (*Atriplex canescens*), allscale (*Atriplex polycarpa*), desert holly (*Atriplex hymenelytra*), and Torrey's sea-blight (*Suaeda moquinii*). Dicoria (*Dicoria canescens*), desert Spanish needles (*Palafoxia linearis*), devil's lantern (*Oenothera deltoides*), plicate coldenia (*Tiquilia plicata*), desert camas (*Zidagenus brevibracteatus*), and desert lily (*Hesperocallis undulata*) are relatively more common in the sand field areas or sandier portions of the Project area than in rocky and less sandy areas.

As previously mentioned, there are approximately 70 drainages and dry washes along the pipeline alignment and a dozen more, including Schulyler Wash, in the proposed wellfield and spreading basin areas that support mesic-adapted plant species, many of which are not found in upland areas. There are both well-developed, sandy-bottomed washes (Exhibits I19, I20, and I21) and less well developed, upland washes (Exhibit I22) that channel rainwater moving east-to-west through both the pipeline alignment and wellfield areas. Dominant perennials occurring alongside the well-developed washes include several species of milkweeds (*Asclepias* ssp.), sweetbush (*Bebbia juncea*), rayless encelia (*Encelia fructescens*), arrow weed (*Pluchea sericea*), desert willow (*Chilopsis linearis* ssp. *arcuata*) (only in a few wellfield areas), bladderpod (*Isomerus arborea*), ditaxis (*Ditaxis neomexicana*), catclaw acacia (*Acacia greggii*), palo verde (*Cercidium floridum*) (south of Old Woman Mountains), smoke tree (*Psorothamnus spinosus*), desert lavender (*Hyptis emoryi*), sandpaper plant (*Petalonyx thurberi*), and Cooper's strangler (*Orobanche cooperi*).

Finally, there is a cohort of weedy natives and non-native plants that are present because of past and persisting disturbances in the area. Some of these, including saltcedar (*Tamarix ramosissima*) and athel (*Tamarix aphylla*), were intentionally planted and persist at some of the railroad communities mostly active between 1920 and 1950 (De Kehoe 2007). According to De Kehoe, local railroads were built in 1910 and General Patton performed extensive, invasive ground maneuvers throughout the area, south of the Burlington Northern Santa Fe Railroad (BNSF) in the early 1940's. The wellfield area in Section 27 is either currently planted in lime groves or has been substantially altered by previous agricultural uses (Figure D1 in Appendix D). The following invasive species were identified in the area and are indicative of moderately-to-heavily degraded habitats: velvet rosettes (*Psathyrotes ramosissima*), Saharan mustard (*Brassica tournefortii*), tansy (*Descurainia pinnata*), flixweed (*Descurainia sophia*), London rocket (*Sisymbrium irio*), Russian thistle (*Salsola tragus*), red-stemmed filaree (*Erodium cicutarium*), little trumpet (*Eriogonum trichopes*), Jimsonweed (*Datura wrightii*), and puncture vine (*Tribulus terrestris*).

3.1.2. *Common Fauna*. The 17 reptile, 53 bird, and 13 mammal species identified during the survey are listed in Appendix B. This list represents a diverse assemblage of reptile species, likely due to the variable habitats ranging from rocky bajadas at Ship and Old Woman mountains, to sand fields proximate to Danby Lake, supporting both creosote bush and saltbush scrub communities. As usual, side-blotched lizard (*Uta stansburiana*) and western whiptail (*Cnemidophorus tigris*) were the most commonly encountered lizard species, although desert iguana (*Dipsosaurus dorsalis*), desert horned lizard (*Phrynosoma platyrhinos*), and long-nosed leopard lizard (*Gambelia wislizenii*) were frequently encountered or detected by diagnostic scat.

Zebra-tailed lizards (*Callisaurus draconoides*) are most common in sandy wash areas and common chuckwallas (*Sauromalus obesus*) are restricted to rocky, cobble-strewn substrates. Long-tailed brush lizard (*Gambelia wislizenii*) and desert spiny lizard (*Sceloporus magister*) were only encountered in the vicinity of train trestles or at bundles of railroad ties stockpiled along the western side of the ARZC ROW. Sidewinders (*Crotalus cerastes*) were occasionally observed and commonly detected throughout both the ARZC ROW and wellfield areas. A single western banded gecko (*Coleonyx variegatus*) was observed in Section 25, which is a common species rarely encountered during daylight hours.

The 53 bird species include a diverse array of species that are resident to the area, incidental seasonal visitors or migrants, and those that are only present because they are attracted to vineyards, orchards, and water sources not often found in remote desert areas. Common year-round residents that likely nest in the area include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), chukar (*Alectoris chukar*) (only in mountainous areas), Gambel's quail (*Callipepla gambelii*) (mostly in washes), mourning dove (*Zenaida macroura*), greater roadrunner (*Geococcyx californianus*), Say's phoebe (*Sayornis saya*), verdin (*Auriparus flavipes*), rock wren (*Salpinctes obsoletus*) (in mountainous areas), and black-throated sparrow (*Amphispiza bilineata*), among a few others.

Although there are a few species typically associated with or benefitted by human development, including killdeer (*Charadrius vociferus*), Eurasian collard-dove (*Streptopelia decaocto*), common barn owl (*Tyto alba*), horned lark (*Eremophila alpestris*), common raven (*Corvus corax*), northern mockingbird (*Mimus polyglottos*), house finch (*Carpodacus mexicanus*), Brewer's blackbird (*Spizella breweri*), and great-tailed grackle (*Quiscalus mexicanus*), there are other species that would not occur in the area if not for the agricultural resources mentioned above.

Such species included a white pelican (*Pelecanus erythrorhynchos*) carcass (Exhibit I23) found near the existing spreading basins in Section 13; a common loon (*Gavia immer*) (Exhibit I24) found between the front tires of one of our vehicles in Section 27; mallard (*Anas platyrhynchos*), American avocet (*Recurvirostra americana*), red-winged blackbird (*Agelaius phoeniceus*), and yellow-headed blackbird (*Xanthocephalus xanthocephalus*). Most of the other species listed in Appendix B are either rare (see Section 3.2.2. below), seasonal visitors, or incidental migrants.

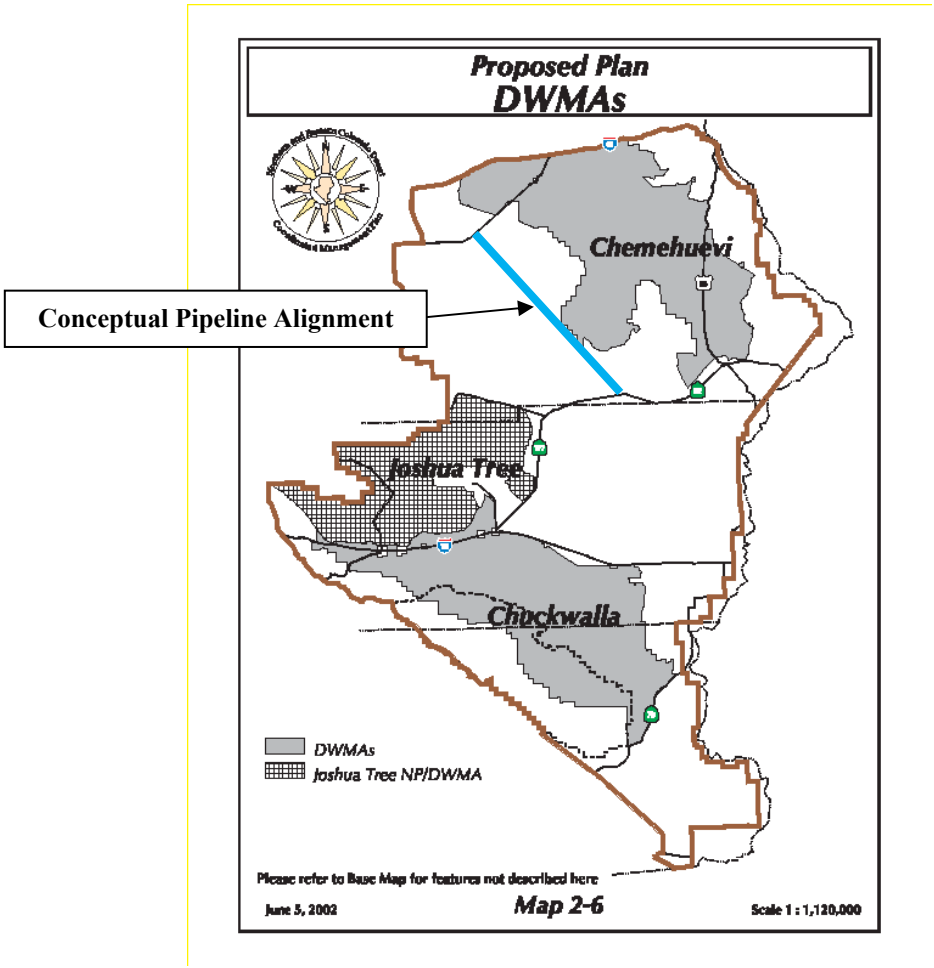
With the exception of pallid bats, which are reported in Section 3.2.2., all mammal species are relatively common to remote desert areas. Small burrowing mammals included round-tailed ground squirrel (*Spermophilus tereticaudis*), antelope ground squirrel (*Ammospermophilus leucurus*), various kangaroo rat species (*Dipodomys* spp.), Botta pocket gopher (*Thomomys bottae*), and desert wood rat (*Dipodomys deserti*). Medium-sized mammals included black-tailed hare (*Lepus californicus*) and Audubon cottontail (*Sylvilagus audubonii*). Predators included coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), and bobcat (*Lynx rufus*).

3.2. Uncommon Biological Resources.

3.2.1. *Regional Land Management for Desert Tortoise*. The County (2004) requires that habitat categories designated by the U.S. Bureau of Land Management (1989) be identified in all desert tortoise technical reports. Although habitat categories apply only to public lands administered by the BLM, regulatory agencies typically determine habitat compensation ratios based on the nearest BLM habitat categories (Desert Tortoise Compensation Team 1991). With the adoption of the Northern & Eastern Colorado Desert Coordinated Management Plan (NECO) (U.S. Bureau of Land Management 2002), all lands that are outside Desert Wildlife Management Areas (DWMA), including the Project area, are characterized as Category 3 Habitat, which is the lowest priority management area for viable populations of the desert tortoise.

The site is not found within desert tortoise critical habitat, which was designated in 1994 (U.S. Fish and Wildlife Service 1994a) nor is it within a DWMA as recommended in the Desert Tortoise (Mojave Population) Recovery Plan (U.S. Fish and Wildlife Service 1994b) and formally adopted in December 2002 as a result of NECO (U.S. Bureau of Land Management 2002). The southwestern boundary of the Chemehuevi DWMA coincides with the southwestern extent of Ward Valley, which approaches the ARZC ROW from the northeast as shown in **Figure 9** below, where the light blue line represents the proposed pipeline alignment. No portions of the Project area are in either Chemehuevi critical habitat or the associated DWMA.

Figure 9. Location of Pipeline Alignment Relative to Chemehuevi DWMA



3.2.2. *Desert Tortoise Survey Findings*. Locations of 16 items of desert tortoise sign found within and adjacent to the ARZC ROW are depicted in Figure C1 and locations of 14 sign found in the proposed wellfield areas are depicted in Figure C2 (see Appendix C for both figures). Proceeding from north-to-south along the ARZC ROW, tortoise sign found during this survey is described in **Table 1**:

Table 1. Desert Tortoise Sign Found along ARZC ROW (Figure C1)

Description	Location	Comment
1. Fresh scat of adult tortoise	±2.75 miles south of north end, **east** side of tracks, within ROW	Scat deposited in 2010 in "greenbelt"
2. Anterior half of plastron of adult female, dead > 4 years	±3.6 miles south of north end, **east** side of tracks, within ROW	See Exhibit I1 (all tortoise exhibits are in Appendix I)
3. 210 mm burrow of adult tortoise with no recent activity	±7 miles south of north end, **west** side of tracks, within ROW	Burrowing owl pellet at burrow but no tortoise sign
4-6. 2 fresh scat of adult tortoise and 1 fresh scat of subadult tortoise	Between 9.0 and 9.75 miles south of north, all on **west** side of tracks, within ROW	These scat, from at least two different tortoises were deposited in 2010
7. 12 scattered pieces of shell and leg bone of adult tortoise, dead > 4 years	±12 miles south of north, on **east** side of tracks, within ROW	Gender of tortoise and cause of death unknown
8. 3 small pieces of marginal bone of adult tortoise, dead > 4 years	In the vicinity of Chubbuck, on **east** side of tracks, within ROW	Gender of tortoise and cause of death unknown
9-11. 3 fresh scat of adult tortoise	At point where Old Woman Mountains meet ROW, **west** side of tracks	Large trestle in this area allows ready access to tortoises either side of tracks
12. Caliche cave with five older scat of an adult tortoise	Where Old Woman Mountains meet ROW, ±1,600 feet **north**	Found during subsequent zone of influence transects
13. Dirt burrow of an adult tortoise with no scat but active given excellent condition	Where Old Woman Mountains meet ROW, ±1,000 feet **north**	Found during subsequent zone of influence transects; see Exhibit I4
14. Portion of plastron of subadult tortoise, dead 1-4 years ago	East of Old Woman Mountains as mapped, ±1,700 feet **north** of Milligan	Found during subsequent zone of influence transects; see Exhibit I2
15. Single piece of carcass, age class unknown, dead > 4 years	±11 miles north of south end, on **west** side of tracks, within ROW	Gender of tortoise and cause of death unknown
16. Single piece of carcass, age class unknown, dead > 4 years	±4,500 feet north of south end, on **west** side of tracks, within ROW	Gender of tortoise and cause of death unknown

The following interpretations are provided relative to these findings:

● Importantly, an approximately equal amount of tortoise sign was found on the north and east side of the tracks (7 items) compared to the south and west side (9 items). Since the elevated berm and railroad tracks atop the berm likely serve as permeable barriers (i.e., tortoises may move under trestles but are less likely able to cross the rail line), these observations suggest that tortoises are as likely to occur on one side as the other within the ARZC ROW.

● Though spread throughout the entire ROW, most of the sign (13 of 16 items, 81%) are found from Old Woman Mountains to the north. All of the evidence of *living* tortoises was found north of Old Woman Mountains; only carcasses were found east and south of the mountains. This suggests that tortoises are more likely to be encountered along the northern 25± miles of the ARZC ROW than along the southern 19± linear miles.

● Only 1 burrow was found within the ARZC ROW, and this one, not active. Therefore, tortoises are most likely resident (i.e., residing in primary burrows) located outside the ARZC ROW with occasional forays into what would be the construction impact area.

Tortoise sign found in proposed wellfield areas is described below in **Table 2**:

Table 2. Desert Tortoise Sign within Wellfield Areas (Figure C2)

Description	Location	Comment
1-2. 2 small pieces of adult tortoise, dead > 4 years	Section 8, near south boundary	Found only 300 feet apart and of similar time since death, these may be part of the same carcass (see Exhibit I3)
3. Leg bone of adult tortoise, dead > 4 years	Section 17, on west boundary	No other parts of carcass found
4. Small piece of *adult* carapace, dead > 4 years	Section 17, near north-center	Though only 700 feet from Item 5, definitely a different tortoise
5. Small piece of *subadult* carapace, dead > 4 years	Section 17, near north-center	Though only 700 feet from Item 4, definitely a different tortoise
6-7. 2 Fresh scat an adult tortoise(s) found in open	Section 17, southeast quadrant	At almost 1,200 feet apart, these scat may have been deposited by more than one tortoise
8. Tracks of adult tortoise	Section 18, south boundary in Schulyler Wash	Found within 350 feet of recently deposited adult tortoise scat
9-10. 1 Fresh and 1 older scat of adult tortoise(s)	Section 18, south boundary in Schulyler Wash	Fresh vs. older scat suggest residency of at least one tortoise
11. Small piece of juvenile/ subadult carcass, dead > 4 years	Section 18, south boundary just outside Schulyler Wash	None
12-13. 2 Caliche caves within several feet of each other, 1 with 4 fresh adult scat and the 2nd with 1 fresh adult scat	Section 18, northeast corner associated with Schulyler Wash	Given their proximity, the same tortoise likely is using these two proximate caliche caves
14. 20 scattered pieces of adult tortoise, dead >>> 4 years	Section 35, southwest corner	There is evidence given the time since death and association with tank tracks (Exhibits I5 & I6) that this tortoise likely died in the tank tracks; anomalous in that no other tortoise sign was found this far west (i.e., 3.25 miles southwest of the next nearest tortoise sign)

The following interpretations are provided relative to these findings:

● 13 out of 14 pieces of sign (93%), including all evidence of living tortoises, was found in the three easternmost sections, including Sections 8, 17, and 18. The only tortoise sign found outside these sections was that of an adult tortoise that apparently died in the 1940's as a result of military maneuvers. From these observations, it appears that tortoises are mostly or completely absent from 8 out of 11 sections, and most likely to be encountered in the three, easternmost sections.

● Schulyler Wash appears to be an important resource to tortoises, with 6 of 14 pieces of sign (43%) found in proximity to this large wash. Tortoises may use this wash as a travel corridor and/or they are relying on resources provided by the wash that apparently concentrates their use in this area.

● Although no tortoise sign was found at the conceptual spreading basin area, it is the easternmost of the Project components, contains some of the most pristine habitats (i.e., with only a few Patton-era tank tracks observed), and is surrounded by undeveloped lands of equal or greater value.

3.2.3. *Desert Tortoise Literature Findings*. In March, April, and June 1999, Ed LaRue led several different biological field crews on the initial surveys of the then-proposed Cadiz pipeline project (CMBC 1999). The 1999-proposed alignment was the same as the current alignment between Cadiz and Chubbuck, where the 1999-proposed alignment then diverged to the southwest through Kilbeck Hills and along either side of Iron Mountains. During that survey, most of the tortoise sign was found east and south of Iron Mountains (well south and west of the current alignment), with a single, older scat of an adult tortoise found several miles north of Chubbuck, within the current alignment / ARZC ROW (CMBC 1999, page 13).

Relative to the wellfield areas, in 1999 two suspect tortoise burrows were found within 300 feet south and west of the pilot spreading basins (CMBC 1999, pages 13 and 14) that were subsequently constructed in Section 13 of the proposed wellfield area. LaRue cited several reasons why these burrows were then considered to be suspect and likely not created by tortoises. Given the plethora of non-tortoise burrows found during the current study (see Burrowing Owl in Section 3.2.2.a., below), the absence of definitive tortoise sign in the vicinity of the pilot spreading basins (CMBC 1998), and the absence of definitive tortoise sign in Section 13 and elsewhere south and west during the current study, LaRue still considers that these were not tortoise burrows.

According to the proposed project map in the Draft EIR for the El Paso natural gas line (U.S. Bureau of Land Management and California State Lands Commission 2004, pages 1-3), Mile Points 220 through 260 occur in the vicinity of the Project proposed pipeline alignment. The El Paso pipeline follows Cadiz Road from near the north end of the ARZC ROW to the southwestern tip of Old Woman Mountains, where it diverges from the ARZC ROW to the southwest and rejoins it near the southern end of Danby Lake. The El Paso Draft EIR (page 4-32) states that tortoises were encountered at Mile Points 109 and 273, which are outside the reaches coincident with the Project. It further indicates that "…an inactive burrow suitable for use by desert tortoise was observed on the Cadiz Lateral" (page 4-32) but does not specifically indicate the location.

In 1991, Dr. Alice Karl and staff conducted presence-absence tortoise surveys for the Bolo Rail Cycle Project, located 6 to 8 miles west of the western boundary of the Project wellfields (Karl 1992). They performed presence-absence surveys over 4,800 acres including peripheral areas, finding only 1 juvenile carcass onsite and four potential burrows in adjacent areas (*in* USFWS 1993, page 12). Dr. Karl concluded "Desert tortoises probably do not occupy the project site but are likely present in low densities in adjacent areas…Other project surveys…[at] agricultural development about seven miles east, yielded similar results" (*in* USFWS 1993, page 12).

3.2.4. *Observable Human Disturbances*. Long, linear projects such as the proposed pipeline along the 44-mile ARZC ROW do not lend themselves to traditional disturbance analyses where observable human disturbances are tallied on a per-unit basis. But given the construction of this rail line in the early 1900's, the continuing use of the tracks since that time, and the historical use of adjacent areas, the ARZC rail line has served as a focal point for concentrated human impacts.

There is a large amount of wood, metal, and glass debris strewn alongside the entire length of the tracks. Surveyors along the east side of the tracks tallied 484 bundles of railroad ties (visible in Exhibits G2, G4, and G7), apparently stored there for future track maintenance and repairs. The most concentrated areas of debris are at Chubbuck, a small mining community that was inhabited from the early 1920's through 1950's, and Milligan, where several brothers currently live, operating a salt mining operation on Danby Lake (see Exhibit G10). There are also extensive debris piles and habitat degradation at the abandoned rail line sidings at Archer and Milligan.

Most importantly, impacts and habitat loss are concentrated along the *west and south* sides of the ARZC rail line. Both creosote and saltbush communities have been severely degraded throughout and completely eliminated by a series of parallel roads along the *west and south* sides of the tracks. The loss of habitats from along the west side coupled with the flow and pooling of runoff along the east side of the tracks, juxtaposes contiguous areas that are severely impacted to the west and relatively more resourceful to the east. Though visible in most of the exhibits in Appendix G, this contrast is most striking in Exhibit I18 in Appendix I.

The consistent survey of transects spaced at 100-foot intervals throughout the proposed wellfield areas allows for direct comparisons among 9 of the 12 sections: Sections 8, 13, 17, 18, 22, 23, 24, 25, and 26. Sections 34 and 35 are only half sections, more than half of Section 27 is under fallow and active agriculture, and the northwest 160-acre parcel and 390-acre spreading basin are smaller, but all were surveyed in the same manner. Corresponding section numbers are depicted in **Figure 10**. **Table 3**, then, tabulates the prevalence of recent observable human disturbances tallied along $1/6^{th}$ of the transects surveyed (i.e., observed along the transects surveyed by LaRue on the 6-member survey team).

Figure 10. Section Numbers Corresponding with Proposed Wellfield Areas

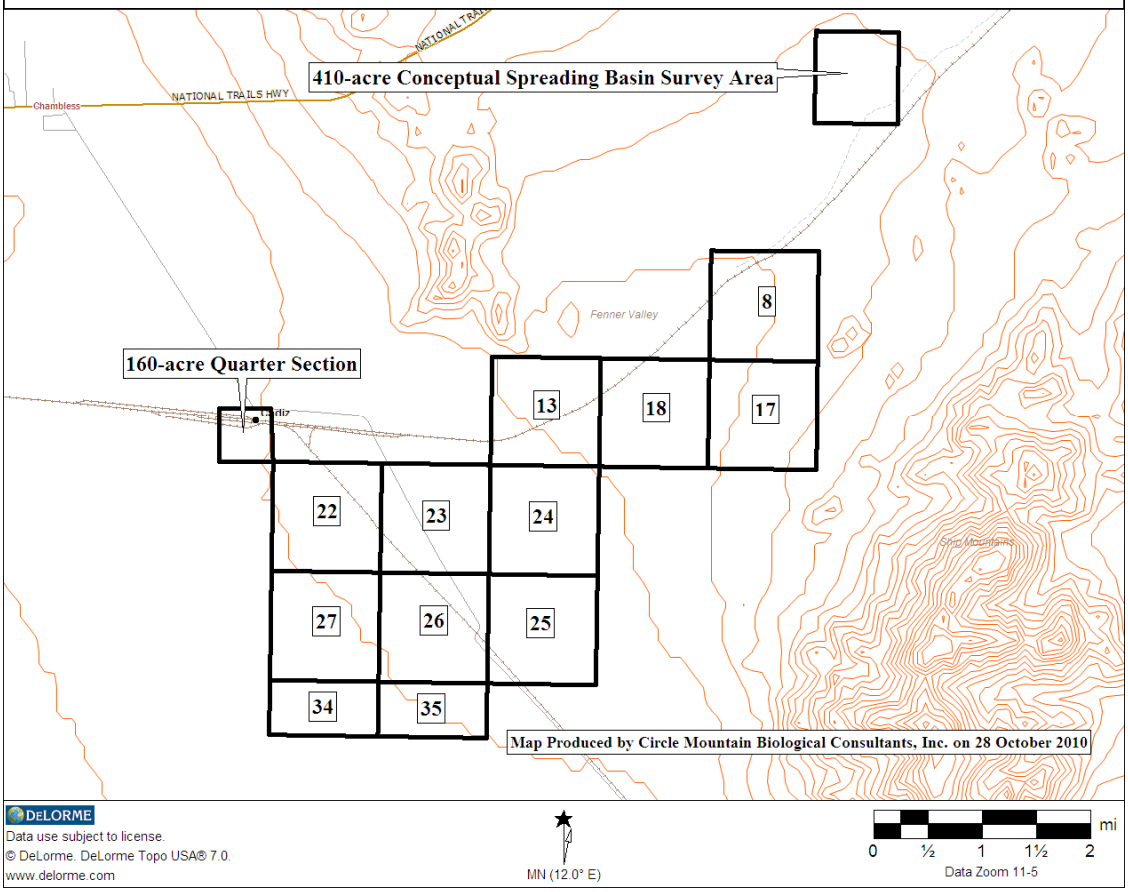


Table 3. Prevalence of Recent Human Disturbances Observed Among Wellfield Sections

		Observable Human Disturbances							
Section #	**OHV**	**Roads**	**Rail Line**	**Rifle**	**Dump**	**Dog**	**Camp Ring**	**Shot Gun**	**Totals ↓**
160a	19	8	3	5	10	5	-	1	**51 (204)***
13	67	62	10	2	-	-	3	1	**145**
18	45	30	5	-	-	-	-	-	**80**
8	50	23	5	-	1	-	-	-	**79**
26	32	21	6	1	1	2	2		**65**
22	33	22	4	-	2	-	-	-	**61**
23	21	11	2	5	3	-	1	2	**45**
35	5	9	-	1	-	-	-	1	**16 (32)***
25	10	13	-	1	-	2	-	1	**27**
34	2	6	-	2	1	2	-	-	**13 (26)***
24	9	4	-	1	-	-	-	-	**14**
17	5	4	-	1	-	-	-	-	**10**
Basin	4	1	-	-	-	-	-	-	**5**
Totals→	**302**	**214**	**35**	**19**	**18**	**11**	**6**	**6**	

First, Section 27 is excluded from Table 3 because disturbances were not tallied in those habitats that are so severely impacted by current and past agricultural uses that all native scrub habitats have been eliminated from that section, which is the most degraded of the wellfield areas. Since the 160-acre area and Sections 34 and 35 are smaller than the other square-mile sections, the 160-acre total tallies have been multiplied by 4 and Sections 34 and 35 tallies are multiplied by 2 so that they are comparable to the other larger sections.

The following interpretations are provided relative to these findings:

● Clearly, off highway vehicle (OHV) tracks and roads/dirt trails are the most common disturbances observed, and the most ubiquitous, as they were recorded in all sections.

● It is noteworthy that disturbance prevalence, particularly OHV tracks and roads, are associated particularly with the BNSF rail line but also the ARZC line. As such, the 4 highest disturbance tallies are associated with the 160-acre parcel and Sections 13, 18, and 8, which are all bisected by the BNSF. The next highest incidences are in Sections 26, 22, and 23, which are bisected by the ARZC. To further support this conclusion, the highest prevalence of disturbances are associated with Section 13 and the BNSF and Section 26 and the ARZC, which are the two sections with the longest stretches of rail line through them. Finally, the lowest disturbance prevalence, in Sections 24, 17, and conceptual spreading basin area do not have rail lines running through them.

● The distributions of various disturbances are also noteworthy:

• Most of the domestic dog sign is in the vicinity of Section 27 and the old town site of Cadiz. Dogs were seen on several occasions with Cadiz employees in the vicinity of the orchards and vineyards.

• Older dumps were found throughout the proposed wellfield areas, but were not tallied, as we focused on recent disturbances. Yet recent dumping is still most prevalent near the abandoned Cadiz site and in sections adjacent to Section 27 with its agricultural uses.

• Rifle cartridges are distributed throughout most areas, observed in 9 of the 13 areas, and were mostly associated with target practice. Shot gun shells were observed in the vicinity of one skeet shooting area but may be mostly associated with hunting small game, including rabbits and birds in wash areas.

• Rather than being associated with remote areas, camping areas – identified by campfire rings – were in the vicinity of the rail lines and are most prevalent in Sections 13 and 26 where relatively more of the rail lines bisect those sections.

These observations reveal that current human uses of the area are centered on the two rail lines bisecting the proposed wellfields. More remote areas, particularly Sections 24, 17, and the conceptual spreading basin area are significantly less impacted by roads, OHV traffic, and other observable disturbances. Although Patton-era impacts were not tallied as recent human impacts, they are prevalent and have likely impacted habitats in very significant ways.

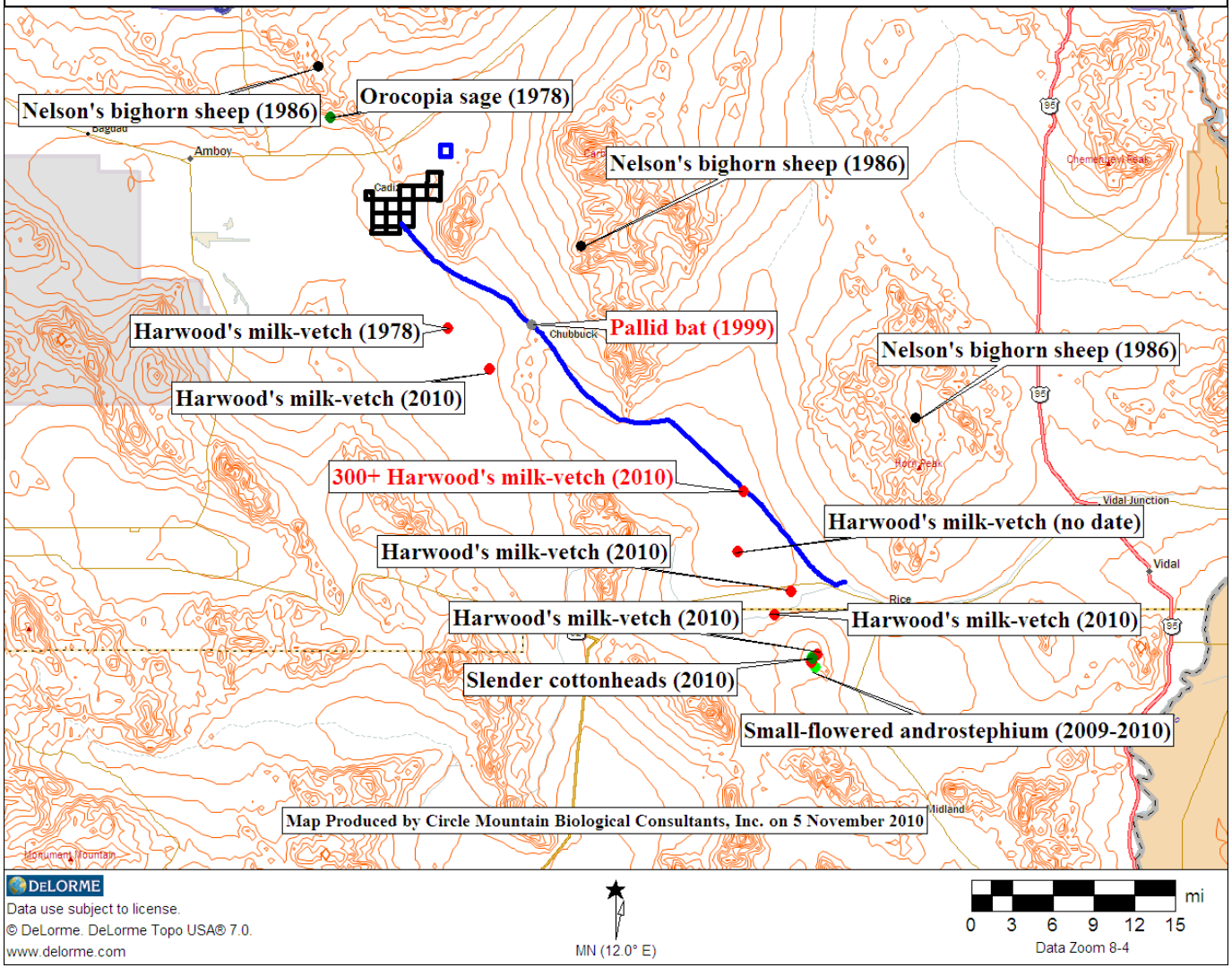
Tank tracks and other OHV tracks associated with military maneuvers in the 1940's were too prevalent to be counted, but they occur throughout the region south of the BNSF rail line. It is noteworthy that only several obvious tank tracks were observed in the conceptual spreading basin area north of BNSF compared to hundreds of tracks in a comparably-sized section south of the BNSF line. There are also earthen ramps, pits, and piles of rusty cans that are distributed across the landscape, suggesting that maneuvers involved many men over a broad regional area.

Herein, we map only those tortoise carcasses that died in recent history, typically within the past 1 to 10 years. However, we did find three or four mineralized carcass fragments that were not mapped. Dr. Brian Henen of the Twentynine Palms Marine Corps Base has suggested that these may be either water turtles or tortoises (personal communication to LaRue in 2009), and they may be from several hundred to several thousand years old. As such, they are not indicators of recent tortoise occupancy and are consequently not mapped.

We did, however, find the carcass of an adult tortoise that was intermediate in its time since death; it had not died in the past 10 years but nor was it mineralized like the fragments described above. It was rock-like in appearance and texture, but unlike the mineralized bone fragments, readily broke when minimal pressure was applied. Approximately 20 scattered pieces of this carcass were found more than three miles west of all the other tortoise sign. Upon closer inspection, we noted that the pieces lay within and adjacent to two old OHV tracks that were sufficiently wide that they were judged to be tank tracks or some other military vehicle. Depicted in Exhibits I5 and I6 in Appendix I, these are compelling evidence that military maneuvers had some, albeit unknown level of impact on tortoises during the early 1940 maneuvers.

3.2.5. *Other Special Status Species*. U.S. Fish and Wildlife Service (2002a), California Department of Fish and Game (2009, 2010b), and California Native Plant Society (CNPS 2010) maintain lists of animals and/or plants considered rare, threatened, or endangered, which are collectively referred to as "special status species." As reported in the following sections, some of these species were observed during CMBC's 2010 surveys of the ARZC ROW, wellfield areas, and conceptual spreading basin. Surveys conducted included protocol level surveys for desert tortoise, burrowing owl, and rare plants. The main literature sources for this section include CDFG's California Natural Diversity Data Base (CDFG CNDDB 2010a), CMBC (1999), Metropolitan Water District of Southern California and U.S. Bureau of Land Management (MWD & BLM 1999), and U.S. Bureau of Land Management and California State Lands Commission (BLM CSLC 2004). Species locations reported to the CDFG CNDDB (2010a) are shown on the next page in **Figure 11**. Current status designations, Latin names, and common names are taken from lists provided in CDFG (2009) for Special Animals and CDFG (2010b) for Special Plants.

Figure 11. Special Status Species in CDFG CNDDB (2010a)



3.2.5.a. *Special Status Plants*. CMBC's 2010 surveys were not performed at an appropriate time of year to detect most of the special status plant species that may occur in the region. There are generally two types of special status plants, depending on the organization that designates them. Most species considered rare by CDFG and/or USFWS are identified by the California Native Plant Society (2010), which lists plants according to their rarity, distribution, and level of threat to the species. These are the typical plants considered in biological technical reports and impacts analyses. In the 1999 analysis (MWD & BLM 1999), biologists considered the presence/absence of 22 different species, many of which are not known from the region.

Table 4 lists these plants and, based on the 2010 field survey findings, judges their likelihood of occurrence within the project area. Focused surveys performed in 1995 (Tierra Madre Consultants, Inc. 1995) and 1999 (Circle Mountain Biological Consultants 1999) are referenced where appropriate. None of these plants is designated by either the CDFG or USFWS. Status designations given in the third column are assigned by CNPS (2010). Codes presented in the table are described as follows. Although there are five lists (i.e., List 1A, List 1B, List 2, List 3, and List 4) and three Threat Ranks, only those applicable to the plants reported from the region are listed below.

Environmental Science Associates (ESA) conducted protocol rare plant surveys along the pipeline route study area in April 2011. The CNDDB (USGS 7.5 minute topographic quadrangles: Cadiz Lake NW, Cadiz Lake NE, Chubbuck, Milligan, Danby Lake, and Africa Mountains) and CNPS online databases were queried to develop a list of special status and rare plant species that have been previously recorded in the Project region, along with this report. Field surveys were focused on 21 plant species identified through the database search results and other research, which were determined to have a medium potential to occur within the pipeline route study area based on the proximity of the project to previously recorded occurrences in the region, on-site vegetation and habitat quality, topography, elevation, soils, surrounding land uses, habitat preferences, and geographic ranges of special status plant species known to occur in the region.

List 1B: Plants Rare, Threatened, or Endangered in California and Elsewhere
The plants of List 1B are rare throughout their range with the majority of them endemic to California. Most of the plants of List 1B have declined significantly over the last century. List 1B plants constitute the majority of the plants in CNPS' Inventory with more than 1,000 plants assigned to this category of rarity. All of the plants constituting List 1B meet the definitions of Section 1901, Chapter 10 (Native Plant Protection Act) or Sections 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and are eligible for state listing. *It is mandatory that they be fully considered during preparation of environmental documents relating to CEQA* [Emphasis added].

List 2: Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere
Except for being common beyond the boundaries of California, the plants of List 2 would have appeared on List 1B. From the federal perspective, plants common in other states or countries are not eligible for consideration under the provisions of the Endangered Species Act. Until 1979, a similar policy was followed in California. However, after the passage of the Native Plant Protection Act, plants were considered for protection without regard to their distribution outside the state.

With List 2, we recognize the importance of protecting the geographic range of widespread species. In this way we protect the diversity of our own state's flora and help maintain evolutionary process and genetic diversity within species. All of the plants constituting List 2 meet the definitions of Sec. 1901, Chapter 10 (Native Plant Protection Act) or Secs. 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and are eligible for state listing. It is mandatory that they be fully considered during preparation of environmental documents relating to CEQA.

List 3: Plants About Which We Need More Information - A Review List

The plants that comprise List 3 are united by one common theme - they lack the necessary information to assign them to one of the other lists or to reject them. Nearly all of the plants remaining on List 3 are taxonomically problematic. For each List 3 plant we have provided the known information. Data regarding distribution, endangerment, ecology, and taxonomic validity will be gratefully received by e-mailing the Rare Plant Botanist at njensen@cnps.org or (916) 324-3816.

Some of the plants constituting List 3 meet the definitions of Sec. 1901, Chapter 10 (Native Plant Protection Act) or Secs. 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and are eligible for state listing. We strongly recommend that List 3 plants be evaluated for consideration during preparation of environmental documents relating to CEQA.

List 4: Plants of Limited Distribution - A Watch List

The plants in this category are of limited distribution or infrequent throughout a broader area in California, and their vulnerability or susceptibility to threat appears relatively low at this time. While we cannot call these plants "rare" from a statewide perspective, they are uncommon enough that their status should be monitored regularly. Should the degree of endangerment or rarity of a List 4 plant change, we will transfer it to a more appropriate list.

Very few of the plants constituting List 4 meet the definitions of Sec. 1901, Chapter 10 (Native Plant Protection Act) or Secs. 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and few, if any, are eligible for state listing. Nevertheless, many of them are significant locally, and we strongly recommend that List 4 plants be evaluated for consideration during preparation of environmental documents relating to CEQA. This may be particularly appropriate for the type locality of a List 4 plant, for populations at the periphery of a species' range or in areas where the taxon is especially uncommon or has sustained heavy losses, or for populations exhibiting unusual morphology or occurring on unusual substrates.

Threat Ranks

The CNPS Threat Rank is an extension added onto the CNPS List and designates the level of endangerment by a 1 to 3 ranking, with 1 being the most endangered and 3 being

the least endangered. A Threat Rank is present for all List 1B's, List 2's and the majority of List 3's and List 4's. List 4's may contain a Threat Rank of 0.2 or 0.3; however an instance in which a Threat Rank of 0.1 is assigned to a List 4 plant has not yet been encountered. List 4 plants generally have large enough populations to not have significant threats to their continued existence in California; however, certain conditions still exist to make the plant a species of concern and hence be placed on a CNPS List. In addition, all List 1A (presumed extinct in California), and some List 3 (need more information) and List 4 (limited distribution) plants, which lack threat information, do not have a Threat Rank extension.

- 0.1-Seriously threatened in California (high degree/immediacy of threat)
- 0.2-Fairly threatened in California (moderate degree/immediacy of threat)
- 0.3-Not very threatened in California (low degree/immediacy of threats or no current threats known)

Plant ranks found in Table 4 include the following:

List 1B.1 plant, indicating that it is Rare, Threatened, or Endangered in California and Elsewhere, and seriously threatened in California (high degree/immediacy of threat).

List 1B.2 plant, indicating that it is Rare, Threatened, or Endangered in California and Elsewhere, and fairly threatened in California (moderate degree/immediacy of threat).

List 1B.3 plant, indicating that it is Rare, Threatened, or Endangered in California and Elsewhere, and not very threatened in California (low degree/immediacy of threats or no current threats known).

List 2.2 plant, indicating that it is Rare, Threatened, or Endangered in California, But More Common Elsewhere, and fairly threatened in California (moderate degree/immediacy of threat).

List 2.3 plant, indicating that it is Rare, Threatened, or Endangered in California, But More Common Elsewhere, and not very threatened in California (low degree/immediacy of threats or no current threats known).

List 4.2. plant, indicating that it is of Limited Distribution - A Watch List, and fairly threatened in California (moderate degree/immediacy of threat).

List 4.3 plant, indicating that it is of Limited Distribution - A Watch List, and not very threatened in California (low degree/immediacy of threats or no current threats known).

Table 4. Plant Species Reported from the Area

Common Name	Scientific Name	Status Designation	Likelihood of Occurrence
Small-flowered androstephium	*Androstephium breviflorum*	List 2.2	Creosote bush scrub and desert dunes between 840 and 4,960 feet; found west of Iron Mountains in 1995 (also Figure 11); **suitable habitat throughout Project area**
White bear poppy	*Arctomecon merriamii*	List 2.2	Rocky soils in creosote bush scrub between 1,520 and 4,910 feet; not found in 1995 or 1999; **site is outside range and elevations are too low**
Harwood's milk-vetch	*Astragalus insularis var. harwoodii*	List 2.2	Sandy or gravelly desert dunes, desert scrub below 930 feet; 300+ plants between Danby Lake and Cadiz Road in 2010 (Figure 11); **suitable habitats and elevations along ARZC ROW and western wellfields**
Borrego milk-vetch	*Astragalus lentiginosus* var. *borreganus*	List 4.3	Sandy soils in creosote bush scrub between 90 and 840 feet; observed in 1995 east of Iron Mountain pumping plant and Cadiz Lake in sand field areas; **suitable habitats and elevations in western wellfields and sandy areas along ARZC ROW particularly near Danby Lake**
Crucifixion thorn	*Castela emoryi*	List 2.3	Deciduous shrub along gravelly washes, slopes, and plains in creosote bush scrub between 280 and 1,890 feet; not found in 1995 or 1999; **as a large shrub occurring in washes, this plant would have been found if present within the ARZC ROW**
Las animas colubrina	*Colubrina californica*	List 2.3	Evergreen shrub in creosote bush scrub between 30 and 3,100 feet; not found in 1995 or 1999; **as a large shrub occurring in washes, this plant (found by LaRue near Desert Center) would have been found if present within the ARZC ROW**
Alverson's foxtail cactus	*Coryphantha alversonii*	List 4.3	Rocky to cobbly soils in creosote bush scrub between 230 and 4,730 feet; found west of Iron Mountain in 1995; **suitable habitats in Section 17 and where Ship and Old Woman Mountains approach ARZC ROW**
Ribbed cryptantha	*Cryptantha costata*	List 4.3	Sandy soils in creosote bush scrub between 180 and 1,550 feet; found in 1995 at Cadiz Lake and in areas of stabilized dunes, but not along Cadiz Road; **suitable habitats east of Danby Lake**
Winged cryptantha	*Cryptantha holoptera*	List 4.3	Sandy to rocky soils in creosote bush scrub between 310 and 3,720 feet; not found in 1995 or 1999; **suitable habitats throughout**
Utah vine milkweed	*Cynanchum utahense*	List 4.2	Dry sandy, gravelly soil in creosote bush scrub between 465 and 4,400 feet; not found in 1995 or 1999; **suitable habitats throughout**

Common Name	*Scientific Name*	Status Designation	Likelihood of Occurrence
Howe's hedgehog cactus	*Echinocereus engelmannii var. howei*	List 1B.1	In creosote bush scrub between 1,333 and 2,400 feet; not found in 1995 or 1999; **elevations too low to be suitable**
Little San Bernardino Mountains linanthus	*Linanthus maculatus*	List 1B.2	Sandy soils in creosote bush scrub between 604 to 6,030; not observed in 1995 or 1999; **found in the vicinity of Joshua Tree, the Project area is well outside the known range of the species**
Spear-leaf matelea	*Matelea parvifolia*	List 2.3	Dry rocky soils in creosote bush scrub between 1,360 and 3,390 feet; not found in 1995 or 1999; **elevations too low to be suitable**
Robison's monardella	*Monardella robisonii*	List 1B.3	Pinyon-juniper woodland between 1,890 and 4,650; not found in 1995 or 1999; **site is outside range and elevations are too low**
Slender cottonheads	*Nemacaulis denudate* var. *gracilis*	List 2.2	Sandy slopes above drainage at 1,560 feet; found in Arica Mountains in 2010 (Figure 11); **suitable habitats and elevations along ARZC ROW and western wellfields**
Short-joint beavertail cactus	*Opuntia basilaris* var. *brachyclada*	List 1B.2	Creosote bush scrub between 1,320 and 5,580 feet; not found in 1995 or 1999; **site is outside range and elevations are too low**
White-margined beardtongue	*Penstemon albomarginatus*	List 1B.1	Sandy soils, stabilized dunes, roadside washes in creosote bush scrub between 1,980 and 3,300 feet; **elevations too low to be suitable**
Stephen's beardtongue	*Penstemon stephensii*	List 1B.3	Carbonate or rocky soils in creosote bush scrub between 3,500 and 5,720 feet; not found in 1995 or 1999; **elevations too low to be suitable**
Lobed ground-cherry	*Physalis lobata*	List 2.3	Decomposed granite in creosote bush scrub between 1,550 and 2,480 feet; not found in 1995 or 1999; **elevations too low to be suitable**
Orocopia sage	*Salvia greatae*	List 1B.3	Broad alluvial bajadas and fans beside washes in creosote bush scrub between 120 and 2,500 feet; found in Marble Mountains in 1978 (see Figure 11); **potentially suitable habitats in Section 17 and where Ship and Old Woman Mountains approach ARZC ROW**
Rusby's desert-mallow	*Sphaeralcea rusbyi* var. *eremicola*	List 1B.2	Creosote bush scrub between 3,020 and 4,650; not observed in 1995 or 1999; **elevations too low to be suitable**

The second broad category of protected plants relates to county and state ordinances. At the county level, the San Bernardino County Development Code was revised and adopted on 12 April 2007. Chapter 88.01 Plant Protection and Management, Section 88.01.020 states, "The provisions of this Chapter apply to the removal and relocation of regulated trees or plants and to any encroachment (for example, grading) within the protected zone of a regulated tree or plant on all private land within the unincorporated areas of the County and on public lands owned by the County, unless otherwise specified..."

Section 88.01.060 Desert Native Plant Protection states, "This Section provides regulations for the removal or harvesting of specified desert native plants in order to preserve and protect the plants and to provide for the conservation and wise use of desert resources…"

Section 88.01.060(c) Regulated Desert Native Plants states, "The following desert native plants or any part of them, except the fruit, shall not be removed except under a Tree or Plant Removal Permit in compliance within Section 88.01.050 (Tree or Plant Removal Permits):

(1) The following desert native plants with stems two inches or greater in diameter or six feet or greater in height:
(A) *Dalea spinosa* (smoke tree).
(B) All species of the genus *Prosopis* (mesquites).
(2) All species of the family *Agavaceae* (century plants, nolinas, yuccas).
(3) Creosote Rings, 10 feet or greater in diameter.
(4) All Joshua trees.
(5) Any part of the following species, whether living or dead:
(A) *Olneya tesota* (desert ironwood).
(B) All species of the genus *Prosopis* (mesquites).
(C) All species of the genus *Cercidium* (palo verdes)."

At the state level, the 1998 Food and Agricultural Code, Division 23: California Desert Native Plants, Chapter 3: Regulated Native Plants, Section 80073 states: The following native plants, or any parts thereof, may not be harvested except under a permit issued by the commissioner or the sheriff of the county in which the native plants are growing:

(a) All species of the family Agavaceae (century plants, nolinas, yuccas).
(b) All species of the family Cactaceae (cacti), except for the plants listed in subdivisions (b) and (c) of Section 80072 (i.e., saguaro and barrel cacti), which may be harvested under a permit obtained pursuant to that section.
(c) All species of the family Fouquieriaceae (ocotillo, candlewood).
(d) All species of the genus *Prosopis* (mesquites).
(e) All species of the genus *Cercidium* (palo verdes).
(f) *Acacia greggii* (catclaw acacia).
(g) *Atriplex hymenelytra* (desert holly).
(h) *Dalea (Psorothamnus) spinosa* (smoke tree).
(i) *Olneya tesota* (desert ironwood), including both dead and live desert ironwood.

Barrel cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree are the plant species included in one or both of the above lists that were observed on the subject property.

3.2.5.b. *Burrowing Owl*. Sometimes referred to as "western burrowing owl," burrowing owl (*Athene cunicularia*) is a California Species of Special Concern and, except for its designation as "BLM Sensitive," has no federal designation. Along with desert tortoise, burrowing owl was one of the two target species sought by focused surveys conducted by CMBC in September and October 2010.

As depicted in **Figure D1** for the pipeline alignment and **Figure D11** for the proposed wellfield areas, CMBC found the following evidence of burrowing owl in these two Project areas:

Cadiz Pipeline Alignment / ARZC ROW
3 Rodent colonies with sign
1 Rodent colony where a single owl was flushed
4 Unknown burrows with sign
1 bundle of railroad ties used as a perch site with sign

Cadiz Wellfield Areas

Section 8	0 owls and 0 active burrows
Section 13	1 owl and 2 active burrows
Section 17	1 owl and 2 active burrows
Section 18	0 owls and 8 active burrows
Section 22	2 owl and 2 active burrows
Section 23	2 owls and 3 active burrows
Section 24	1 owl and 2 active burrows
Section 25	0 owls and 1 active burrow
Section 26	0 owls and 0 active burrows
Section 27	0 owls and 0 active burrows
Half-Section 34	0 owls and 3 active burrows
Half-Section 35	0 owls and 0 active burrows
160-acre Parcel	0 owls and 0 active burrows
Spreading Basin	0 owls and 1 active burrows

As mentioned in Section 2.3, for burrowing owl, there are four types of burrows available for use by owls, which may modify existing burrows but rarely create their own: larger rodent colonies, inactive kit fox dens, badger digs, and single-entrance burrows created by an unknown source (ambiguous burrows likely created by badger or kit fox). Caliche caves are one additional location where burrowing owl sign was found. Since this is a formal Phase 1 and Phase II habitat assessment, it is prudent to report the results of (1) burrow types occupied by owls and (2) burrow types available to owls (excluding available caliche caves, which were not counted), which will then allow us to determine the relative values of a given area for this species.

Table 5 reports the burrow types occupied by burrowing owls in the pipeline alignment / ARZC ROW and wellfield areas. Within each column, the numbers of owls observed are shown in red font and the numbers of occupied burrows are shown in blue font.

Table 5. Burrow Types Occupied by Burrowing Owl

	Types of Burrows Occupied				
Project Area	**Colonies**	**Unknown**	**Kit Fox**	**Badger**	**Other**
Pipeline	1 + 3	4	-	-	1 Tie bundle
Wellfield	1 + 1	2 + 10	1 + 5	1 + 1	3 Caliche 2 No Burrows
Totals	**2** + **4**	**2** + **14**	**1** + **5**	**1** + **1**	**2** + **4**

The following observations are provided relative to these findings:

- Burrowing owls have been observed at all four burrow types; 2 were flushed from areas where no burrows were found (i.e., "2 No Burrows"). Four of the 6 owls observed at burrows occurred at colonies and unknown burrows, with the other 2 owls flushed from an inactive kit fox den and badger dig.
- Of the 24 burrows observed where owl sign was found, 14 (58%) occurred at unknown burrows, 5 (21%) occurred at inactive kit fox dens, 4 (17%) occurred at colonies, and 1 (4%) occurred at a badger dig.

These results indicate that although burrowing owls may be found at all burrow types, their sign is most often detected at unknown burrows and kit fox dens, which included 79% of the occupied burrow types. Another important consideration, then, is the availability of each of each burrow types. Which burrow types are most and least common in the Project area? Whereas the wellfield sections are obvious ways to segregate the data for those areas, the pipeline alignment / ARZC ROW is less obvious. For purposes of reporting the results in **Table 6** and providing the comparisons given in Table 5, the pipeline alignment / ARZC ROW is segregated into 9 reaches including Areas 1 through 8 that are each about 5 linear miles and Area 9, which is the residual area of about 4 linear miles (see Figure D1 in Appendix D). Data for each Area is presented in descending order, with the most burrows in the top row and least at bottom.

Table 6. All Burrow Types Available along the Pipeline Alignment / ARZC ROW

Types of Available Burrows					
Project Area	**Colonies**	**Unknown**	**Kit Fox**	**Badger**	**Totals**
Area 7	85	36	25	12	**158**
Area 6	104	31	8	8	**151**
Area 2	119	21	2	4	**146**
Area 8	91	14	8	6	**119**
Area 3	60	37	2	12	**111**
Area 4	48	11	4	4	**67**
Area 9	41	12	9	3	**65**
Area 1	21	7	0	1	**29**
Area 5	7	11	3	3	**24**
Totals	**576 (66%)**	**180 (21%)**	**61 (7%)**	**53 (6%)**	**870**

The following interpretations are provided relative to these findings:

● The prevalence of burrows in descending order is 576 colonies, 180 unknown burrows, 61 kit fox dens, and 53 badger digs.

● By comparing these data with the data summarized in Table 5, although the 576 colonies comprise the most available burrow type (66%), owl sign was found at relatively fewer colonies (17%) than other burrow types, excepting badger digs, comprising 4%.

● Interestingly, most burrows were found in Areas 2 and 3 between Ship and Old Woman Mountains and in Areas 6, 7, and 8, which are southeast of Old Woman Mountains. The fewest burrows were found in Area 1 west of Ship Mountains and Area 5 west of Old Woman Mountains. The prevalence of burrows in Areas 2, 3, 6, 7, 8, and 9 is due to the open sandy substrates comprising those reaches compared to the rocky, cobble-strewn substrates in Areas 1, 4, and 5 where the fewest numbers of burrows were found.

● In fact, of the 9 places where owls were detected, 4 signs were in Area 2, 1 sign was in Area 3, and 3 signs were in Area 6. So, 8 of 9 signs (89%) of the detected burrowing owl signs were found at burrows in Areas 2, 3, and 6.

● These data will be very useful in designing focused breeding bird surveys by identifying those areas where burrowing owls are most likely to occur.

Similar to Table 5, in **Table 7** all available burrow types are shown, with wellfield sections presented in descending order from most to fewest total burrows.

Table 7. All Burrow Types Available within Wellfield Areas

Types of Available Burrows					
Project Area	**Colonies**	**Unknown**	**Kit Fox**	**Badger**	**Totals**
Section 13	184	12	13	6	**215**
Section 24	104	56	17	5	**182**
Section 18	118	30	9	20	**177**
Basin	118	35	12	3	**168**
Section 23	122	31	9	2	**164**
Section 25	118	24	12	3	**157**
Section 26	137	12	2	0	**151**
Section 22	113	7	2	2	**124**
Section 8	86	14	5	5	**110**
Section 17	44	13	1	9	**67**
Section 35	54	3	4	0	**61**
Section 34	31	8	2	3	**44**
160 acres	12	2	0	1	**15**
Section 27	10	3	0	0	**13**
Totals	**1251 (76%)**	**250 (15%)**	**88 (5%)**	**59 (4%)**	**1648**

The following interpretations are provided relative to these findings:

● The prevalence of available burrow types is in the same descending order of prevalence observed along the pipeline ROW, namely colonies, then unknown burrows, then inactive kit fox dens, and finally badger digs.

● There are relatively more colonies within the wellfield areas (76%) than along the pipeline alignment / ARZC ROW (66%) and relatively more unknown burrows along the pipeline alignment / ARZC ROW (21%) than in the wellfield areas (15%).

● Though one of the least disturbed, pristine sections within the wellfield areas, Section 17 has a depressed number of burrows because, like the ARZC ROW in the vicinities of Ship and Old Woman mountains, substrates are relatively more rocky in Section 17 than in any other section.

● In descending order of prevalence, owls sign was found in the following sections: Section 18 (8 occupied burrows), Section 23 (2 owls, 3 burrows), Section 22 (2 owls, 2 burrows), Sections 13, 17, and 24 (each with 1 owl, 2 burrows), half-Section 34 (3 burrows), and Section 25 and the spreading basin (each with 1 burrow). There seems to be no clear relationship between the numbers of available burrows and the prevalence of owl sign.

● Although there are suitable burrows for burrowing owls throughout the wellfield areas (excepting Section 27 with its prevalence of agricultural impacts), the sections identified in the preceding bullet will help direct the locations of focused burrowing owls breeding surveys.

In general, these data and observations suggest that burrowing owls may occupy any of the four available burrows, and caliche caves. They are more likely to occur in sandy areas than in rocky areas, the latter of which support fewer burrows for burrowing owls to occupy.

3.2.5.c. *Cooper's Hawk*. Cooper's hawk (*Accipiter cooperii*) is included on CDFG's Watch List and has no federal status. Although none was observed along the ARZC ROW, 6 were observed during the wellfield surveys (see Figure E2), including several that were flushing small passerine birds from orchards. There are both resident and migratory populations in southern California, and those observed at this time of year were likely to be migrants. Cooper's hawk is more likely to forage than nest in the Project area.

3.2.5.d. *Prairie Falcon*. Prairie falcon (*Falco mexicanus*) is included on CDFG's Watch List and is designated by CDFG as a USFWS Bird of Conservation Concern. Figures E1 and E2 show locations of 5 prairie falcons observed along the ARZC ROW and 6 observed during surveys of the wellfields. Prairie falcons were observed chasing mourning doves near the lime orchard in Section 27 and likely depredate birds throughout the Project area, where there is suitable foraging habitat. They likely nest in the Ship and Old Woman Mountains, but would not nest in the immediate Project area.

3.2.5.e. *Vaux's Swift*. Vaux's swift (*Chaetura vauxi*) is a California Species of Special Concern and not federally designated. A single bird was observed passing over the southern portion of the ARZC ROW in late September. A seasonal migrant through the area, Vaux's swifts may be observed in the spring and fall but would not nest and forage minimally in the Project area.

3.2.5.f. *LeConte's Thrasher*. LeConte's thrasher (*Toxostoma lecontei*) is designated by CDFG as a California Species of Special Concern and identified by CDFG as a USFWS Bird of Conservation Concern. Individual LeConte's thrashers were observed in two places, including 1 along the east side of Danby Lake (Figure E1) and 1 at the conceptual spreading basins (Figure E2). The species is very secretive and likely more common than observed. Two were reported in Schulyler Wash and 1 at an undisclosed place in the conceptual spreading basins during previous surveys (MWD and & BLM 1999, page 41). All sandy-bottom, well-developed washes with streamside growth are considered ideal habitats for this species, which will both nest and forage in such habitats.

3.2.5.g. *Loggerhead Shrike*. Loggerhead shrike (*Lanius ludovicianus*) is designated as a California Species of Special Concern and has no federal status. They appear to be the most common special status bird species in the region. Shrikes were identified by sight and sign during CMBC's surveys. **Figures E1 and E2** in Appendix E show the locations of 6 shrikes observed along the ARZC ROW and 14 that were observed within the wellfield areas, respectively. However, since shrikes regurgitate distinctive pellets that can be readily identified in the field, Figure E1 shows 93 additional locations, including 58 under train trestles and 35 at bundled railroad ties, where loggerhead shrikes have recently occurred. Loggerhead shrike apparently occurs throughout the Project area, would nest in larger trees particularly alongside washes, and is one of several species that may actively seek out railroad trestles for various resources, including perch sites and foraging.

The six bird species listed above were the only ones detected during the 2010 surveys. **Table 8** below lists the other bird species reported from the region (MWD & BLM 1999) that were not observed in 2010 and their status designations. In the third column, the first status designation is for CDFG followed by its federal designation, if any (CDFG 2009).

Table 8. Special Status Bird Species Previously Reported But Not Observed in 2010

Common Name	Scientific Name	Status Designation	Reported Occurrence
Northern harrier	*Circus cyaneus*	Species of Special Concern None	1 observed in 1999 near Iron Mountain
Sharp-shinned hawk	*Accipiter striatus*	Watch List None	2 observed in 1999 in agricultural areas
Swainson's hawk	*Buteo swainsoni*	Threatened Bird of Conservation Concern	Not reported but likely to occur as incidental migrant
Ferruginous hawk	*Buteo regalis*	Watch List Bird of Conservation Concern	2 observed in 1999 in agricultural areas

Common Name	Scientific Name	Status Designation	Reported Occurrence
Golden eagle	*Aquila chrysaetos*	Watch List Bird of Conservation Concern	1 observed west of Iron Mountain in 1999
Merlin	*Falco columbarius*	Watch List None	Not reported but likely to occur as incidental migrant
Western snowy plover	*Charadrius alexandrinus nivosus*	Species of Special Concern Bird of Conservation Concern	Not reported but may occur in suitable habitats on Danby Lake
Mountain plover	*Charadrius montanus*	Species of Special Concern Bird of Conservation Concern	Not reported with potentially suitable habitats in fallow agricultural areas
Long-eared owl	*Asio otus*	Species of Special Concern None	1 observed in 1999 west of Iron Mountain in smoke tree wash

The 5 hawk species, 1 falcon species, and 1 owl species are all likely to occasionally forage over both natural desert scrub areas and some, like ferruginous hawk and merlin, to forage in agricultural areas. None of these species would nest in the Project area. No ideally suitable habitats exist within the Project area for either of the plover species.

3.2.5.h. *Special Status Mammals*. The two special status mammals detected during CMBC's 2010 surveys included pallid bat and American badger. Observations for these two species are given below, followed by Table 9, which lists other special status mammals reported from the region.

3.2.5.h.i. *Pallid Bat*. Pallid bat (*Antrozous pallidus*) is designated as a California Species of Special Concern and is not designated by the USFWS. The following information is taken from MWD & BLM (1999). Pallid bats are distributed from south-central British Columbia to central Mexico and frequent arid regions with rocky outcroppings, particularly near water. The gregarious species usually roosts in small colonies of 20 or more individuals in rock crevices and buildings, but occasionally roosts in caves, mines, and tree cavities. It feeds chiefly on large prey that is taken on the ground or perhaps less frequently in flight within a few meters of the ground or from surfaces of vegetation.

Previously, on 25 May 1999, a pair of pallid bats was observed at an active night roost at a train trestle east of Kilbeck Hills (CDFG CNDDB 2010b). Based on the 2010 survey, we now know that they are much more common in the Project area along the ARZC ROW than previously noted. Surveyors closely inspected approximately 70 train trestles for the presence or evidence of pallid bats. As shown in Figure F1 in Appendix F, surveyors observed 163 bats (Exhibits I13, I14, and I15) at 13 different trestles (Exhibits I16 and I17) located along the entire length of the rail line. Also indicated in Figure F1, there were 9 other trestles where bat guano was observed but not bats, and 45 trestles where neither bats nor guano were observed.

There are at least four different types of trestles, including cement (Exhibit I16 and I17), wood (Exhibit I20), a combination of the two, and corrugated culverts (Exhibit I22) along the ARZC ROW. Pallid bats were mostly observed at the cement and wood trestles, less so an at the combined type, and never in the corrugated culverts. Surveyors also checked a half-dozen similar trestles along the BNSF line in the wellfield areas but did not find any bats or guano. It may be that the heavy train traffic on the BNSF line compared to only 2 or 3 trips per day on the ARZC line precludes bats from the BNSF but not the ARZC ROW.

3.2.5.h.ii. *American Badger*. American badger (*Taxidea taxus*) is considered a Species of Special Concern by CDFG and has no federal designation. Found throughout California except the extreme northwest, badgers mostly prey on ground squirrels. As part of the burrowing owl habitat assessment, surveyors collected UTM coordinates for 53 badger digs along the ARZC ROW and 59 digs in the surveyed wellfield areas. They appear to be widespread throughout all Project areas.

3.2.5.g.iii. *Other Special Status Mammals*. Pallid bats and American badger were the only two rare mammals observed or detected. The previous analysis (MWD & BLM 1999) considered 10 additional bat species, southern grasshopper mouse, Yuma mountain lion, and Nelson's bighorn sheep which are included in **Table 9** on the next page. Each of these species is a California Species of Special Concern. Though not designated by either CDFG or USFWS, Nelson's bighorn sheep is included because it is considered sensitive by the BLM.

Table 9. Special Status Mammal Species Previously Reported But Not Observed in 2010

Common Name	Scientific Name	Status Designation	Reported Occurrence
California leaf-nosed bat	*Macrotus californicus*	Species of Special Concern None	Roosts in abandoned mine tunnels, open buildings, cellars, porches, rock shelters, and mines; not found in 1995 or 1999; **Project area within range**
Arizona myotis	*Myotis occultus*	Species of Special Concern None	May occur in desert areas near open water sources, roosting in mines and natural cavities; not found in 1995 or 1999; **Project area within range**
Cave myotis	*Myotis velifer*	Species of Special Concern None	Occurs in large colonies in caves but also mine shafts and buildings; not found in 1995 or 1999; **Project area within range**
Spotted bat	*Euderma maculatum*	Species of Special Concern None	Day roosts on open cliff faces in rock crevices; not found in 1995 or 1999; **Project area within range**

Common Name	Scientific Name	Status Designation	Reported Occurrence
Townsend's big-eared bat	*Corynorhinus townsendii*	Species of Special Concern None	Hibernate in caves and mines, feeding entirely on moths; not found in 1995 or 1999; **Project area within range**
Pocketed free-tailed bat	*Nyctinomops femorosaccus*	Species of Special Concern None	Roosts in crevices in rugged cliffs, slopes, and tall rocky outcrops; not found in 1995 or 1999; **Project area within range**
Big free-tailed bat	*Nyctinomops macrotis*	Species of Special Concern None	Inhabits rocky areas, roosting on cliff faces but also buildings; not found in 1995 or 1999; **Project area within range**
Western mastiff bat	*Eumops perotis californicus*	Species of Special Concern None	Most common in rugged, rocky canyons and cliffs; **observed foraging at Iron and Ship mountains and Kilbeck Hills in 1999** (MWD & BLM 1999, page 43-44)
Fringed myotis	*Myotis thysanodes*	Species of Special Concern None	Roosts in caves, mines, and buildings; **maternity colony reported 15 miles north of wellfields, may occur in Ship Mountains** (MWD & BLM 1999, page 44)
Southern grasshopper mouse	*Onychomys torridus ramona*	Species of Special Concern None	Located in sandy areas in Sonoran and Mojave deserts; **suitable habitat occurs in all Project areas**
Yuma mountain lion	*Puma concolor browni*	Species of Special Concern None	Prefers rocky and hilly terrain; not previously observed; **suitable habitats in Ship, Iron, and Old Woman mountains, and Kilbeck Hills**
Nelson's bighorn sheep	*Ovis canadensis nelsoni*	None BLM Sensitive	Prefers rocky and hilly terrain but may cross wide open areas between mountain ranges; **reported from Marble, Old Woman, and Turtle mountains (see Figure 11).**

CMBC is fairly certain that only pallid bats were observed at train trestles as described in Section 3.2.2.g.i., above. The Project area is within the known range of the other bat species. It would require focused echolocation studies to determine the occurrence of these and other bat species in the area. Similarly, it would require focused trapping studies to determine the presence and distribution of southern grasshopper mouse in the Project area. Though residents of regional mountainous areas, there is some potential for Yuma mountain lion and Nelson's bighorn sheep to occasionally enter the Project area en route to more suitable, mountainous habitats.

3.3. Other Protected Biological Resources. Stream courses provide relatively important resources to animals and plants. In dry years, and particularly during prolonged drought, annual plants may only germinate in the vicinity of washes where the water table is relatively near the surface. Perennial shrubs adjacent to washes are often the only plants that produce flowers and fruit, which in turn are important to insects and the avian predators that feed on them. Shrubs also tend to be somewhat taller and denser alongside washes, which provides cover for medium and larger sized animals that may use them as travel corridors. Biodiversity is generally enhanced by washes, and there are often both annual and perennial plants that are either restricted to or mostly associated with wash margins. There are both anecdotal accounts and published literature on washes being important to tortoises, which use them as travel corridors and access to nearby annual forage.

CMBC has prepared a separate report and jurisdictional delineation for the +/- 70 washes crossing the ARZC ROW and others, particularly Schulyler Wash, in the wellfield areas.

4.0. Conclusions and Recommendations

4.1. Impacts to the Desert Tortoise and Proposed Mitigation.

4.1.1. *Findings*. Though only one older scat of an adult tortoise had been found during previous surveys of the ARZC ROW between Cadiz and Chubbuck (Circle Mountain Biological Consultants 1999), during September 2010 as depicted in Figure C1, CMBC found 4 scat [3 from adult(s) and 1 from a subadult tortoise], 3 carcasses, and 1 burrow along the same ROW stretch. All evidence of living tortoises was found between the north end of the ARZC ROW and Old Woman Mountains, with three carcasses found to the south. Tortoises may be absent or occur in very low densities south of Old Woman Mountains and are not common anywhere along the ARZC ROW, apparently occurring in low densities along northern reaches.

In the wellfield areas (see Figure C2), evidence of living tortoises was restricted to Sections 17 and 18, with carcasses found in Sections 8 and 35. The carcass found in Section 35 appears to have died in the early 1940's and was the only tortoise sign found in central and western portions of the wellfield areas. Based on these results, CMBC concludes that tortoises are most likely to be encountered in the eastern wellfield areas (particularly Section 17 and 18, and perhaps Section 8) and least likely to be encountered elsewhere. Though not detected at the spreading basin area, habitats there are among the least impacted, most suitable, and tortoise(s) may occur there in the future, if not already (i.e., we cannot say that they are absent because a 100% coverage, along 30-foot transects, was not surveyed).

Protocol-level surveys were performed throughout the pipeline ROW but not in the wellfield or spreading basin areas. There may be tortoises present in these areas that would have been found along transects spaced at 30-foot intervals but were not detected along the transects we surveyed at 100-foot intervals. The results do likely show the regional pattern of occurrence for tortoises, with relatively higher densities to the east and lower densities or no tortoises in central and western portions of the wellfield areas. This level of effort is judged to be sufficient for purposes of preparing the Draft EIR analysis and would not change any of the recommended mitigation measures discussed below. Cadiz has indicated its willingness to perform more detailed surveys further along in the wellfield and spreading basin design process and/or at the request of pertinent regulatory agencies.

Regardless of survey results and conclusions given herein, tortoises are protected by applicable State and federal laws, including the California Endangered Species Act and Federal Endangered Species Act, respectively. As such, if a tortoise is found on-site at the time of construction, all activities likely to affect that animal(s) should cease and the County contacted to determine appropriate steps.

Importantly, nothing given in this report, including recommended mitigation measures, is intended to authorize the incidental take of desert tortoises during site development. Such authorization must come from the appropriate regulatory agencies, including CDFG (i.e., authorization under section 2081 of the Fish and Game Code) and USFWS [i.e., authorization under section 10(a)(1)(B) of the Federal Endangered Species Act].

4.1.2. *Impacts*. Even in low density areas, such as occur along the ARZC ROW and within wellfield and spreading basin areas, tortoises could be adversely affected by both authorized and unauthorized activities (e.g., routine maintenance or well development prior to formal Project authorization).

Although most of the pipelines interconnecting the north-south and east-west grids between extraction wells will be buried, during the installation of these pipelines (and the main water conveyance pipeline within the ARZC ROW) tortoises and occupied habitats are most likely to be adversely affected, as compared to other Project components. If in the proposed pipeline alignments during construction, a tortoise could be accidentally crushed or become entrapped if trenches are left open. The increased presence of construction personnel in the area will predictably attract both coyotes and ravens, which are documented predators of adult and subadult tortoises, respectively. Similarly, if the spreading basins result in standing water during percolation, both coyotes and ravens are likely to be attracted to and benefit from this new regional water source.

Future impacts may include crushing burrows and construction or personnel vehicles accidentally crushing tortoises crossing the road. Schulyler Wash is an apparently important resource to many animals, including tortoises, which seem to concentrate their activities along this wash. Impeding flow of water to this wash by installing pipelines or creating berms at the spreading basin may constitute an adverse indirect impact to tortoises that are not otherwise directly affected. The project area drainage should be returned to its previous condition.

The extraction of ground water is not likely to affect upland vegetation. There is existing evidence water has been pumped into the wellfield areas from existing wells, creating lush habitat where creosote bushes and other plants have already responded with greener foliage and taller statures. Again, tortoise predators may be attracted to these temporary inundation areas.

4.1.3. *Mitigation Measures*. In the past, the regulatory agencies have equated tortoise sign with occupied habitat; there is no requirement that an animal be observed on-site. Both the USFWS and CDFG have required incidental take permits when tortoise sign (not animals) was the only evidence found. In fact, on 20 March 2002 USFWS issued a biological opinion for the previously proposed Cadiz pipeline project (USFWS 2002b) even though no tortoises had been observed during CMBC's 1999 studies.

Given the findings of this study, development of the water conveyance pipeline, extraction wells, and some ancillary facilities may adversely impact the desert tortoise, depending on the locations of those facilities (i.e., impacts may be more likely north of Old Woman Mountains along the ARZC ROW and in eastern portions of wellfield areas). Since the tortoise is a State-listed species, any adverse impacts would be considered significant under CEQA. Since it is a threatened species, Cadiz will either need to avoid or mitigate the impact.

Project development could result in the loss of occupied habitat and potential injury or death to tortoises occurring on the site, which would constitute "take" under State (CESA) and federal endangered species acts (FESA). As such, prior to development, Cadiz will likely need incidental take permits from the CDFG and USFWS.

Both the CDFG and USFWS must authorize incidental take, since both State and federal governments list the tortoise as threatened. Although there are stream courses within the pipeline alignment and wellfield area that will require a *Streambed Alteration Agreement* from the CDFG, these watercourses are probably not under the jurisdiction of the U.S. Army Corps of Engineers. Despite this, other components of the project may trigger federal involvement. Section 7 of FESA is available when a federal agency *finds, authorizes, or carries out* some portion of the project that *may affect* the desert tortoise. The federal action may be the issuance of a permit under section 404 of the Clean Water Act by the U.S. Army Corps of Engineers for a project that affects a jurisdictional water of the U.S. This determination is made by the U.S. Army Corps of Engineers.

If a federal nexus is not identified, then development of the site would need to be authorized under authority of a federal section 10(a)(1)(B) incidental take permit (i.e., 10a permit) and a State section 2081 incidental take permit. The CDFG has the option, under Section 2080.1, to adopt the federal permit and allow it to authorize take at the State level as well. Regardless, take permits will identify both *minimization measures* and *mitigation measures* to offset the impacts.

Minimization measures are applied on-site at the time of construction. As the name implies, the intent of these measures is to minimize direct impacts to tortoises and

occupied habitat. These measures typically include hiring a biological monitor to remove all tortoises from harm's way. Importantly, this project may require that tortoises are moved out of harm's way but mass translocation would NOT be required. Tortoise awareness programs are given to construction personnel who are prohibited from driving cross-country, littering, bringing pets into the area, etc.

Mitigation measures are applied off-site. In every 10a permit issued thus far for the tortoise, proponents have purchased compensation lands in tortoise conservation areas. Given the location of the subject property outside a DWMA, the compensation ratio would be 1:1. For each acre of impact, one acre would be acquired and conserved for the tortoise. Given the Project site's proximity to the Chemehuevi DWMA, that would likely be the best critical habitat unit and DWMA in which to acquire compensation habitat.

Collectively, these measures are part of a *conservation strategy* that is intended to *fully mitigate impacts to the maximum extent practicable*, as required by the USFWS. The CDFG's fully mitigate standard is worded somewhat differently, but the conservation strategy outlined in the 2081 permit would be the same as in the federal permit. For compliance with FESA, consultation with the USFWS and U.S. Army Corps of Engineers would be required to determine whether section 7 or 10a would be applicable.

4.2. Impacts to Other Biological Resources and Proposed Mitigation.

4.2.1 *Other Special Status Species*. The following subsections identify those special status plants and animals and other biological resources that may or may not be affected by Project development.

4.2.1.a. *Special Status Plants*. Given the information presented herein, that these species are likely absent or would have been detected if present, CMBC judges that none of the following special status plant species reported from the area would be significantly affected by Project development: White bear poppy, crucifixion thorn, las animas colubrina, Alverson's foxtail cactus, Howe's hedgehog cactus, Little San Bernardino Mountains linanthus, spear-leaf matela, Robison's monardella, short-joint beavertail cactus, white-margined beardtongue, Stephen's beardtongue, lobed ground-cherry, Orocopia sage, and Rusby's desert-mallow.

There is some unknown potential for the following plant species to occur, as they would not have been detected during CMBC's September-October 2010 surveys: small-flowered androstephium, Borrego milk-vetch, ribbed cryptantha, winged cryptantha, Utah vine milkweed, and slender cottonheads.

The County may require a Desert Native Plant Assessment to identify the numbers and locations of protected plants to be in compliance with the County Plant Protection Ordinance and California Native Plant Protection Act (County of San Bernardino 2006). The following species are known to occur on or adjacent to the Project area and may therefore be adversely affected at unknown levels by Project development: Harwood's milk-vetch, barrel cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree.

Rare Plant surveys were conducted by ESA biologist along the pipeline ROW. Findings of this report are included under separate cover within an appendix of the Draft EIR.

4.2.1.b. *Special Status Birds*. Given the information presented herein, CMBC judges that none of the following special status bird species reported from the area would be significantly affected by Project development: Northern harrier, sharp-shinned hawk, Swainson's hawk, ferruginous hawk, golden eagle, merlin, or long-eared owl. These species may incidentally occur in the area and occasionally forage there but none of them would nest in the Project area, so no significant impacts are anticipated. Development of the water conveyance pipeline within the ARZC ROW, construction of the wellfield interconnecting pipelines, and other ancillary facilities will affect only a fraction of the 8,249 acres comprising the Project site. Vaux's swift, observed as an incidental migrant through the area would also not be affected.

The status of western snowy plover and mountain plover within the Project area remain unknown. Snowy plovers would occur, if at all, in association with one of the regional dry lakes, Danby Lake being the most proximate to the Project area. However, since the ARZC ROW is located some distance from barren portions of Danby Lake, impacts to snowy plovers is not likely. Mountain plover is more likely to occur in fallow agricultural areas, such as comprise Section 27. Again its status in the Project area is unknown and impacts, if any, remain unknown.

A presence/absence survey for Mountain plover should be conducted prior to construction within all fallow agricultural areas being impacted by project implementation to determine whether or not impacts to the species would occur.

Bird species encountered during CMBC's 2010 survey included: burrowing owl, Cooper's hawk, prairie falcon, LeConte's thrasher, and loggerhead shrike.

For **burrowing owl**, CDFG (California Department of Fish and Game 1995) has stipulated that the following should be considered impacts to the species:

> • *Disturbance within 50 meters (approximately 160 feet), which may result in harassment of owls at occupied burrows;*
>
> • *Destruction of natural or artificial burrows (i.e., culverts, concrete slabs, and debris piles that provide shelter to burrowing owls); and*
>
> • *Destruction and/or degradation of foraging habitat adjacent [within 100 meters (approximately 320 feet)] of an occupied burrow(s).*

If impacts cannot be avoided, specified mitigation measures include (a) avoiding occupied burrows during the breeding season, between February 1 and August 31; (b) purchasing and permanently protecting 6.5 acres of foraging habitat per pair or unpaired resident bird impacted; (c) creating new burrows or enhancing others when destruction of occupied burrows is unavoidable; (d) implementing passive relocation if owls must be moved; and (e) provide funding for long-term management and monitoring of protected lands.

Given this information, CMBC reiterates that it is highly advisable (and cost effective) to avoid impacts. CDFG (1995) states the following:

> *If avoidance is the preferred method of dealing with potential project impacts, then no disturbance should occur within 50 meters (approximately 160 feet) of occupied burrows during the nonbreeding season of September 1 through January 31 or within 75 meters (approximately 250 feet) during the breeding season of February 1 through August 31. Avoidance also requires that a minimum of 6.5 acres of foraging habitat be permanently preserved contiguous with occupied burrow sites for each pair of breeding burrowing owls (with or without dependent young) or single unpaired resident bird. The configuration of the protected habitat should be approved by the Department [CDFG].*

CMBC contacted the CDFG, Bermuda Dunes office, to inquire about the Project site, CDFG[3] staff indicated that it would be appropriate to perform breeding burrowing owl surveys as a follow-up to this habitat assessment. Based on the findings of the burrowing owl survey, CDFG would then advise Cadiz of appropriate steps to either avoid impacts or mitigate them according to latest CDFG standards.

Like the other raptor species mentioned above, **Cooper's hawk** and **prairie falcon** are more likely to forage in the area than nest. Only an incremental amount of potential foraging habitat would be lost to Project development. Based on the minimal availability of foraging habitat for these speceis, no mitigation measures are recommended.

Both **LeConte's thrasher** and **loggerhead shrike** were encountered during surveys, although shrikes appear to be much more common and ubiquitously distributed than LeConte's thrasher. Even so, both are likely to be primarily associated with the well-developed washes in the area, particularly those vegetated by smoke tree, desert willow, and palo verde, and in particular, Schulyler Wash. Both species are likely to nest in these areas during the spring and have young present through the summer. Minimizing impacts to wash areas at all times is recommended. Breeding and nesting activities occur between late February and early June, although the sensitivity of nesting birds to proximate construction activities is unknown. LaRue has observed both species persist at nest sites in spite of proximate construction activities.

4.2.1.c. *Special Status Mammals*. Insufficient information is available to determine if Project development would affect the following special status mammal species: California leaf-nosed bat, Arizona myotis, cave myotis, spotted bat, Townsend's big-eared bat, pocket free-tailed bat, big free-tailed bat, western mastiff bat, fringed myotis, and southern grasshopper mouse. Ship Mountains, Old Woman Mountains, and Kilbeck Hills are the three areas proximate to the ARZC ROW most likely to support roosting locations and/or colonies for some of these bat species. The status of grasshopper mouse remains unknown in the project area. In the absence of focused

[3] Personal correspondence with Jim Sheridan, CDFG Bermuda Dunes Office, on 27 September 2010.

studies for these species, CMBC cannot determine the level of impacts that may occur or recommend mitigation measures. Surveys should be conducted prior to construction to ascertain the potatntial presence of these species. If these species are present, avoidance measures should be implemented to minimize effects.

For **pallid bats**, the surveys were sufficient to detect more than 160 individual bats at 22 of the 70 trestles inspected. In two places, smaller bats were seen with the larger ones, likely indicating local reproduction. It is also noteworthy that a pair of pallid bats was detected under one of these trestles east of Kilbeck Hills in May 1999, indicating some tenacity and long-term occupation of these trestles by the species. If no pallid bats are using the same types of trestles under the BNSF rail line that crosses through the well fields, this may suggest that the ARZC line is uniquely suited for occupation by pallid bats. In any case, this is considered a regionally significant resource for the species.

These bats were detected late enough in the year that we cannot determine if the trestles are serving as maternity roosts and early enough in the year that we cannot determine if they are serving as winter hibernacula, which is an important consideration in determining both the level of impact and recommended mitigation measures (Tom Egan, AMEC Earth and Environmental, personal communication on 5 November 2010). If pallid bats are using the trestles for one or the other, but not both, it may be possible to schedule construction during a time of year when pallid bats are absent. We also do not know how tolerant pallid bats are of proximate construction activities, but do know that pipeline installation would occur within 100 feet of trestles occupied by these bats. As suggested above with other bat species, it would be appropriate to conduct both winter and spring surveys along the pipeline alignment by qualified bat experts to determine these questions and get their input on likely impacts and recommended mitigation measures.

American badgers, though not observed, occur throughout all Project areas. No primary burrow systems were observed, though evidence of their foraging is ubiquitous. Installation of pipeline and construction of ancillary facilities is not likely to kill any badgers but may cause them to disperse into adjacent areas, which is not considered to be a significant impact.

4.2.2. *Other Protected Biological Resources.* Impacts to washes, such as spoil deposition or alteration, are regulated by the CDFG. Impacts to the wash on-site will likely require a 1601-03 Streambed Alteration Agreement from CDFG. CMBC's jurisdictional waters analysis will be provided as baseline information for this agreement. At the time of this writing, CDFG biologist, Jim Sheridan in the Bermuda Dunes office is the appropriate contact.
Herein, CMBC has iterated the relative effectiveness of the drainages and ponding areas in establishing the more robust desert habitat on the north and east sides of the ARZC line. Numerous passerine birds were observed in this area, as were predator scat, such as coyotes and bobcats.

At the time of this writing, Cadiz has not finalized its engineering plans for this pipe but has indicated that it may cross under the ARZC rail line in as many as four or five places. CMBC emphasizes that it is *highly advisable to install the pipeline along the south and west sides of the tracks* where existing disturbances such as dirt roads and trails are prevalent and where the more robust habitat would be avoided.

5.0. Literature Cited

Beauchamp, R. 1986. *A Flora of San Diego County, California.* Sweetwater River Press. National City, CA.

California Department of Fish and Game. 1995. Staff report on burrowing owl mitigation. Memo from C.F. Raysbrook, Interim Director to Biologist, Environmental Services Division, Department of Fish and Game. Sacramento, CA.

California Department of Fish and Game. 2009. Special Animals (883 Taxa). Animal species list published and updated by State of California, The Resources Agency, Department of Fish and Game, Biogeographic Data Branch, California Natural Diversity Data Base. Dated July 2009. Sacramento, CA. 59 pp.

California Department of Fish and Game. (CDFG CNDDB) 2010a. Electronic database of rare plant and animal species reported to The State Resources Agency, Natural Heritage Division, California Natural Diversity Data Base. Sacramento, CA.

California Department of Fish and Game, Natural Diversity Database. 2010b. Special Vascular Plants, Bryophytes, and Lichens List. Plant species list published and updated quarterly by State of California, The Resources Agency, Department of Fish and Game, Biogeographic Data Branch, California Natural Diversity Data Base. Dated January 2010. Sacramento, CA. 71 pp.

California Native Plant Society (CNPS). 2010. Inventory of Rare and Endangered Plants (online edition, v7-10a). California Native Plant Society. Sacramento, CA. Accessed on 5 February 2010 from http://www.cnps.org/inventory.

CH2MHill. 2010. Cadiz Groundwater Conservation and Storage Project.

Circle Mountain Biological Consultants. 1998. Cadiz groundwater storage pilot project: Focused desert tortoise survey and biological resource inventory. Unpublished report prepared on behalf of P&D Consultants, Inc. Wrightwood, CA.

Circle Mountain Biological Consultants. 1999. Cadiz groundwater storage and dry-year supply program: Biological resources technical report: Focused desert tortoise survey and special-status reptile inventory. Unpublished report prepared by Ed LaRue for P&D Consultants, Inc. Wrightwood, CA. Dated June 1999 and updated October 1999.

County of San Bernardino. 2004. Standards for assessing impacts to the desert tortoise and Mohave ground squirrel. Unpublished protocol provided by the County of San Bernardino, Public and Support Services Group, Land Use Services Department, Advance Planning Division, dated December 2004. San Bernardino, CA.

County of San Bernardino. 2006. Report protocol for biological assessment reports. Unpublished protocol provided by the County of San Bernardino, Public and Support Services Group, Land Use Services Department, Advance Planning Division, dated 31 August 2006. San Bernardino, CA.

De Kehoe, J. 2007. *The Silence and the Sun: An historical account of the people, places, and events on old Route 66 and railroad communities in the Eastern Mojave Desert, California.* Trails End Publishing Company.

Desert Tortoise Compensation Team. 1991. Compensation for the desert tortoise. An unpublished report prepared for the Desert Tortoise Management Oversight Group by the Desert Tortoise Compensation Team, and approved by the Desert Tortoise Management Oversight Group on 13 November 1991.

GeoScience. 2010. Geohydrologic Assessment of the Fenner Gap Area.

GeoScience Support Services Inc. 1999 Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report for Groundwater Resources, Volume I.

Hickman, J. Editor. 1993. *The Jepson Manual: Higher Plants of California.* University of California Press. Berkeley, CA.

Holland, R. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game. Sacramento, CA.

Ingles, L. 1965. *Mammals of the Pacific States: California, Oregon, Washington.* Stanford University Press. Stanford, CA.

Jaeger, E. 1969. *Desert Wild Flowers.* Stanford University Press. Stanford, CA.

Karl, A. 1992. Desert tortoise survey, project site – Bolo station facilities, San Bernardino County, California. Prepared for Rail Cycle, Los Angeles, California.

Metropolitan Water District of Southern California and U.S. Bureau of Land Management (MWD & BLM). 1999. Cadiz Groundwater Storage and Dry-Year Supply Program environmental planning technical report, biological resources.

Metropolitan Water District of Southern California. 2001. Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement Volume I.

Munz, P. 1974. *A Flora of Southern California.* University of California Press. Berkeley, CA.

Sawyer, J. and T. Keeler-Wolf. 1995. *A Manual of California Vegetation.* California Native Plant Society. Sacramento, CA.

Sibley, D. 2000. National Audubon Society, the Sibley Guide to Birds. First Edition. New York, N.Y.

Stebbins, R. 2003. *A Field Guide to Western Reptiles and Amphibians.* Third Edition. The Peterson Field Guide Series. Houghton Mifflin Company. New York, NY.

Tierra Madre Consultants, Inc. 1995. Cadiz Valley rare plant surveys. Draft report. Unpublished report prepared 7 June 1995 on behalf of Cadiz Land Company, Inc. Riverside, CA.

U.S. Bureau of Land Management. 1989. Map produced by BLM for the California Desert Conservation Area, dated January 1989, showing desert tortoise Category 1, 2, and 3 Habitats in California. Riverside, CA.

U.S. Bureau of Land Management. 2002. Final Environmental Impact Statement for the Proposed Northern & Eastern Colorado Desert Coordinated Management Plan, an amendment to the California Desert Conservation Area Plan 1980 and Sikes Act Plan with the CDFG. Moreno Valley, CA.

U.S. Bureau of Land Management and California State Lands Commission. 2004. El Paso Line 1903 Pipeline Conversion Project Draft Environmental Impact Report/Environmental Assessment.

U.S. Fish and Wildlife Service. 1992. Field survey protocol for any nonfederal action that may occur within the range of the desert tortoise. Ventura, CA.

U.S. Fish and Wildlife Service. 1993. Biological opinion for the Rail-Cycle/Bolo Station Landfill project, San Bernardino County, California (CA 932.5, 1-6-93-F-16). Prepared by the Ventura Field Office of the USFWS. Dated 4 August 1993.

U.S. Fish and Wildlife Service. 1994a. Endangered and threatened wildlife and plants; determination of critical habitat for the Mojave population of the desert tortoise. Federal Register 55(26):5820-5866. Washington, D.C.

U.S. Fish and Wildlife Service. 1994b. Desert Tortoise (Mojave Population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. Pp. 73, plus appendices.

U.S. Fish and Wildlife Service. 2002a. Birds of Conservation Concern. Division of Migratory Bird Management. Arlington, VA.

U.S. Fish and Wildlife Service. 2002b. Biological opinion on the Cadiz Groundwater Storage and Dry-Year Supply Program, San Bernardino County, California (CA 932.5, 1-8-00-F-22). Prepared by the Ventura Field Office of the USFWS. Dated 20 March 2002.

U.S. Fish and Wildlife Service. 2010. Preparing for any action that may occur within the range of the Mojave desert tortoise (*Gopherus agassizii*). USFWS Desert Tortoise Recovery Office. Reno, NV.

Appendix A. Plant Species Detected

The following plant species were identified on-site during the general biological inventory described in this report. Those plant species that are protected by pertinent County and/or State ordinances are signified by "(SC)" following the common name. Those species first found along the pipeline are preceded by "P." Those species that may occur along the pipeline but were only detected within the wellfield area are denoted by "W."

GNETAE	GNETAE
Ephedraceae	**Joint-fir family**
W *Ephedra californica*	Desert tea
ANGIOSPERMAE: DICOTYLEDONES	DICOT FLOWERING PLANTS
Amaranthaceae	**Amaranth family**
P *Tidestromia oblongifolia*	Honeysweet
Asclepiadaceae	**Milkweed family**
P *Asclepias erosa*	Milkweed
P *Asclepias subulata*	Milkweed
P *Sarcostemma hirtellum*	Hairy milkweed
Asteraceae	**Sunflower family**
P *Ambrosia dumosa*	Burrobush
P *Atrichoseris platyphylla*	Gravelghost
W *Baileya* sp.	Woolly marigold
P *Bebbia juncea*	Sweetbush
P *Chaenactis fremontii*	Desert pincushion
P *Chrysothamnus paniculatus*	Wash rabbitbrush
W *Dicoria canescens*	Dicoria
P *Encelia actoni*	Acton encelia
P *Encelia fructescens*	Rayless encelia
P *Geraea canescens*	Desert sunflower
P *Hymenoclea salsola*	Cheesebush
P *Malacothrix glabrata*	Desert dandelion
W *Monoptilon bellioides*	Gray desert star
P *Palafoxia linearis*	Desert Spanish-needles
W *Pectis papposa*	Chinch weed
W *Pluchea sericea*	Arrow weed
P *Porophyllum gracile*	Odora
P *Psathyrotes ramosissima*	Velvet rosettes
P *Stephanomeria exigua*	Milk aster
P *Stephanomeria pauciflora*	Desert milk aster

Bignoniaceae		**Bigonia family**
W	*Chilopsis linearis* ssp. *arcuata*	Desert willow
Boraginaceae		**Borage family**
P	*Amsinckia tessellata*	Fiddleneck
P	*Cryptantha angustifolia*	Narrow-leaved forget-me-not
P	*Cryptantha barbigera*	Fuzzy forget-me-not
P	*Cryptantha nevadensis*	Nevada forget-me-not
P	*Cryptantha pterocarya*	Wing-nut forget-me-not
W	*Pectocarya heterocarpa*	Combseed
W	*Pectocarya penicillata*	Slender combseed
P	*Pectocarya platycarpa*	Broad-margined combseed
P	*Pectocarya recurvata*	Curved combseed
P	*Tiquilia plicata*	Plicate coldenia
Brassicaceae		**Mustard family**
P	**Brassica tournefortii*	Saharan mustard
P	**Descurainia pinnata*	Tansy
P	**Descurainia sophia*	Flixweed
W	*Guillenia lasiophylla*	California mustard
P	*Lepidium flavum*	Peppergrass
W	*Lepidium lasiocarpum*	Sand peppergrass
P	**Sisymbrium irio*	London rocket
Cactaceae		**Cactus family**
P	*Ferocactus cylindraceus (acanthodes)*	Barrel cactus (SC)
P	*Opuntia basilaris*	Beavertail cactus (SC)
P	*Opuntia echinocarpa*	Silver cholla (SC)
W	*Opuntia ramosissima*	Pencil cholla (SC)
Capparaceae		**Caper family**
P	*Isomerus arborea*	Bladderpod
Chenopodiaceae		**Goosefoot family**
P	*Atriplex canescens*	Four-winged saltbush
P	*Atriplex hymenelytra*	Desert holly (SC)
P	*Atriplex polycarpa*	Allscale
P	**Salsola tragus*	Russian thistle
P	*Suaeda moquinii*	Torrey's sea-blight
Cucurbitaceae		**Gourd family**
P	*Cucurbita palmata*	Coyote gourd
Cuscutaceae		**Dodder family**
P	*Cuscuta* sp.	Dodder

Euphorbiaceae	**Spurge family**
P *Chamaesyce (Euphorbia) polycarpa*	Sandmat
P *Ditaxis neomexicana*	Ditaxis
Fabaceae	**Pea family**
P *Acacia greggii*	Catclaw acacia (SC)
P *Cercidium floridum*	Palo verde (SC)
P *Dalea mollissima*	Dalea
P *Lupinus* c.f. *arizonicus*	Arizonia lupine
P *Marina orcuttii* var. *orcuttii*	California marina
P *Psorothamnus (Dalea) emoryi*	Indigo bush
P *Psorothamnus spinosus*	Smoke tree (SC)
Geraneaceae	**Geranium family**
P **Erodium cicutarium*	Red-stemmed filaree
Hydrophyllaceae	**Water-leaf family**
W *Nama demissum*	Purple mat
P *Phacelia* c.f. *tanacetifolia*	Phacelia
Krameriaceae	**Krameria family**
P *Krameria grayi*	White rhatany
Lamiaceae	**Mint family**
P *Hyptis emoryi*	Desert lavender
P *Salvia columbariae*	Chia
Loasaceae	**Stick-leaf family**
P *Mentzelia* sp.	Blazing star
P *Mentzelia* c.f. *albicaulis*	Little blazing star
P *Mentzelia laevicaulis*	Blazing star
P *Petalonyx nitidus*	Sniny-leaved sandpaper plant
P *Petalonyx thurberi*	Sandpaper plant
Malvaceae	**Mallow family**
P *Eremalche rotundifolia*	Desert fivespot
Nyctaginaceae	**Four o'clock family**
P *Mirabilis bigelovii*	Desert wishbone plant
Onagraceae	**Evening-primrose family**
P *Camissonia boothii*	Red primrose
P *Camissonia brevipes*	Yellow cups
P *Camissonia claviformis*	Brown-eyed primrose
P *Oenothera* c.f. *deltoides*	Devil's lantern

Orobanchaceae	**Broom-rape family**
P *Orobanche cooperi*	Cooper's strangler
Plantaginaceae	**Plantain family**
P *Plantago ovata*	Plantain
Polemoniaceae	**Phlox family**
P *Gilia* sp.	Gilia
P *Loeseliastrum (Langloisia) matthewsii*	Sunbonnets
P *Loeseliastrum (Langloisia) schottii*	Loeseliastrum
P *Linanthus* c.f. *dichotomus*	Evening snow
Polygonaceae	**Buckwheat family**
P *Chorizanthe brevicornu*	Brittle spineflower
P *Chorizanthe rigida*	Rigid spineflower
P *Eriogonum inflatum*	Desert trumpet
P *Eriogonum nidularium*	Whiskbroom
P *Eriogonum trichopes*	Little trumpet
W *Eriogonum viridescens*	Buckwheat
Resedaceae	**Mignonette family**
P *Oligomeris linifolia*	Narrowleaf oligomeris
Solanaceae	**Nightshade family**
P *Datura wrightii (meteloides)*	Jimsonweed
P *Nicotiana obtusifolia (trigonophylla)*	Desert tobacco
P *Physalis crassifolia*	Thick-leaf ground-cherry
Tamaricaceae	**Tamarisk family**
P **Tamarix aphylla*	Athel
P **Tamarix ramosissima*	Tamarisk
Viscaceae	**Mistletoe family**
P *Phorodendron californicum*	Mesquite mistletoe
Zygophyllaceae	**Caltrop family**
P *Larrea tridentata*	Creosote bush
W **Tribulus terrestris*	Puncture vine
ANGIOSPERMAE: MONOCOTYLEDONES	MONOCOT FLOWERING PLANTS
Liliaceae	**Lily family**
P *Hesperocallis undulata*	Desert lily
P *Zidagenus brevibracteatus*	Desert camas

Poaceae	**Grass family**
P *Pleuraphis (Hilaria) rigida*	Big galleta
P **Schismus* sp.	Split-grass
P *Vulpia octiflora*	Vulpia

* - indicates a non-native (introduced) species.
c.f. - compares favorably to a given species when the actual species is unknown.

Some species may not have been detected because of the seasonal nature of their occurrence. Common names are taken from Beauchamp (1986), Hickman (1993), Jaeger (1969), and Munz (1974).

Appendix B. Animal Species Detected

The following animal species were detected during the 2010 general biological inventory described in this report. Special status animal species are signified by "(SC)" following the common names. Although highly mobile and capable of occurring throughout the project area, those species first found along the pipeline are preceded by "P" and those first found within the wellfield area are denoted by "W."

REPTILIA	REPTILES
Testudinidae	**Land tortoises**
P & W *Gopherus agassizii*	Desert tortoise (SC)
Gekkonidae	**Geckos**
W *Coleonyx variegatus*	Western banded gecko
Iguanidae	**Iguanids**
P *Dipsosaurus dorsalis*	Desert iguana
P *Sauromalus obesus*	Common chuckwalla
P *Callisaurus draconoides*	Zebra-tailed lizard
P *Uma scoparia*	Mojave fringe-toed lizard (SC)
P *Gambelia wislizenii*	Long-nosed leopard lizard
P *Sceloporus magister*	Desert spiny lizard
P *Uta stansburiana*	Side-blotched lizard
P *Urosaurus graciosus*	Long-tailed brush lizard
P *Phrynosoma platyrhinos*	Desert horned lizard
Xantusiidae	**Night lizards**
W *Xantusia vigilis*	Desert night lizard
Teiidae	**Whiptails**
P *Cnemidophorus tigris*	Western whiptail
Colubridae	**Colubrids**
P *Masticophis flagellum*	Red racer
W *Salvadora hexalepis*	Western patch-nosed snake
W *Pituophis melanoleucus*	Gopher snake
Viperidae	**Vipers**
P *Crotalus cerastes*	Sidewinder

AVES	BIRDS
Gaviidae	**Loons**
W *Gavia immer*	Common loon
Pelecanidae	**Pelicans**
W *Pelecanus erythrorhynchos*	American white pelican
Anatidae	**Ducks, geese and swans**
W *Anas platyrhynchos*	Mallard
Cathartidae	**Vultures**
W *Cathartes aura*	Turkey vulture
Accipitridae	**Hawks, eagles, harriers**
W *Accipiter cooperii*	Cooper's hawk (SC)
P *Buteo jamaicensis*	Red-tailed hawk
Falconidae	**Falcons**
P *Falco sparverius*	American kestrel
P *Falco mexicanus*	Prairie falcon (SC)
Phasianidae	**Grouse and quail**
P *Alectoris chukar*	Chukar
P *Callipepla gambelii*	Gambel's quail
Recurvirostridae	**Stilts and avocets**
P *Recurvirostra americana*	American avocet
Charadriidae	**Plovers**
P *Charadrius vociferus*	Killdeer
Columbidae	**Pigeons and doves**
W *Streptopelia decaocto*	Eurasian collared-dove
P *Zenaida macroura*	Mourning dove
Cuculidae	**Cuckoos**
P *Geococcyx californianus*	Greater roadrunner
Tytonidae	**Barn Owls**
P *Tyto alba*	Common barn owl
Strigidae	**Typical owls**
W *Bubo virginianus*	Great horned owl
P & W *Athene cunicularia*	Burrowing owl (SC)

Camprimulgidae	**Nightjars**
P *Chordeiles acutipennis*	Lesser nighthawk
Apodidae	**Swifts**
P *Chaetura vauxi*	Vaux's swift (SC)
Tyrannidae	**Tyrant flycatchers**
P *Sayornis saya*	Say's phoebe
Alaudidae	**Larks**
P *Eremophila alpestris*	Horned lark
Hirundinidae	**Swallows**
P *Stelgidopteryx serripennis*	Northern rough-winged swallow
W *Hirundo rustica*	Barn swallow
Corvidae	**Crows and jays**
P *Corvus corax*	Common raven
Remizidae	**Verdins**
P *Auriparus flavipes*	Verdin
Troglodytidae	**Wrens**
P *Salpinctes obsoletus*	Rock wren
Cinclidae	**Dippers**
Cinclus maxicanus	American dipper
Muscicapidae	**Thrushes and allies**
W *Regulus calendula*	Ruby-crowned kinglet
P *Polioptila caerula*	Blue-gray gnatcatcher
P *Polioptila melanura*	Black-tailed gnatcatcher
Mimidae	**Mockingbirds and thrashers**
P *Mimus polyglottos*	Northern mockingbird
W *Oreoscoptes montanus*	Sage thrasher
P *Toxostoma lecontei*	LeConte's thrasher (SC)
Motacillidae	**Wagtails and pipits**
W *Anthus spinoletta*	Water pipit
Laniidae	**Shrikes**
P *Lanius ludovicianus*	Loggerhead shrike (SC)
Vireonidae	**Vireos**
W *Vireo huttoni*	Hutton's vireo

Emberizidae		**Sparrows, warblers, tanagers**
P	*Vermivora celata*	Orange-crowned warbler
W	*Dendroica coronata*	Yellow-rumped warbler
P	*Geothlypis trichas*	Common yellowthroat
P	*Wilsonia pusilla*	Wilson's warbler
P	*Spizella breweri*	Brewer's sparrow
W	*Chondestes grammacus*	Lark sparrow
P	*Amphispiza bilineata*	Black-throated sparrow
P	*Amphispiza belli*	Sage sparrow
P	*Zonotrichia leucophrys*	White-crowned sparrow
W	*Agelaius phoeniceus*	Red-winged blackbird
P	*Sturnella neglecta*	Western meadowlark
W	*Xanthocephalus xanthocephalus*	Yellow-headed blackbird
P	*Euphagus cyanocephalus*	Brewer's blackbird
W	*Quiscalus mexicanus*	Great-tailed grackle
Fringillidae		**Finches**
W	*Carduelis psaltria*	Lesser goldfinch
P	*Carpodacus mexicanus*	House finch
MAMMALIA		MAMMALS
Vespertilionidae		**Evening bats**
P	*Antrozous pallidus*	Pallid bat (SC)
Leporidae		**Hares and rabbits**
P	*Lepus californicus*	Black-tailed hare
P	*Sylvilagus audubonii*	Audubon cottontail
Sciuridae		**Squirrels**
P	*Spermophilus tereticaudis*	Round-tailed ground squirrel
P	*Ammospermophilus leucurus*	Antelope ground squirrel
Geomyidae		**Pocket gophers**
P	*Thomomys bottae*	Botta pocket gopher
Heteromyidae		**Pocket mice**
P	*Dipodomys* sp.	Kangaroo rat
P	*Dipodomys deserti*	Desert kangaroo rat
Cricetidae		**Rats and mice**
P	*Neotoma lepida*	Desert wood rat
Canidae		**Foxes, wolves and coyotes**
P	*Canis latrans*	Coyote
P	*Vulpes macrotis*	Kit fox

Mustelidae	**Weasels and skunks**
P & W *Taxidea taxus*	American badger (SC)
Felidae	**Cats**
P *Lynx rufus*	Bobcat

Nomenclature follows Stebbins, *A Field Guide to Western Reptiles and Amphibians* (2003), third edition; Sibley, National Audubon Society, the Sibley Guide to Birds (2000), first edition; and Ingles, Mammals of the Pacific States (1965), second edition.

Appendix C. Locations of Desert Tortoise Sign

Figure C1. Tortoise Sign along Pipeline Alignment

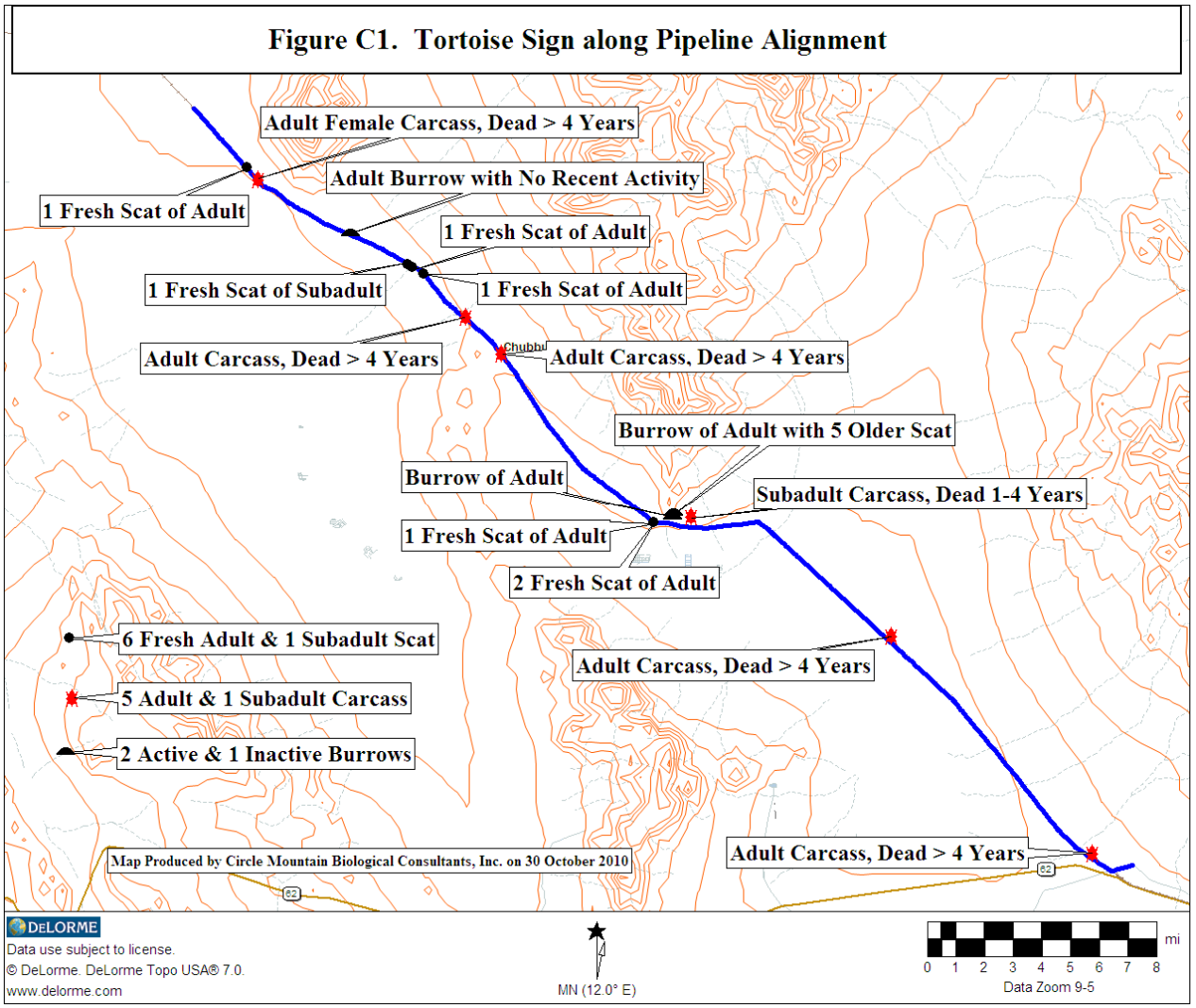
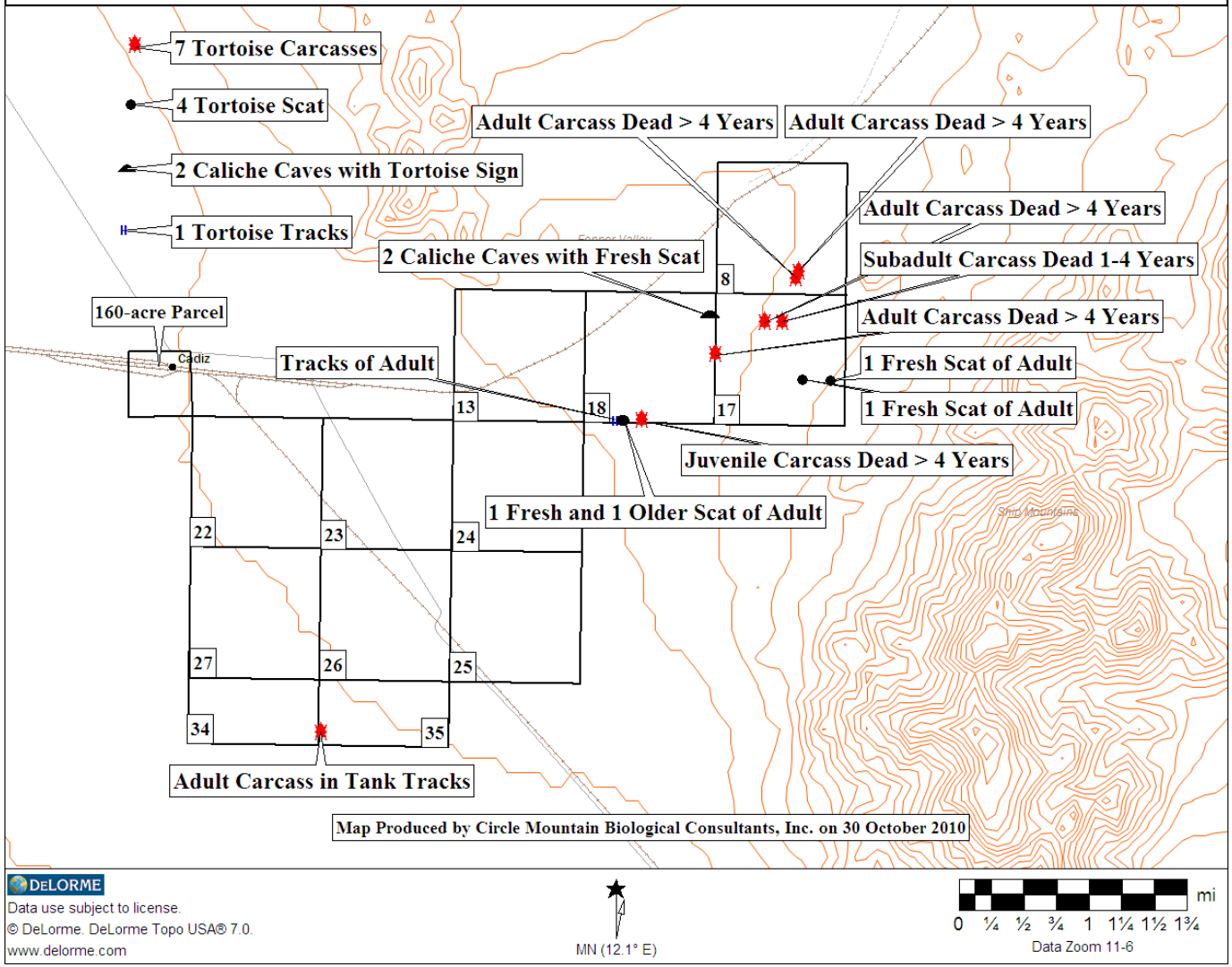


Figure C2. Desert Tortoise Sign at Wellfield Areas



Appendix D. Locations of Burrowing Owl Sign and Burrows

Figure D1. Index Map for Burrowing Owl Sign Along Pipeline Alignment

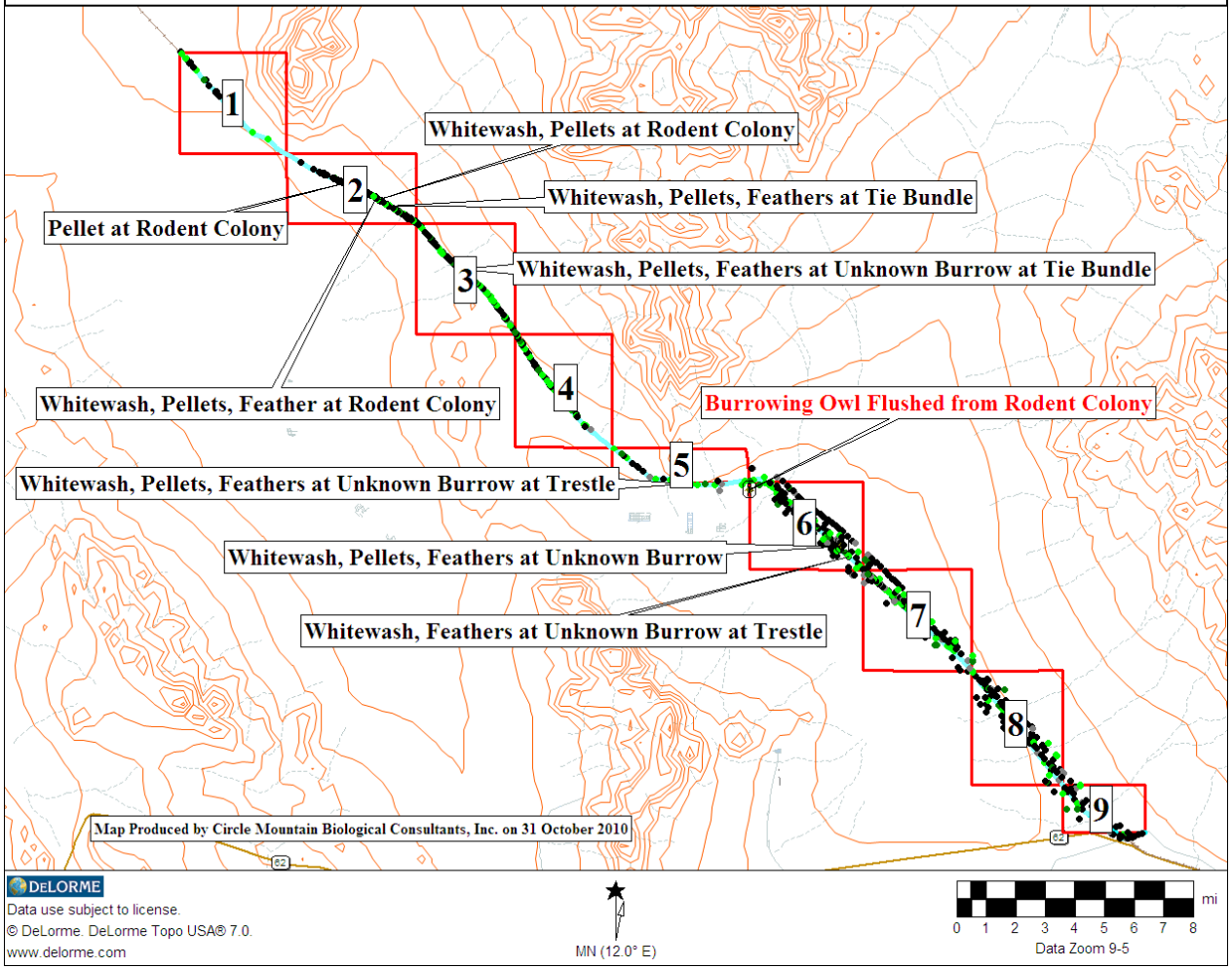


Figure D2. Burrow Data for Area 1 along Pipeline Alignment

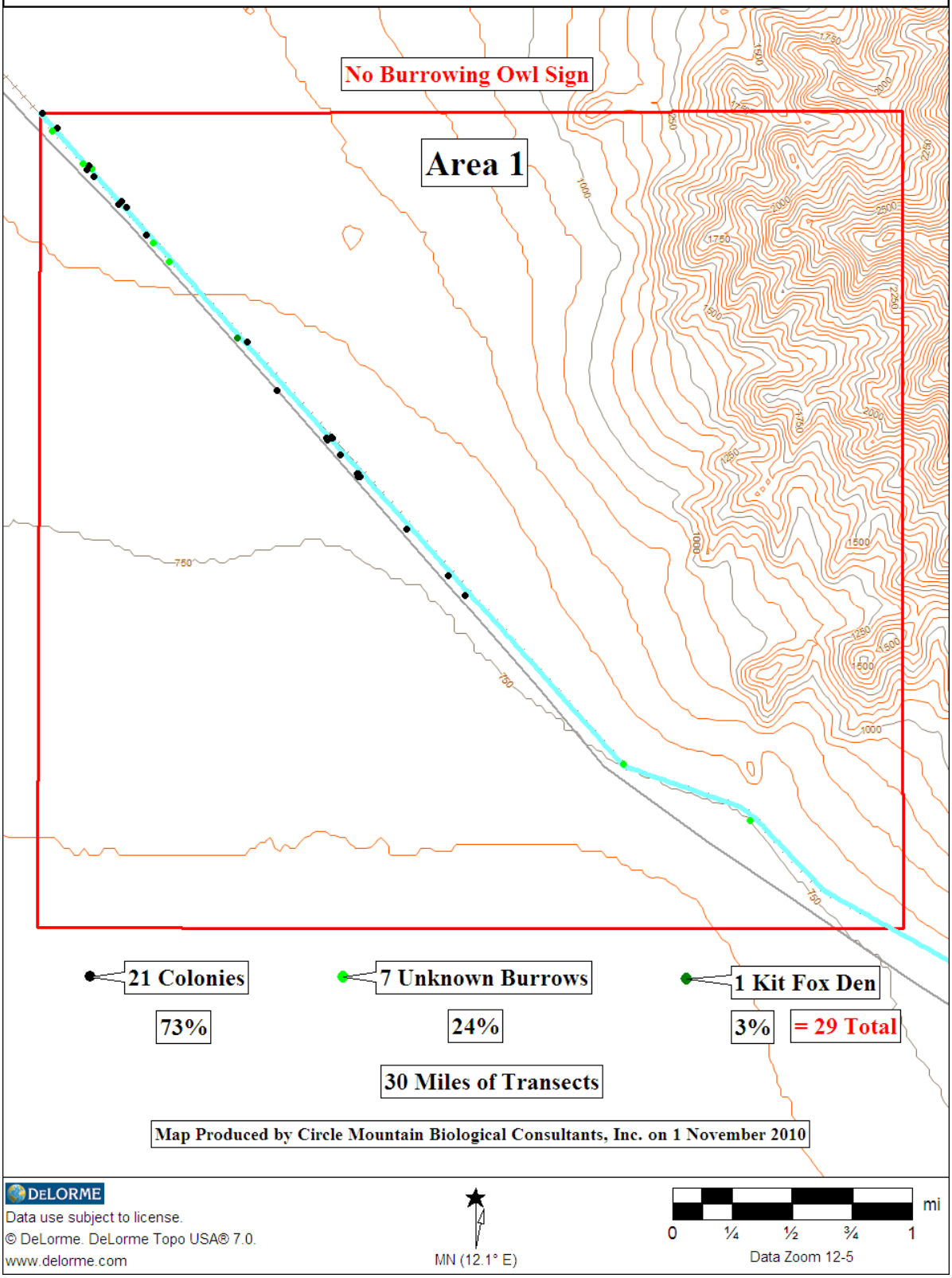


Figure D3. Burrow Data for Area 2 along Pipeline Alignment

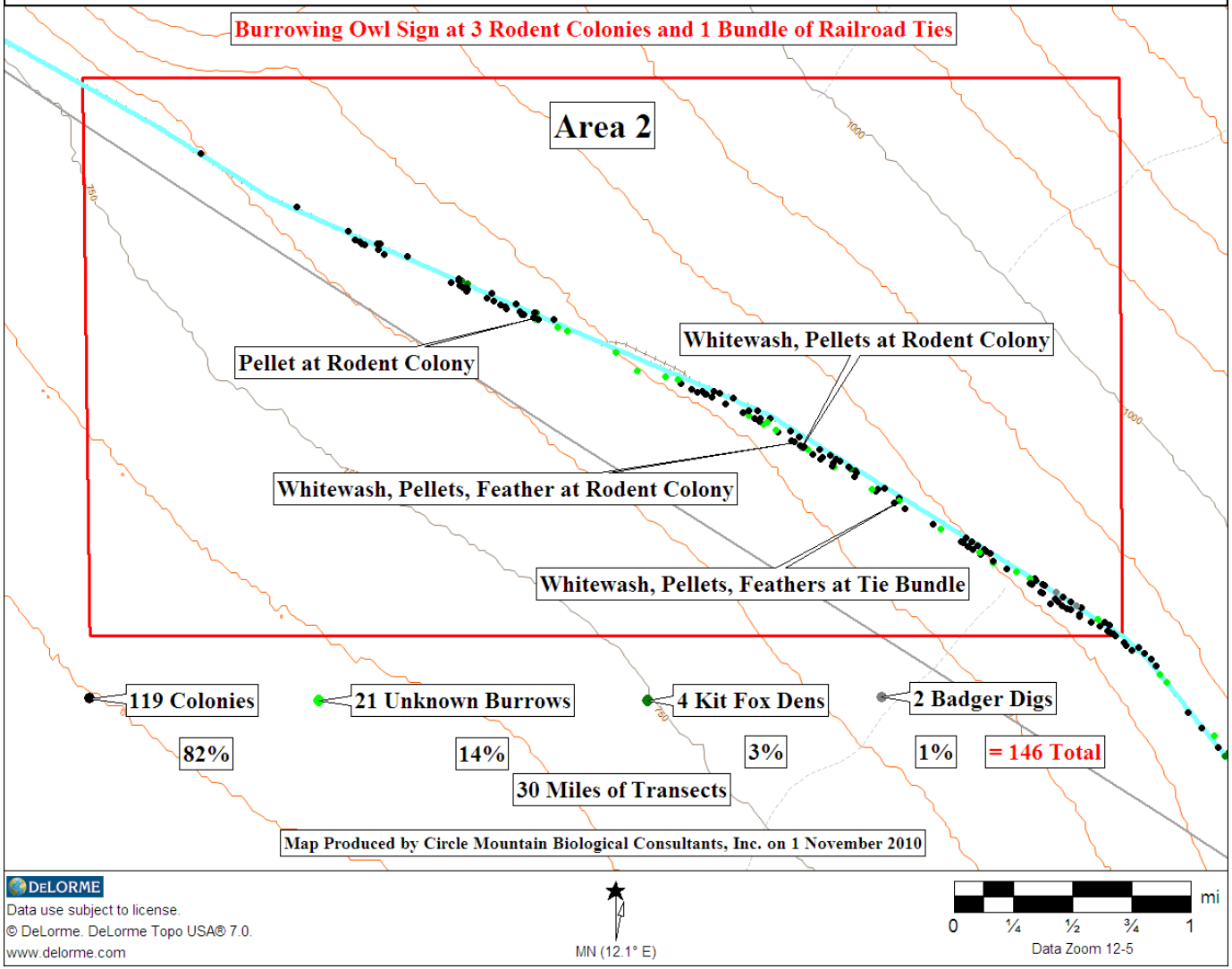


Figure D4. Burrow Data for Area 3 along Pipeline Alignment

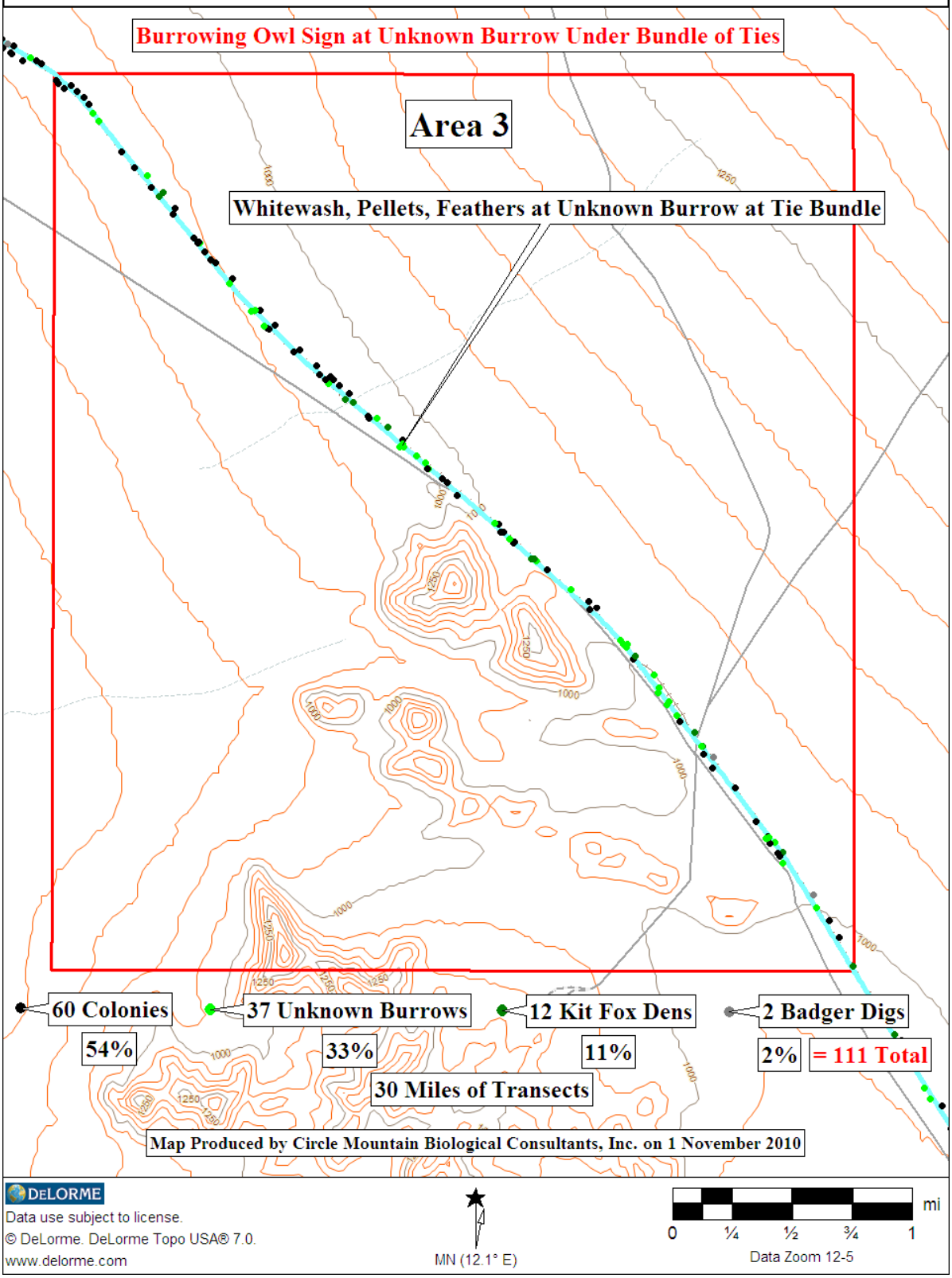


Figure D5. Burrow Data for Area 4 along Pipeline Alignment

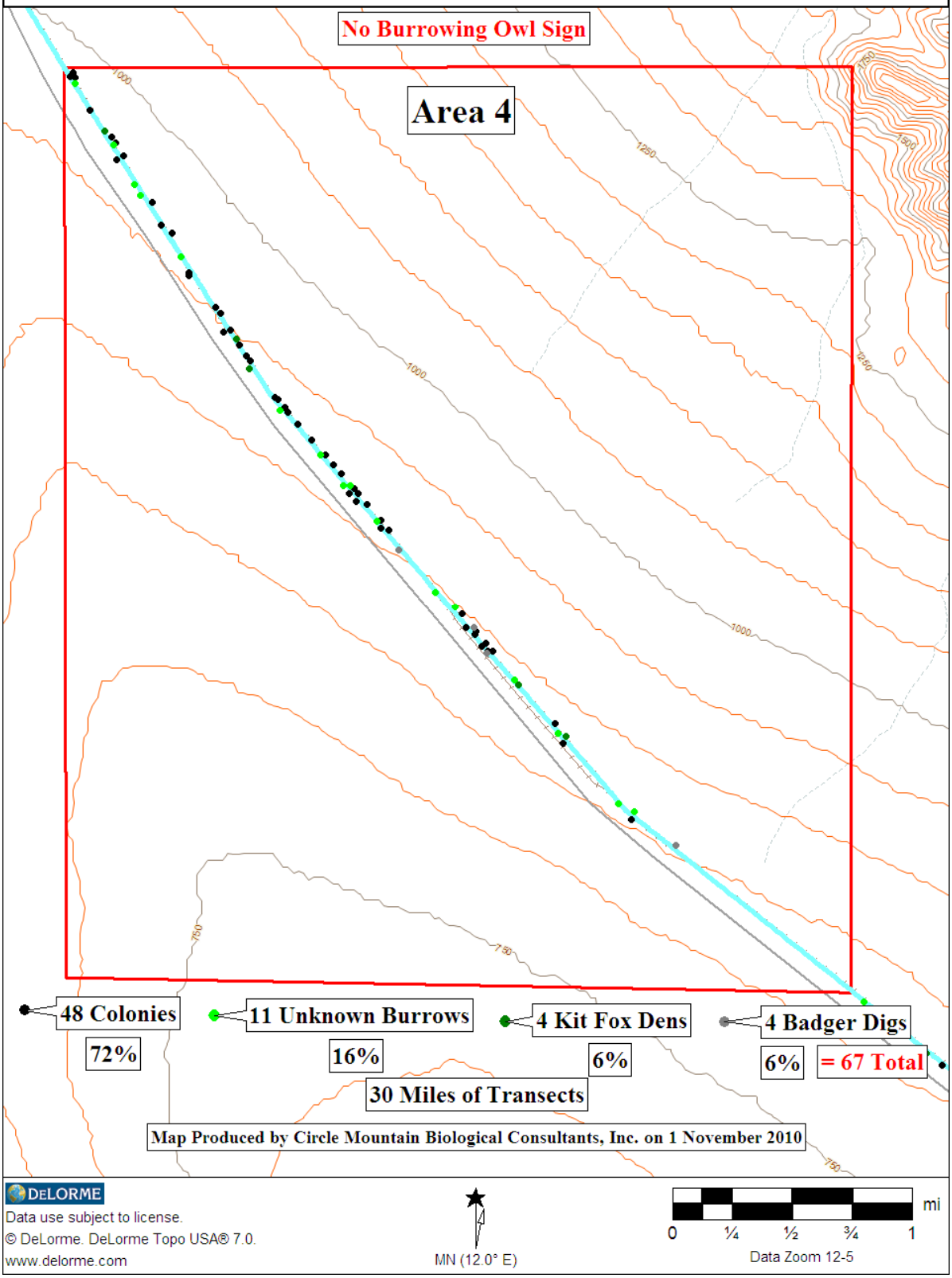


Figure D6. Burrow Data for Area 5 along Pipeline Alignment

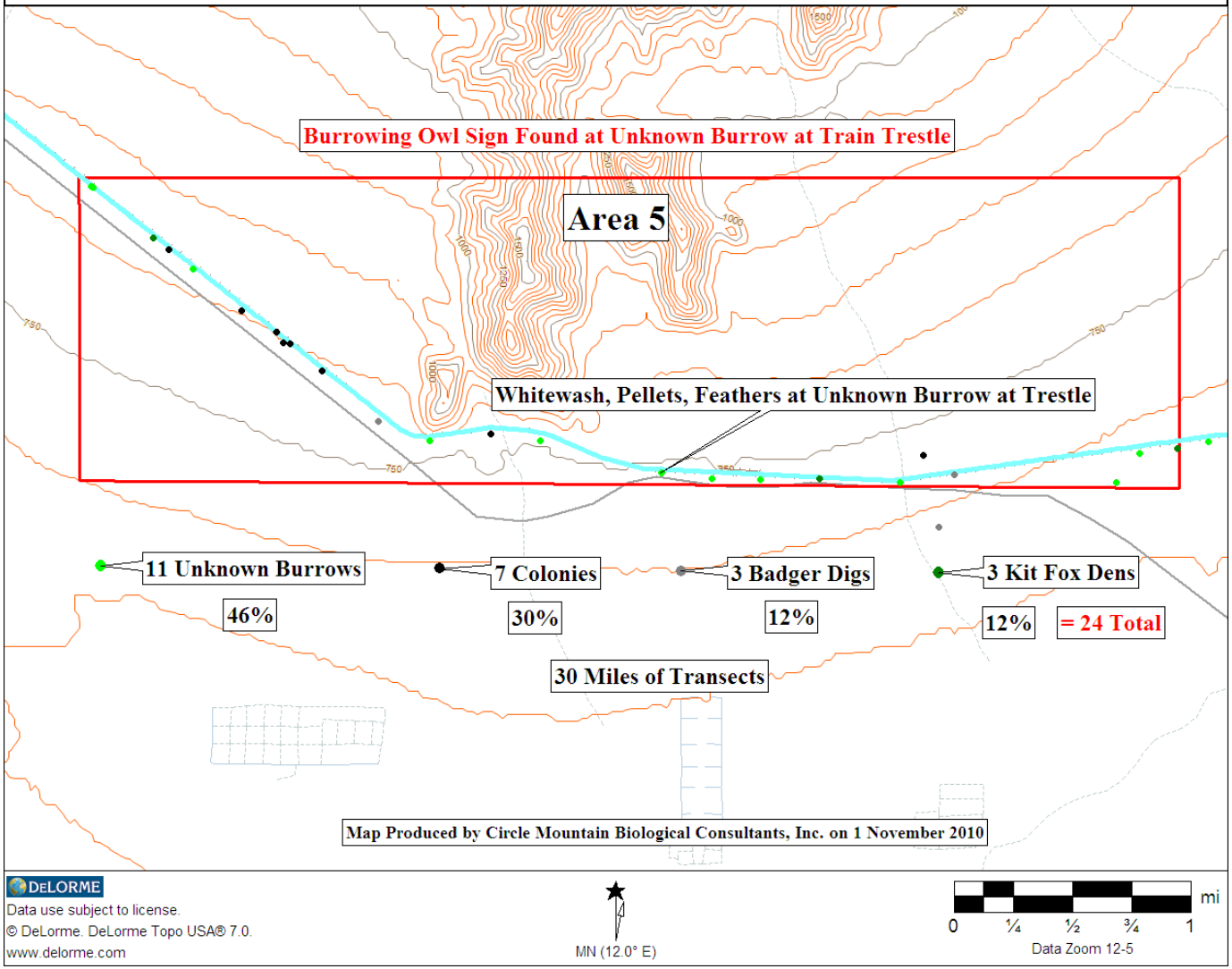


Figure D7. Burrow Data for Area 6 along Pipeline Alignment

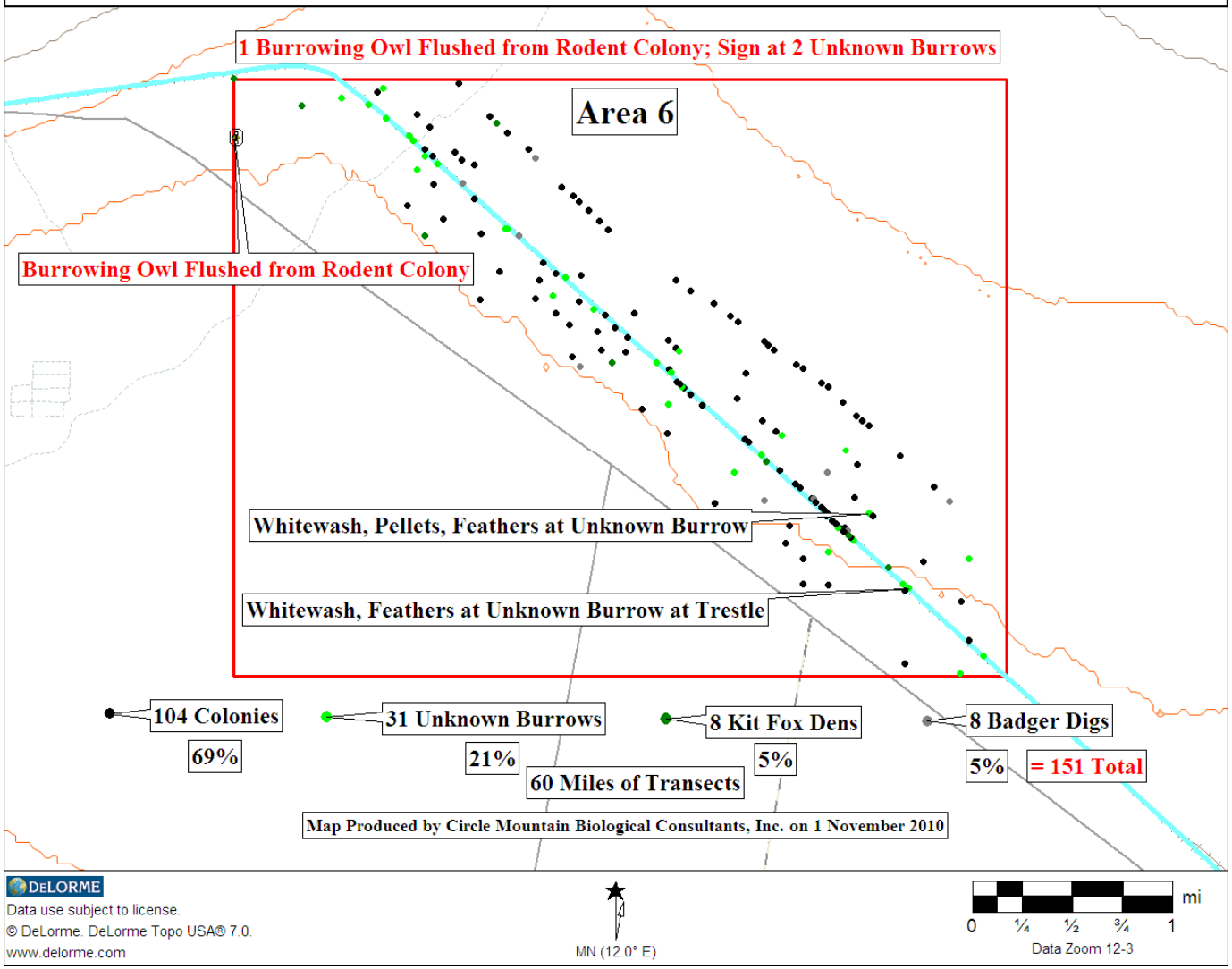


Figure D8. Burrow Data for Area 7 along Pipeline Alignment

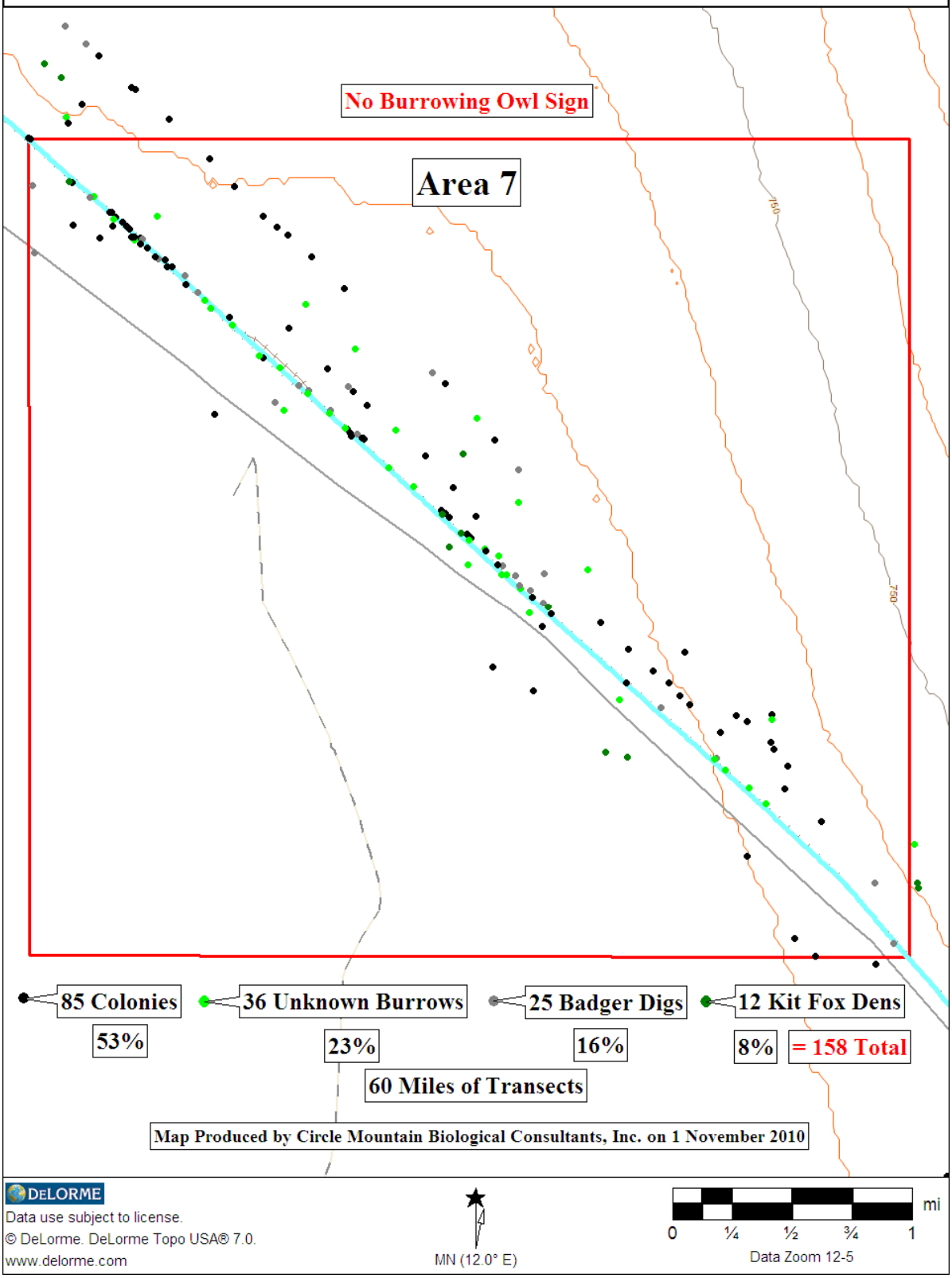


Figure D9. Burrow Data for Area 8 along Pipeline Alignment

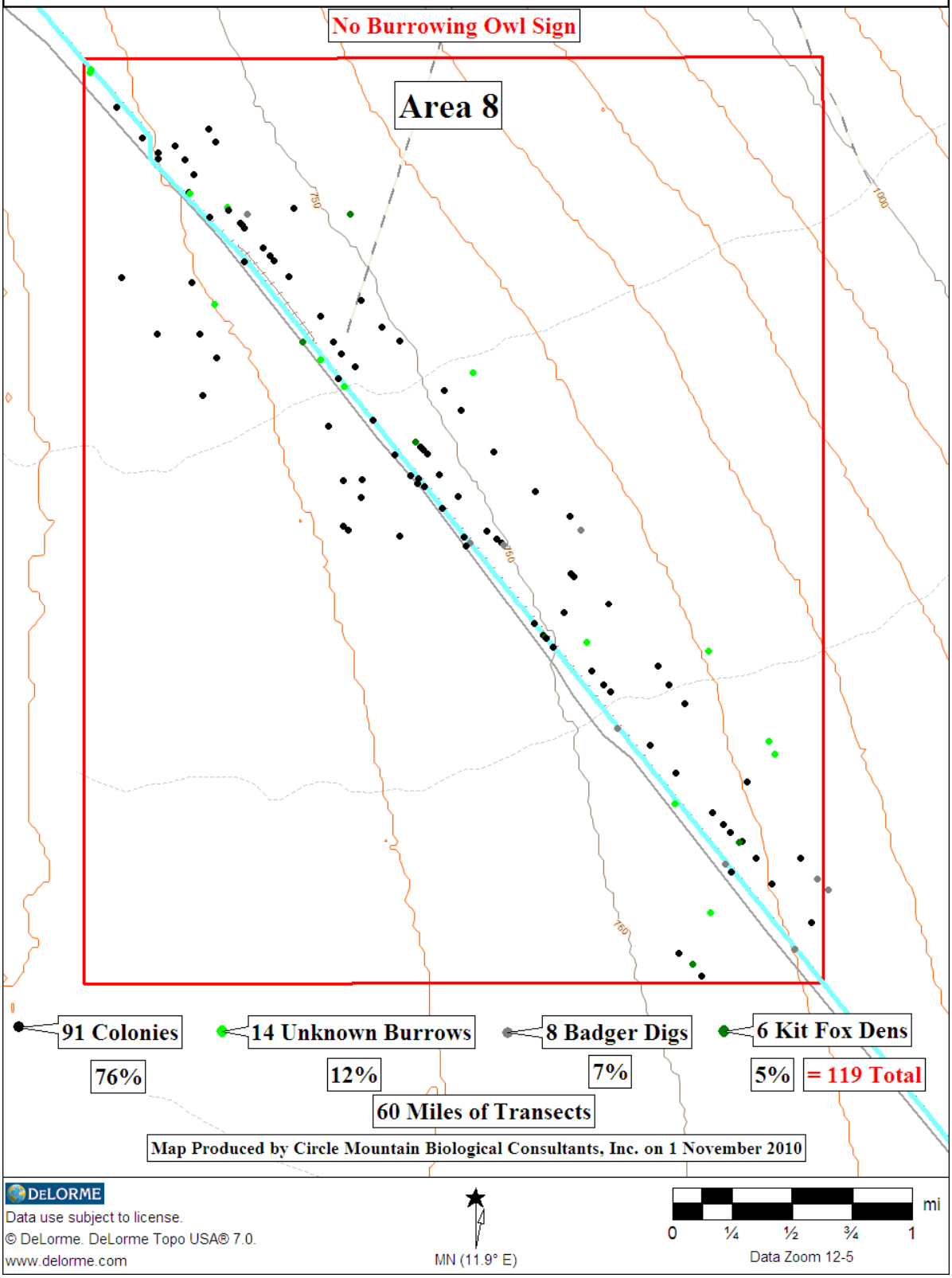


Figure D10. Burrow Data for Area 9 along Pipeline Alignment

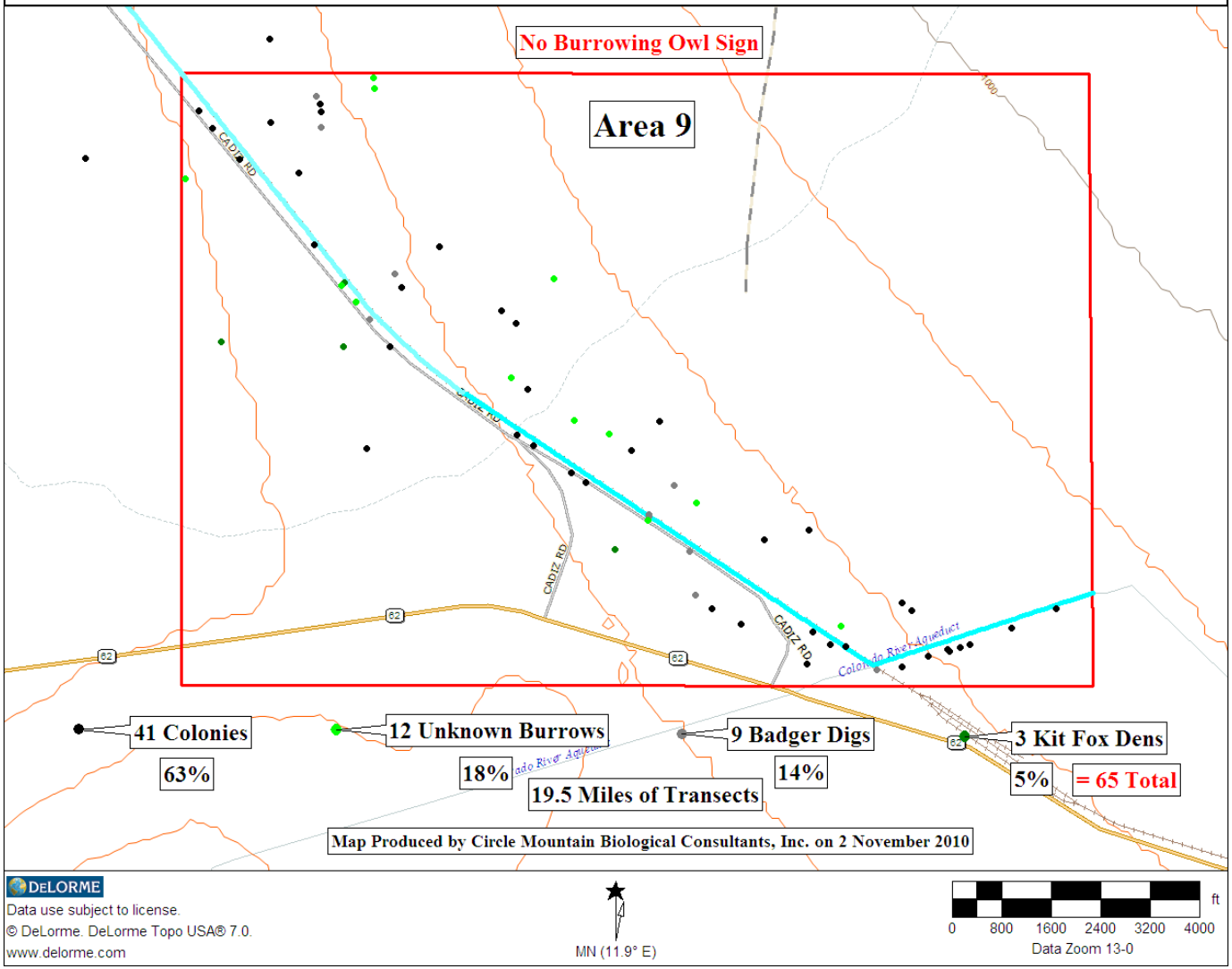


Figure D11. Burrowing Owl Data for All Wellfield Sections & Spreading Basin

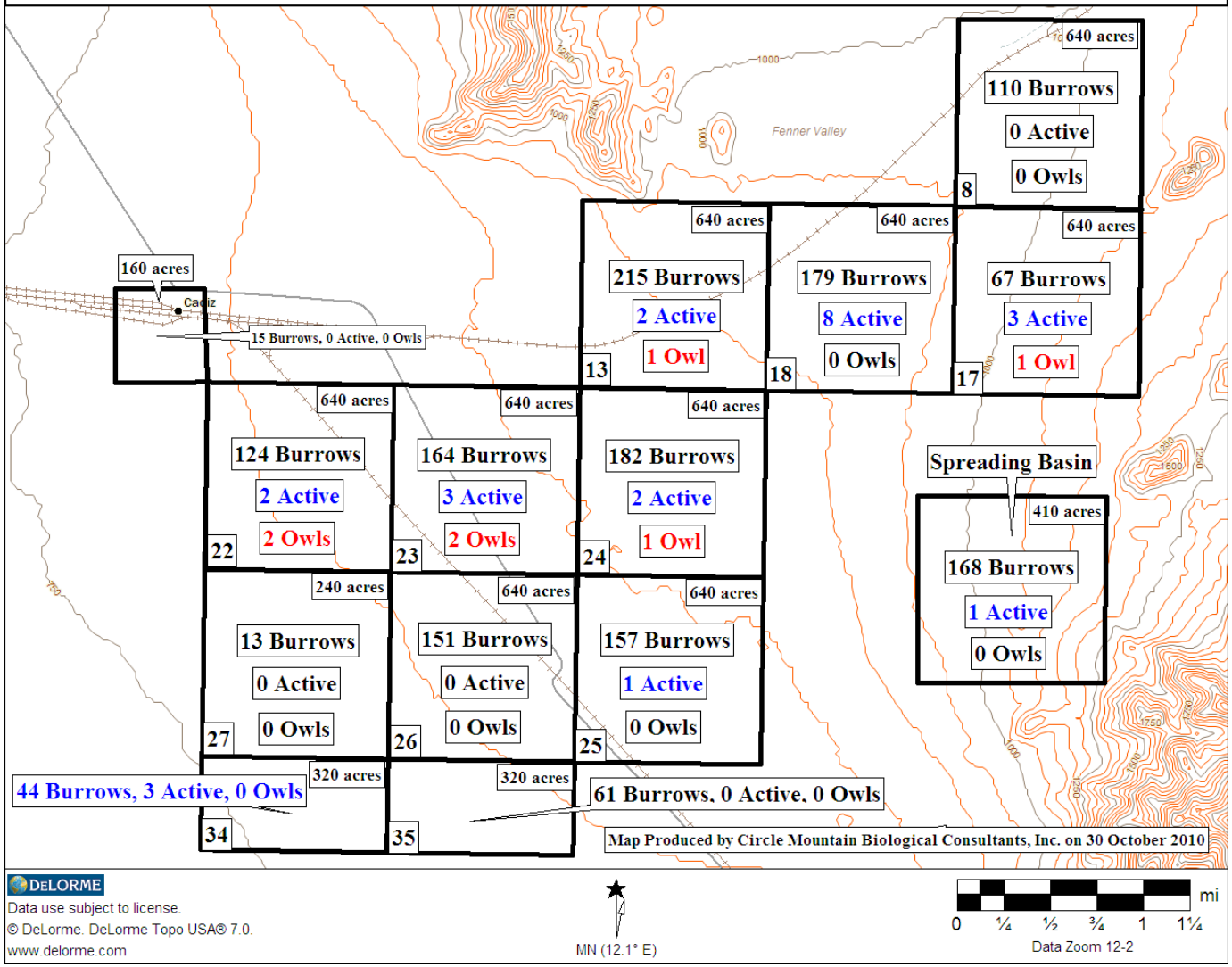


Figure D12. Burrow Data for Section 8 Wellfield Area

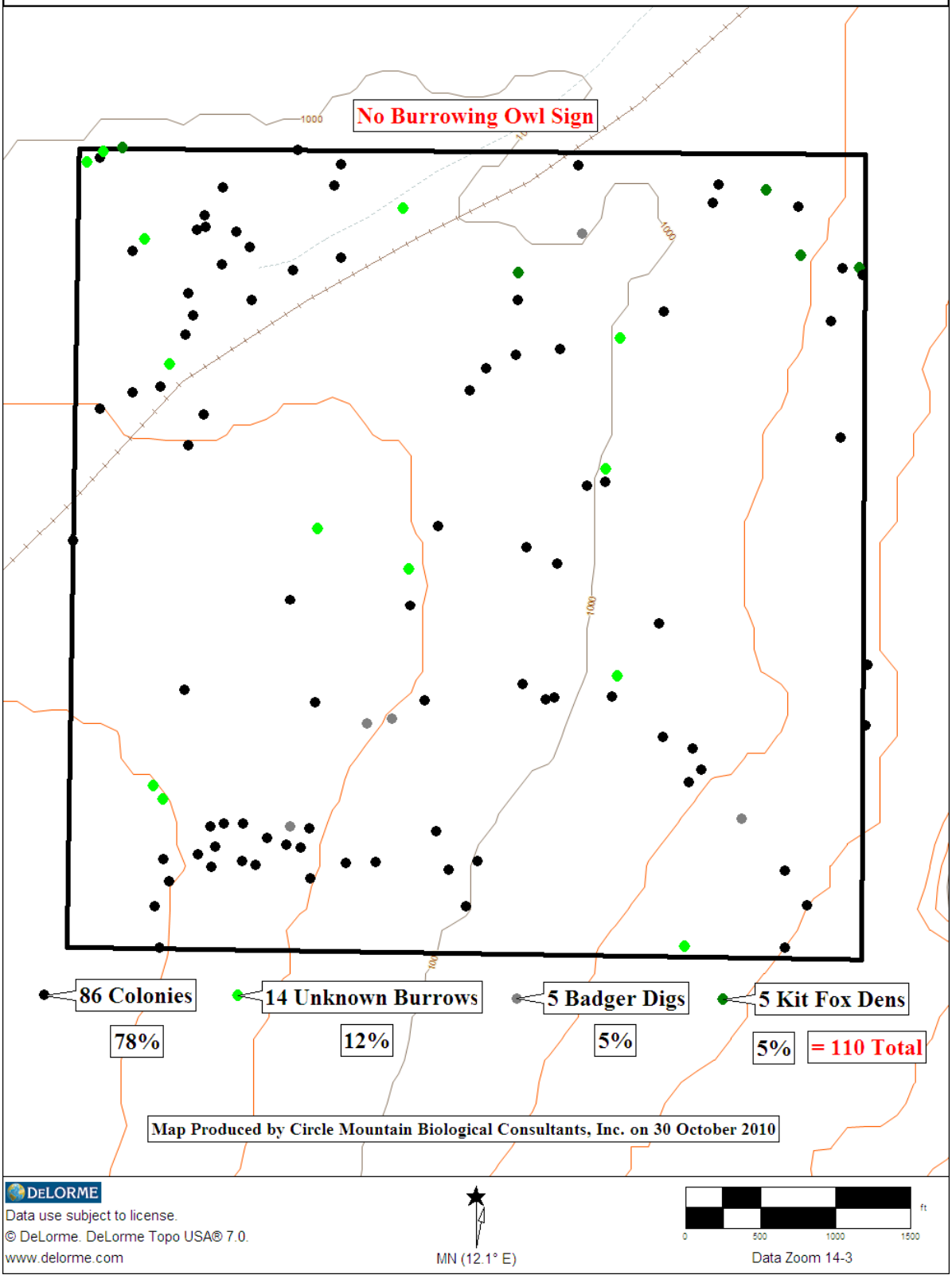


Figure D13. Burrow Data for Section 13 Wellfield Area

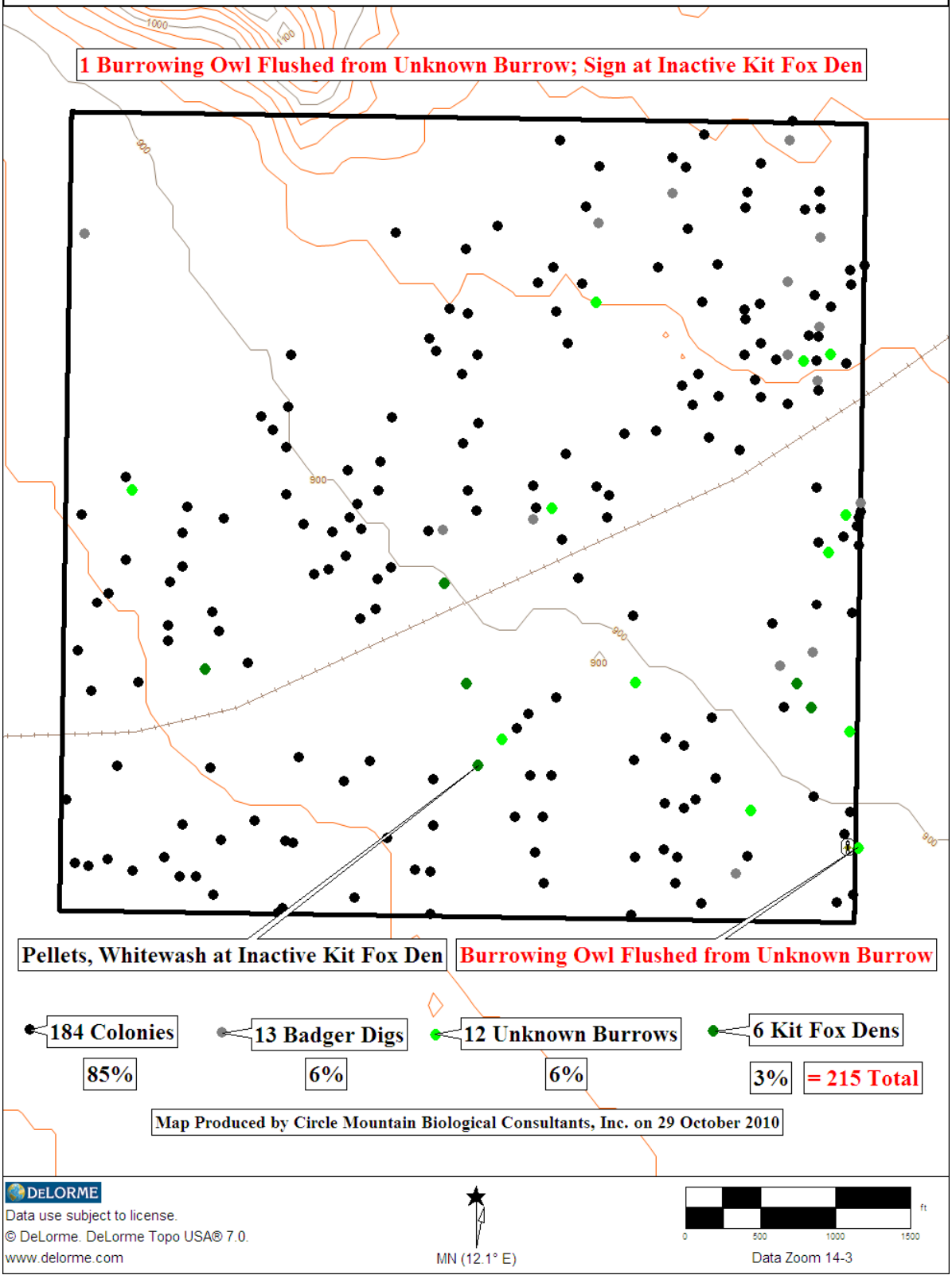


Figure D14. Burrow Data for Section 17 Wellfield Area

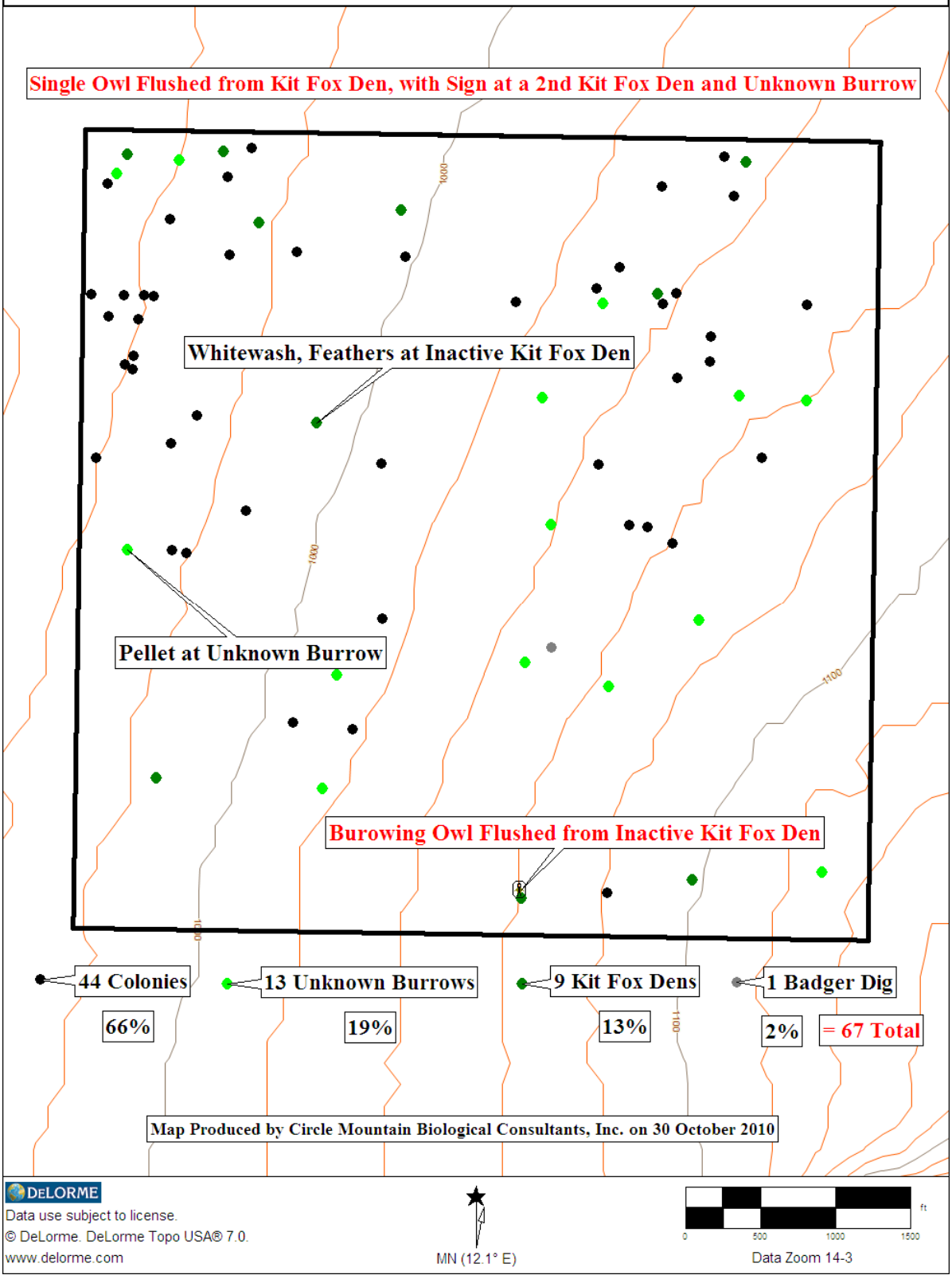


Figure D15. Burrow Data for Section 18 Wellfield Area

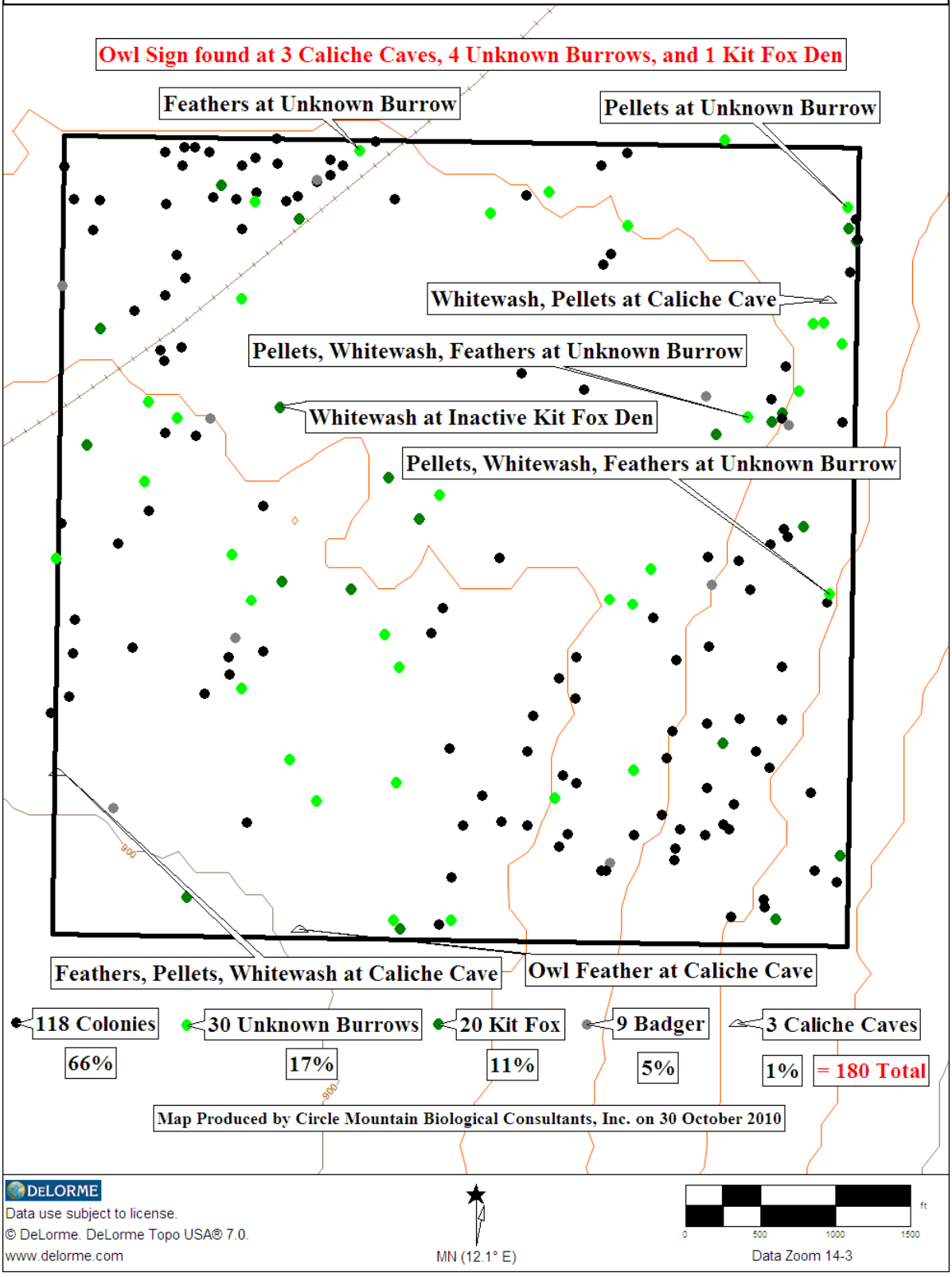


Figure D16. Burrow Data for Section 22 Wellfield Area

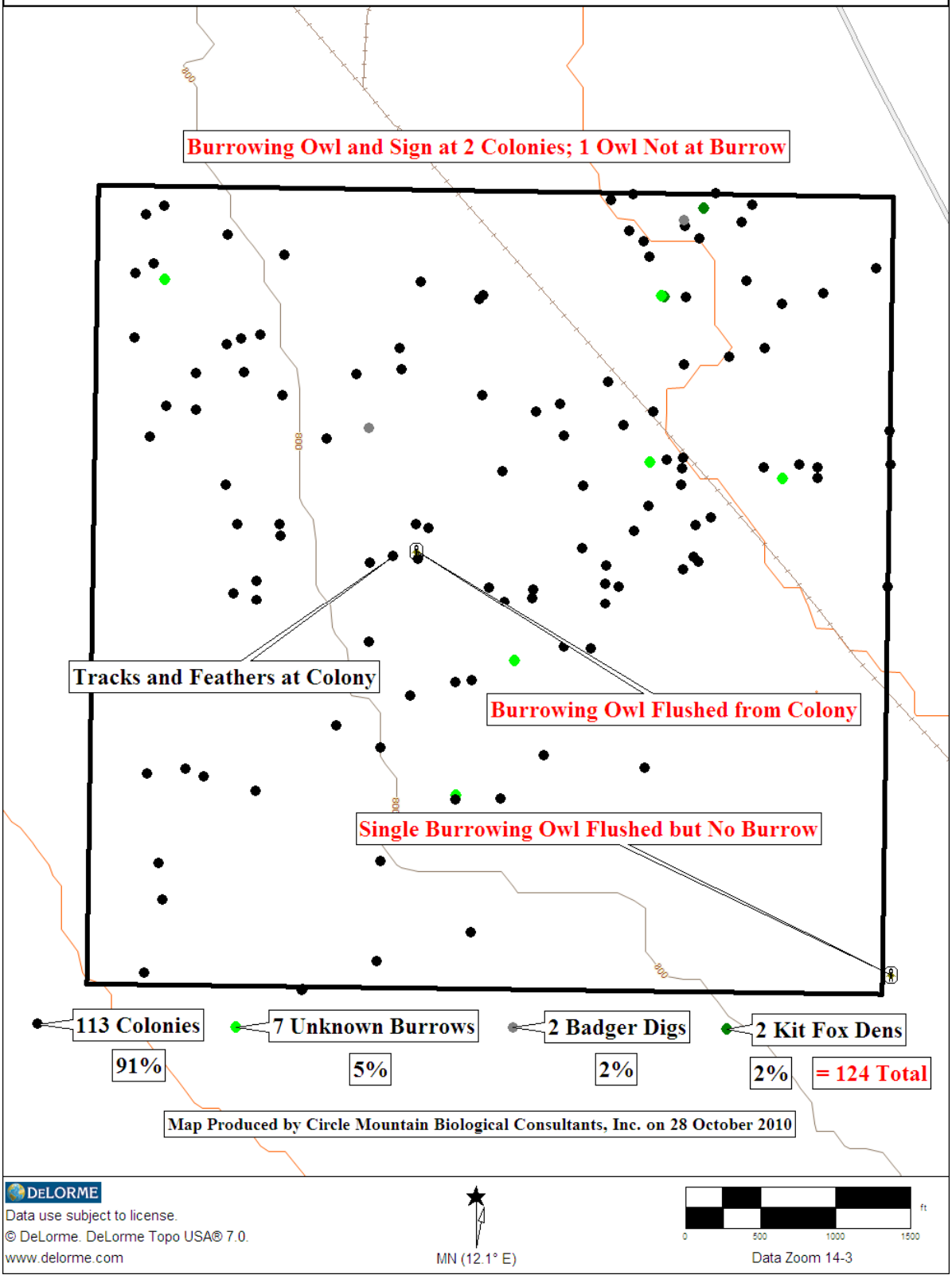


Figure D17. Burrow Data for Section 23 Wellfield Area

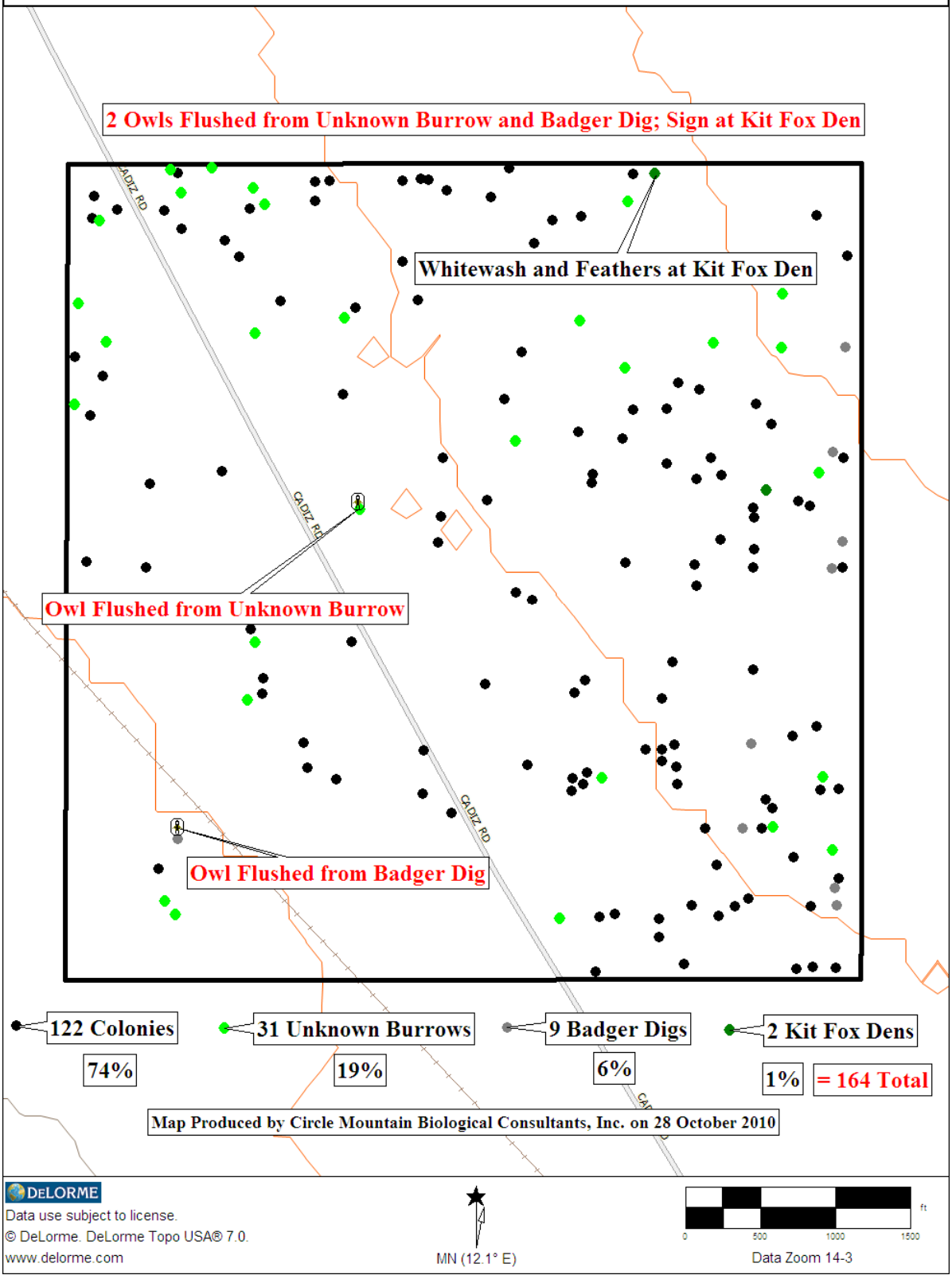


Figure D18. Burrow Data for Section 24 Wellfield Area

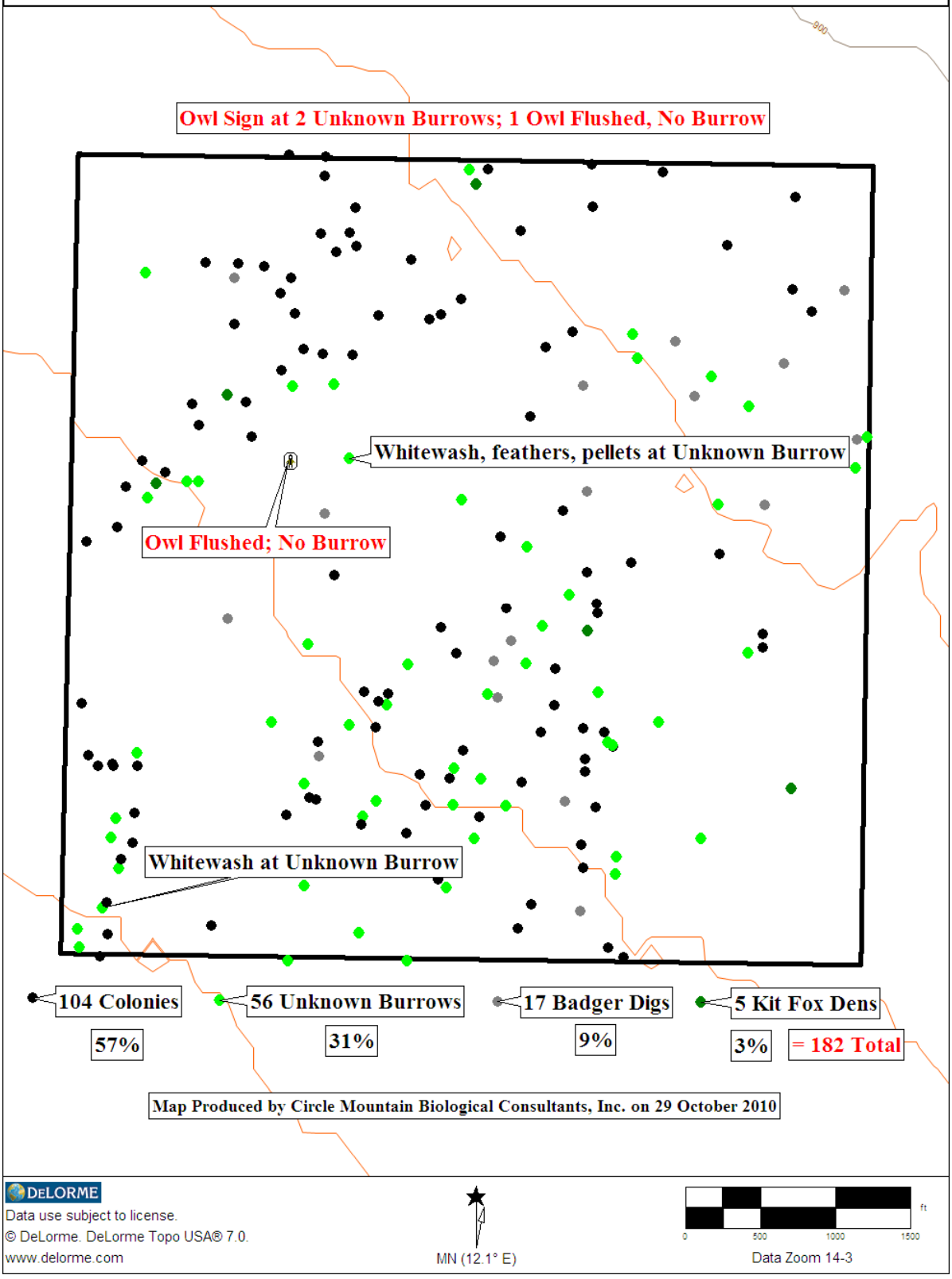


Figure D19. Burrow Data for Section 25 Wellfield Area

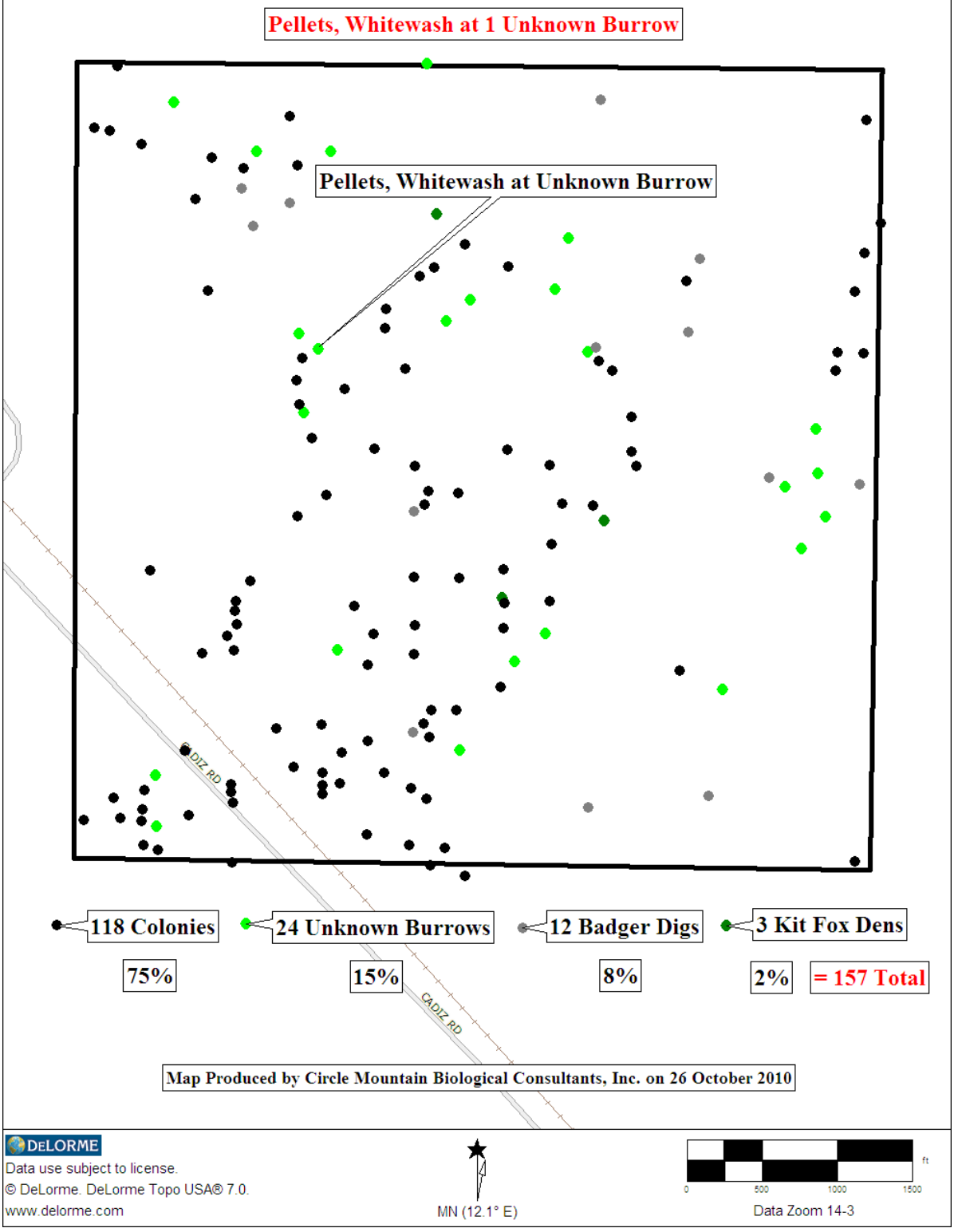


Figure D20. Burrow Data for Section 26 Wellfield Area

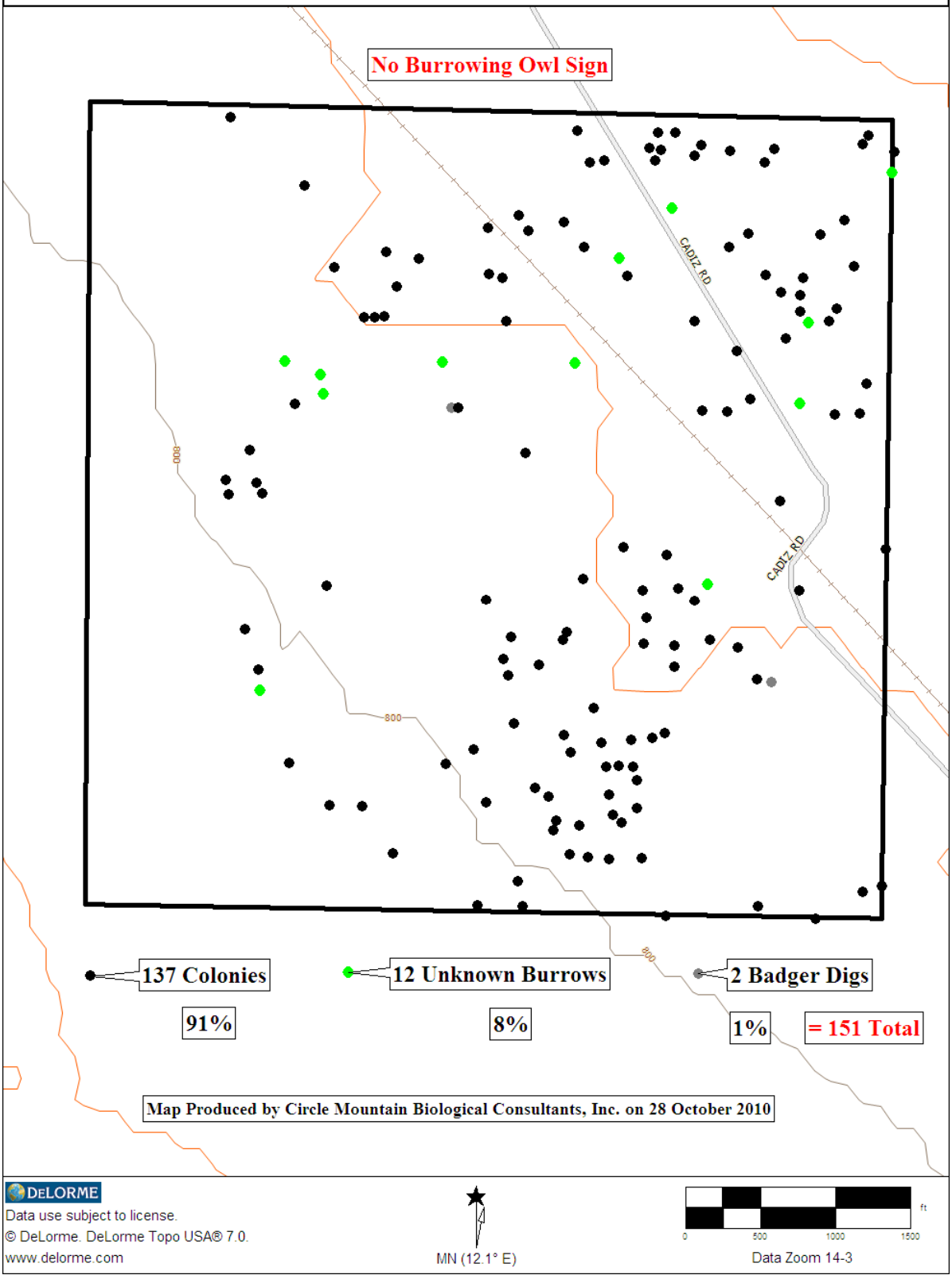


Figure D21. Burrow Data for Section 27 Wellfield Area

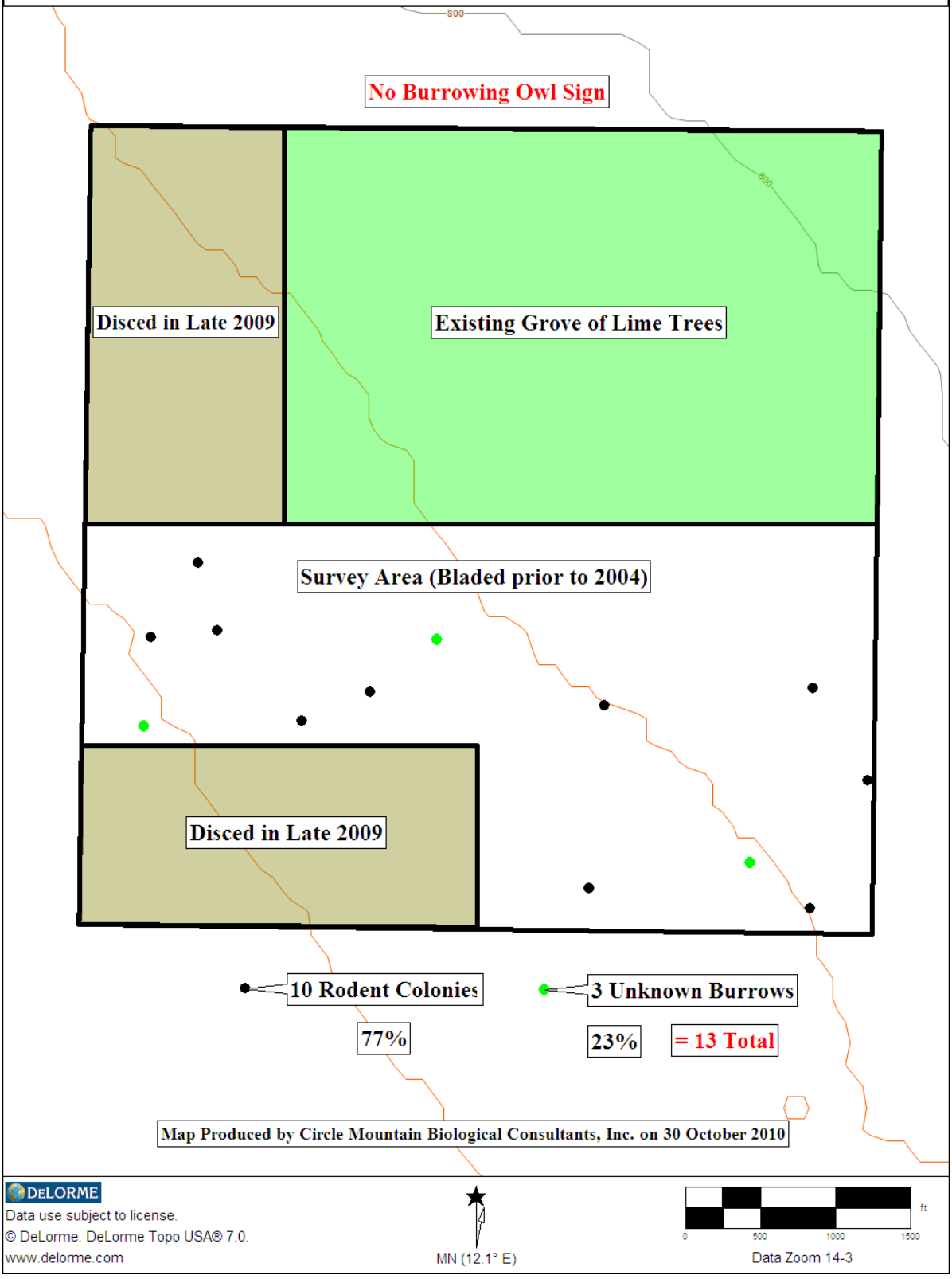


Figure D22. Burrow Data for Half-Section 34 Wellfield Area

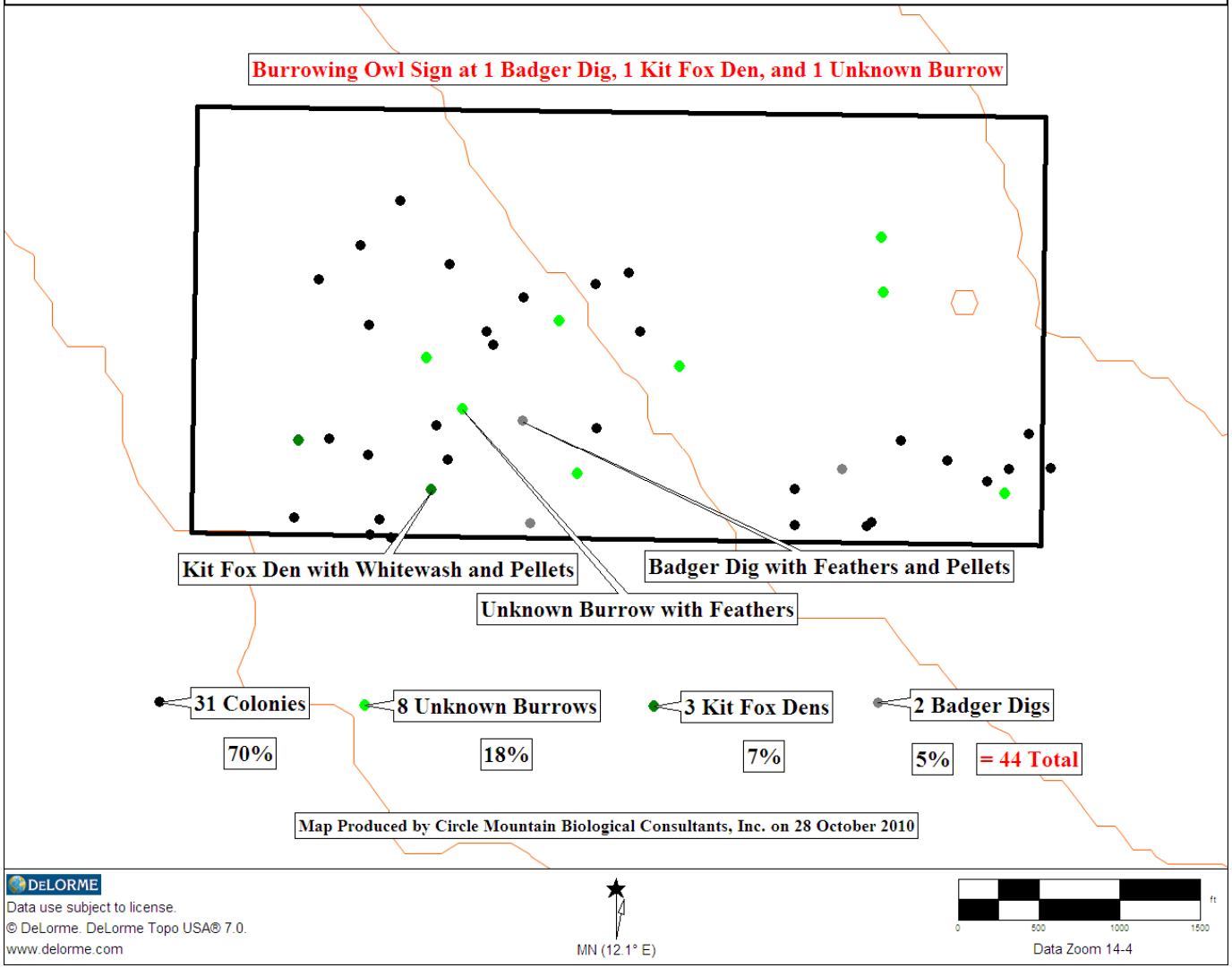


Figure D23. Burrow Data for Half-Section 35 Wellfield Area

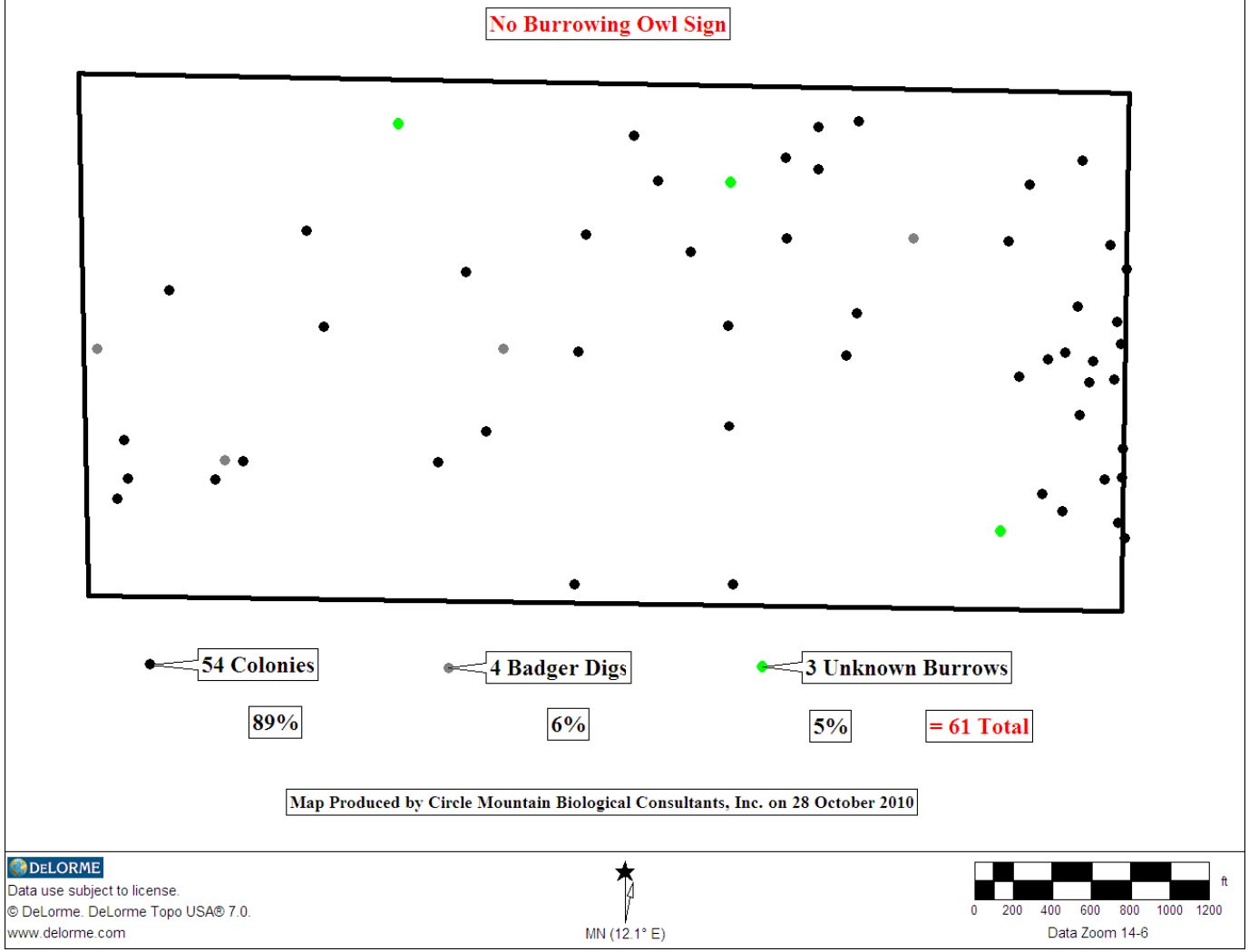


Figure D24. Burrow Data for 160-acre Wellfield Area

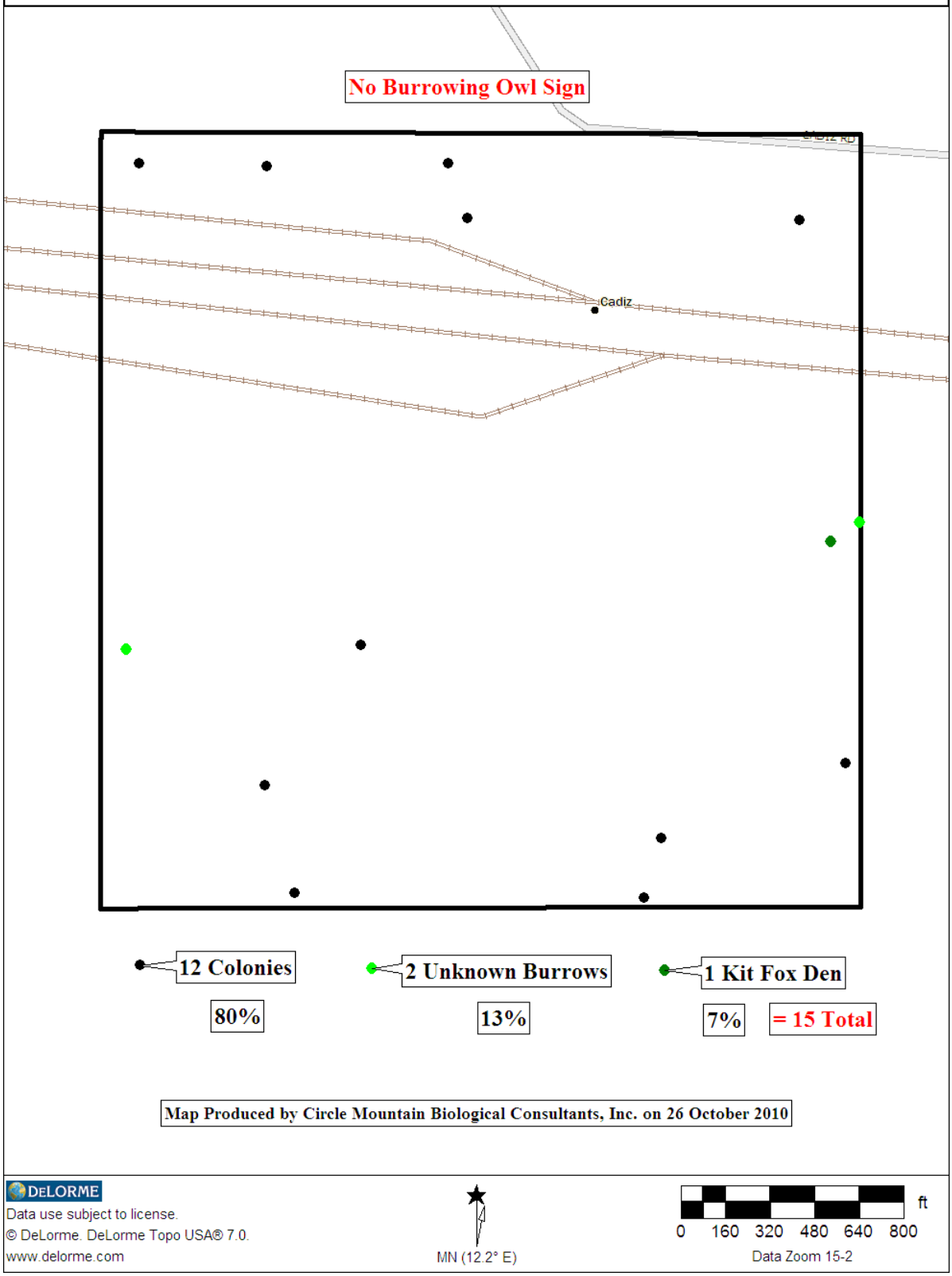
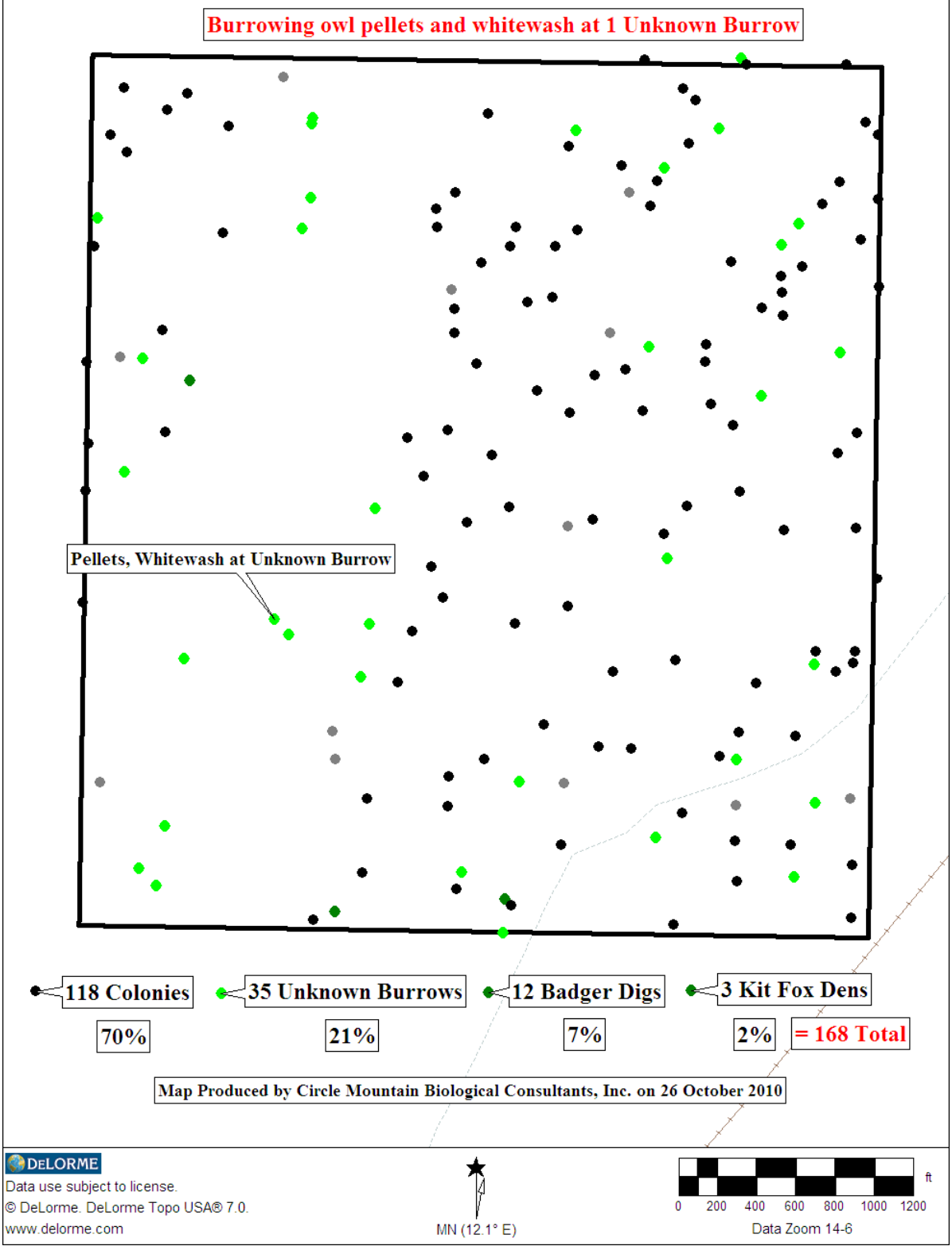


Figure D25. Burrow Data for Spreading Basin Area



Appendix E. Locations of Other Special Status Bird Species

Figure E1. Special Status Birds along Pipeline Alignment

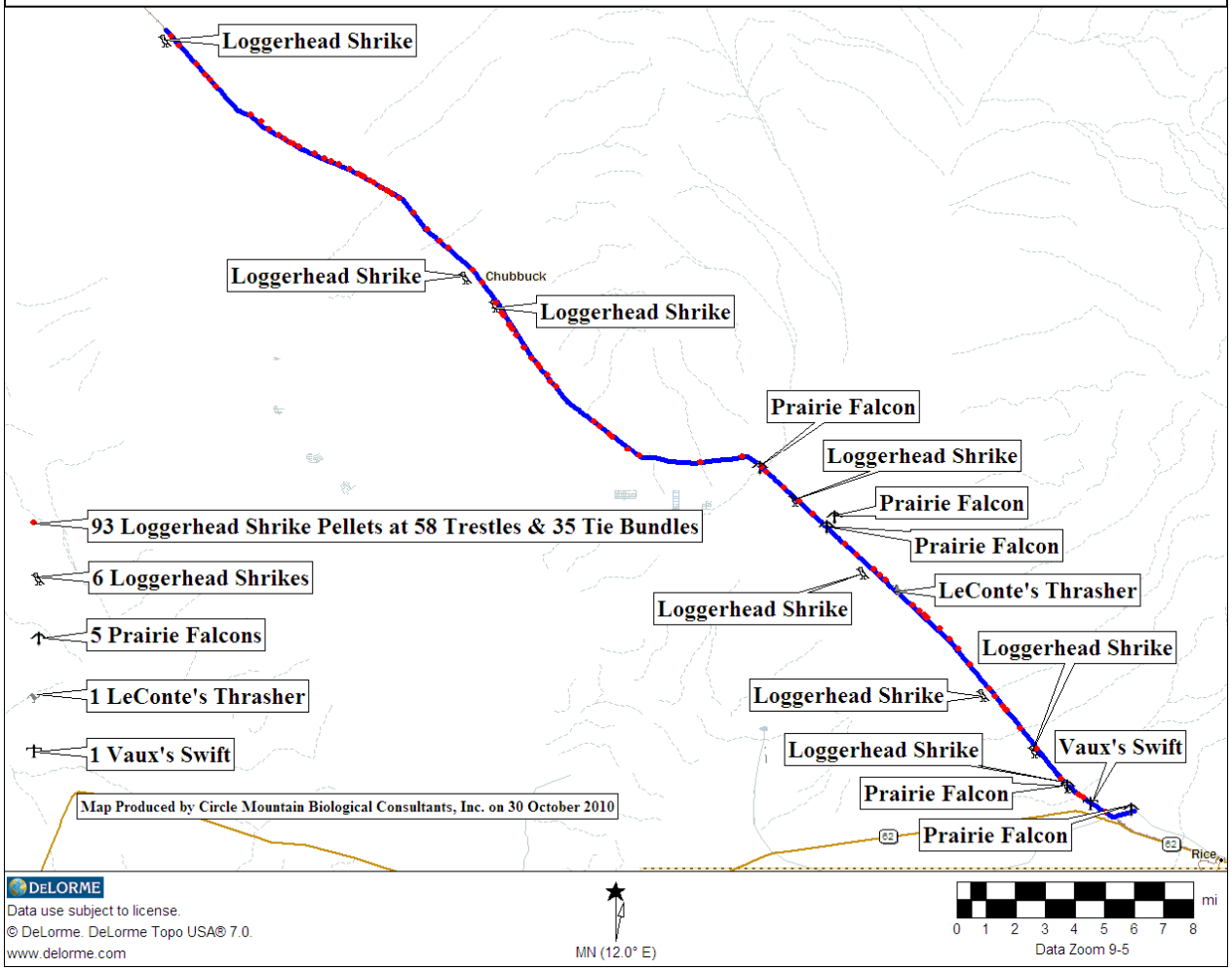
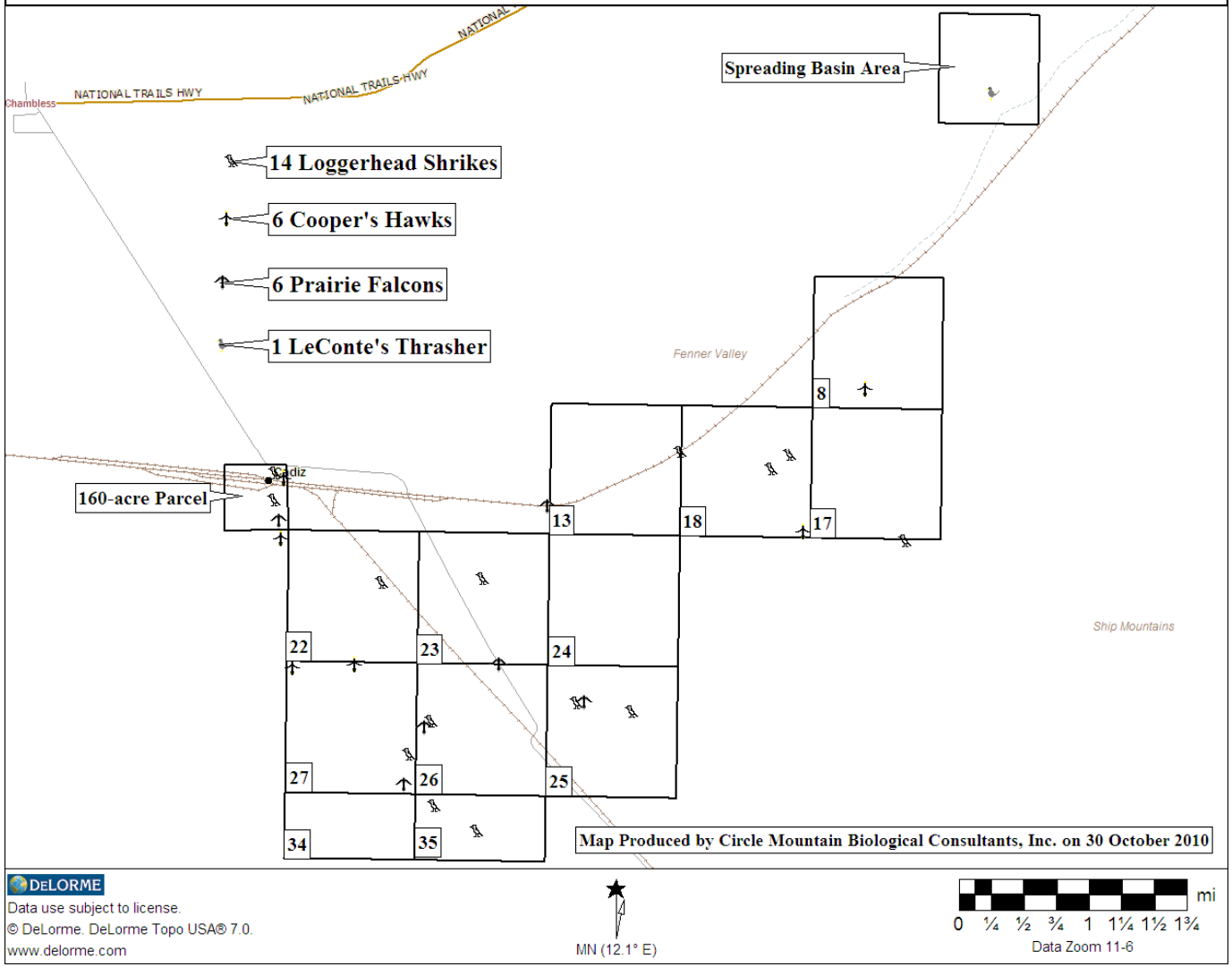
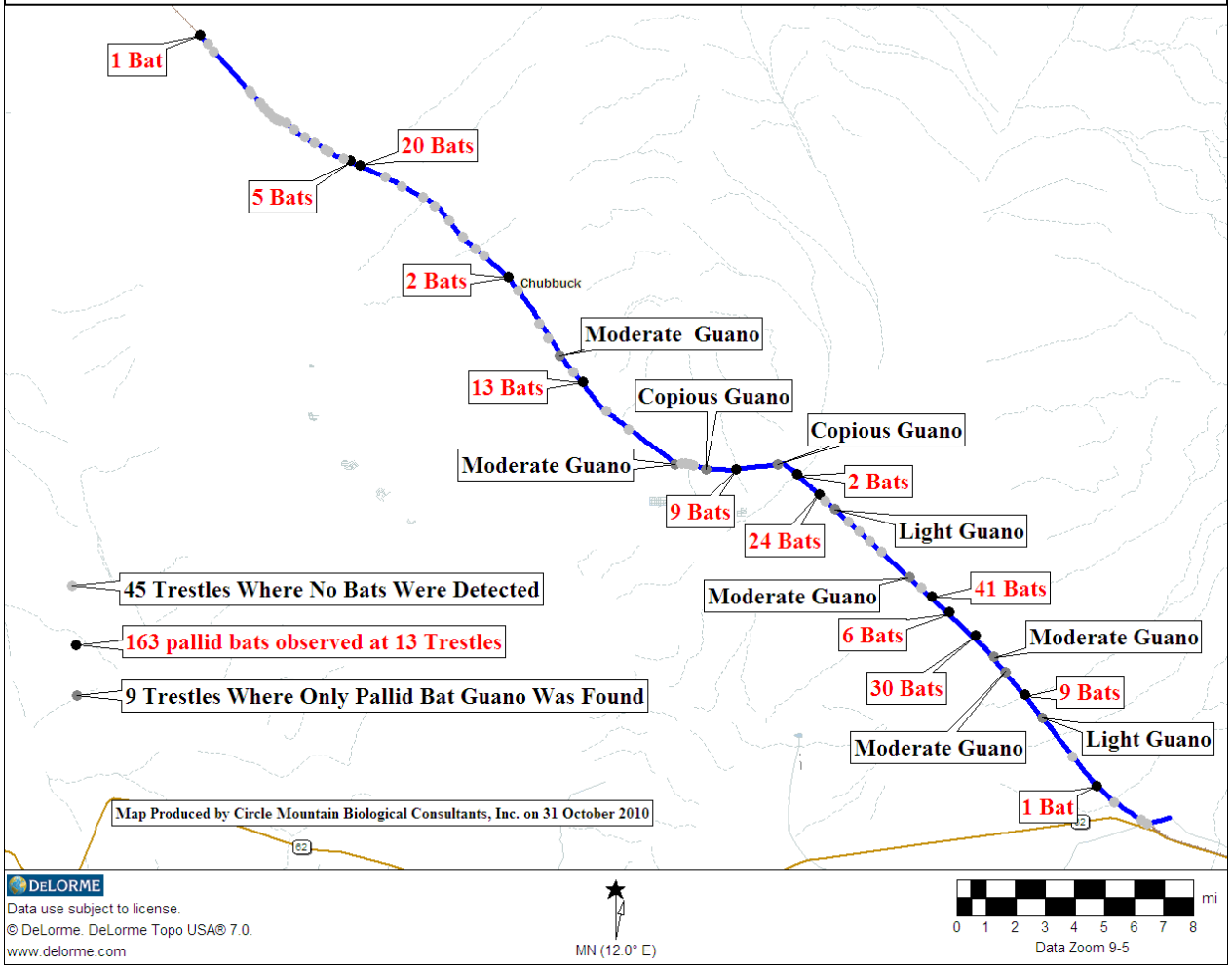


Figure E2. Special Status Birds at Wellfields & Spreading Basin Area

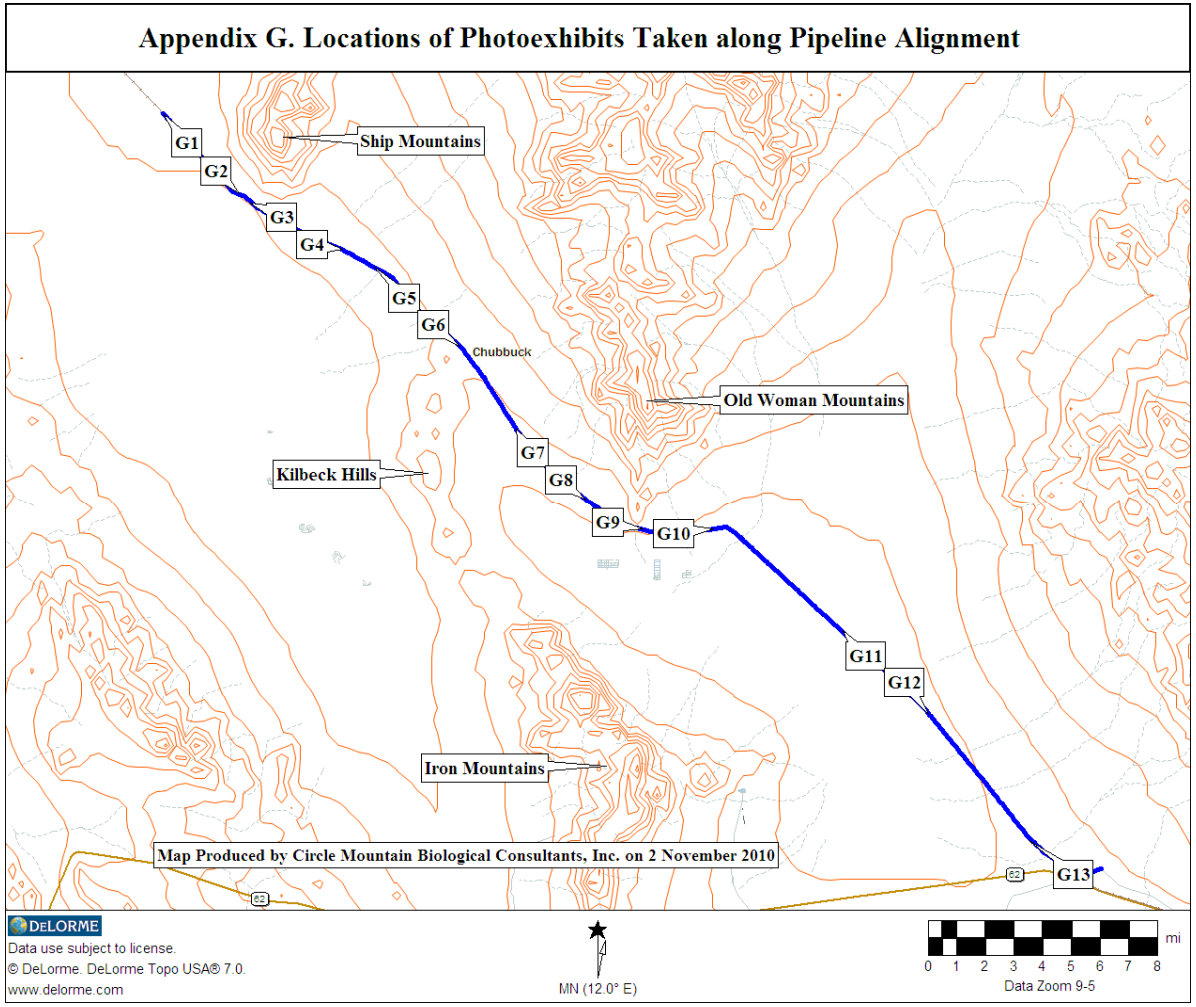


Appendix F. Locations of Pallid Bats and Sign

Figure F1. Locations of Pallid Bats and Guano along Pipeline Alignment



Appendix G. Photographic Exhibits along ARZC Right-Of-Way



Locations of the 13 photographic exhibits on the next 7 pages are depicted above.

Exhibit G1. View along ARZC ROW, facing north towards Cadiz.

Exhibit G2. View from same location as G1, facing south towards Ship Mountains.

Exhibit G3. View along ARZC ROW, facing north towards Ship Mountains.

Exhibit G4. View from same location as G3, facing south towards Old Woman Mountains.

Exhibit G5. View along ARZC ROW, facing north towards Ship Mountains.

Exhibit G6. View from same location as G5, facing south towards Iron Mountains.

Exhibit G7. View along ARZC ROW, facing north towards Kilbeck Hills.

Exhibit G8. View from same location as G7, facing south towards Old Woman Mountains.

Exhibit G9. View along ARZC ROW at tip of Old Woman Mountains, facing south.

Exhibit G10. View of some of the buildings at the historic site of Milligan, facing east.

Exhibit G11. View along ARZC ROW, facing north towards Old Woman Mountains.

Exhibit G12. View from same location as G11, facing southeast.

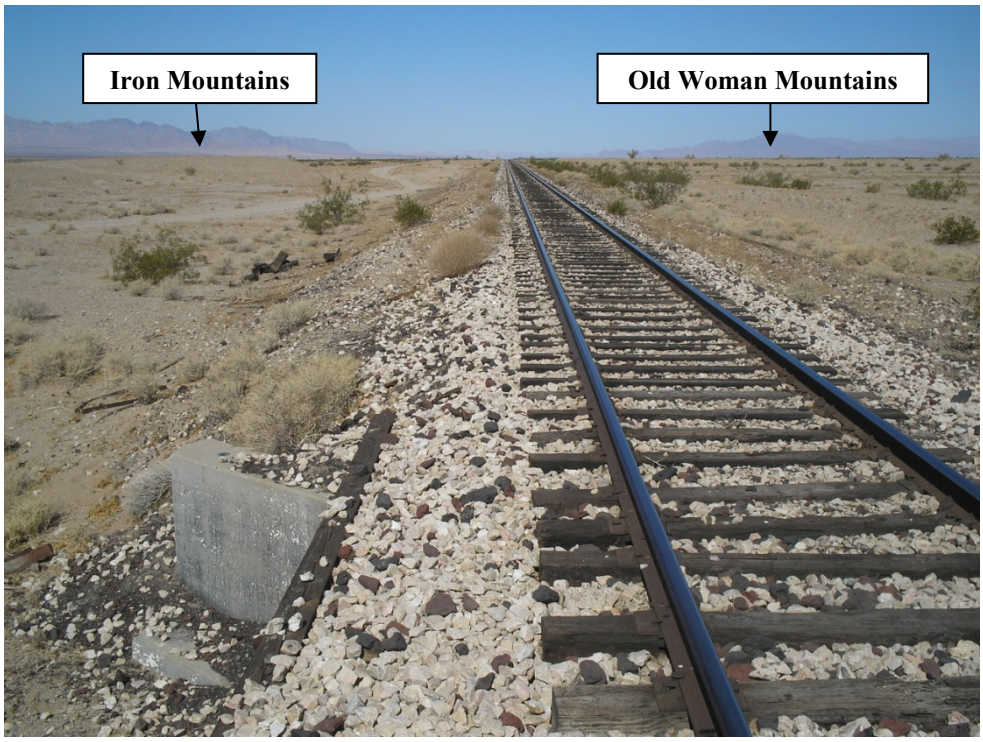
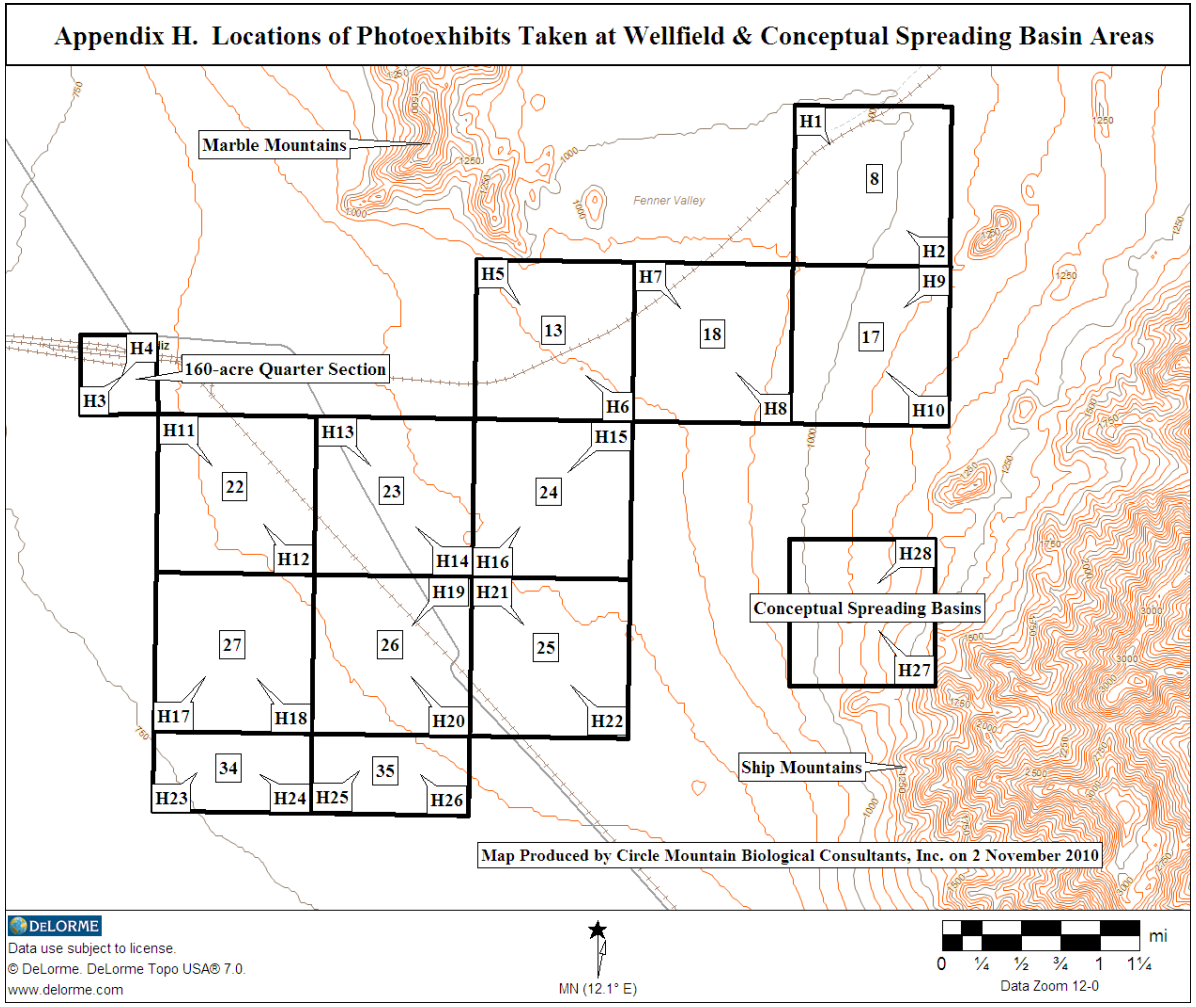


Exhibit G13. View from the southern terminus of the ARZC ROW, facing north.

Appendix H. Photographic Exhibits within Wellfield and Conceptual Spreading Basins Areas



Locations of the 28 photographic exhibits on the next 14 pages are depicted above.

Exhibit H1. Section 8 Wellfield: View from northwest corner of Section 8, facing southeast.

Exhibit H2. Section 8 Wellfield: View from southeast corner of Section 8, facing northwest.

Exhibit H3. 160-acre Wellfield: View from southwest corner, facing northeast.

Exhibit H4. 160-acre Wellfield: View from northeast corner, facing southwest.

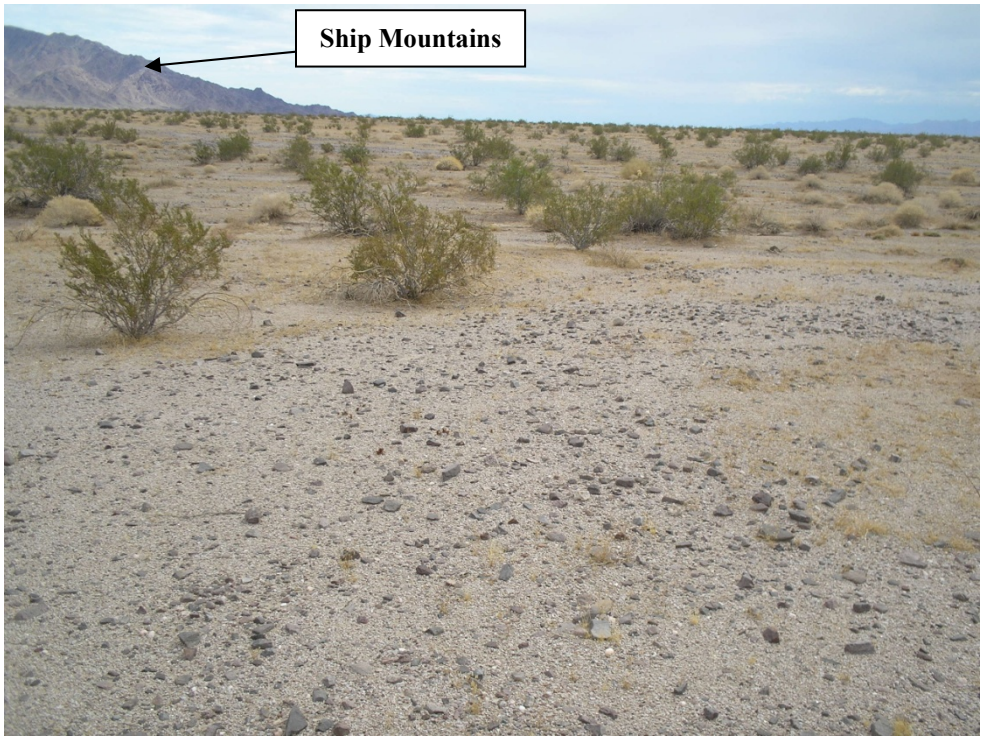


Exhibit H5. Section 13 Wellfield: View from northwest corner of Section 13, facing southeast.

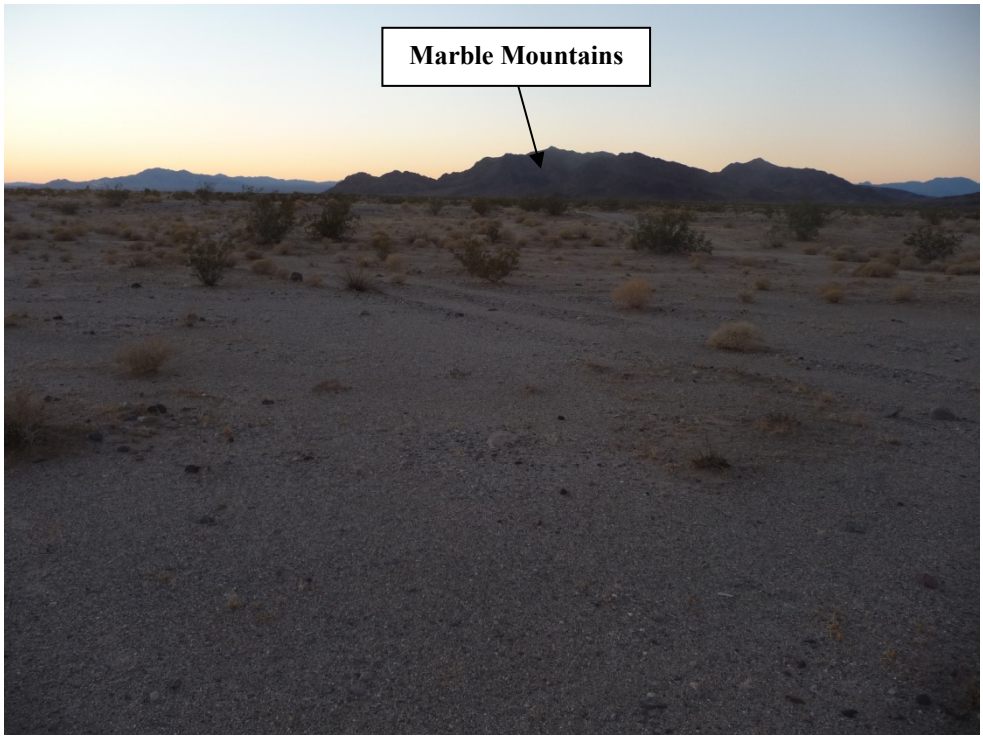


Exhibit H6. Section 13 Wellfield: View from southeast corner of Section 13, facing northwest.

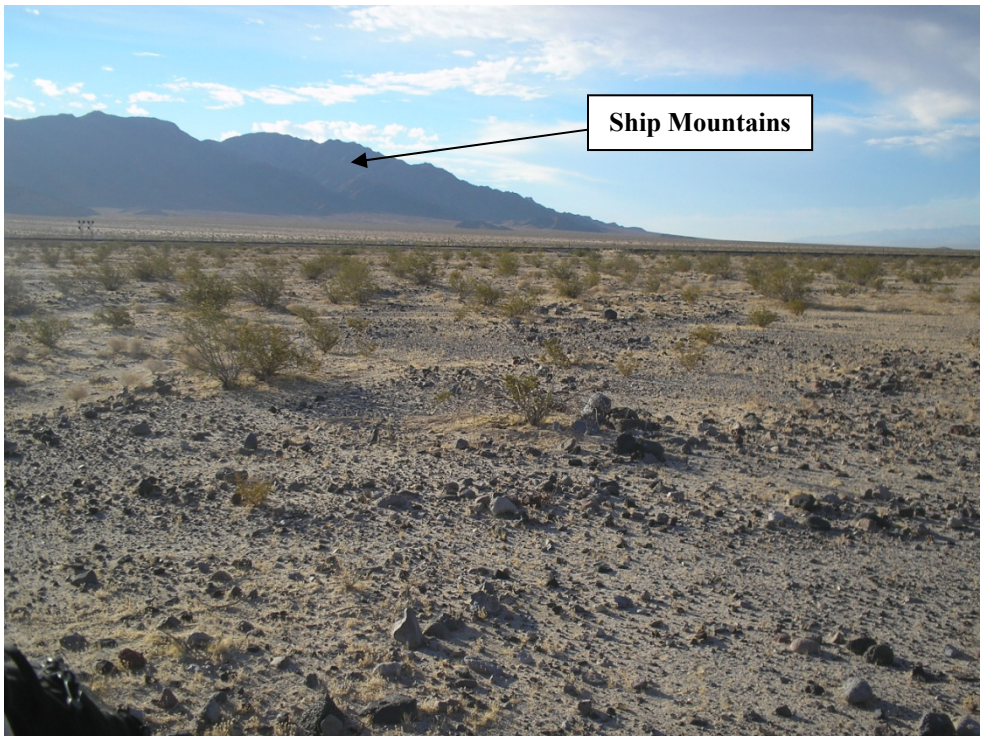


Exhibit H7. Section 18 Wellfield: View from northwest corner of Section 18, facing southeast.

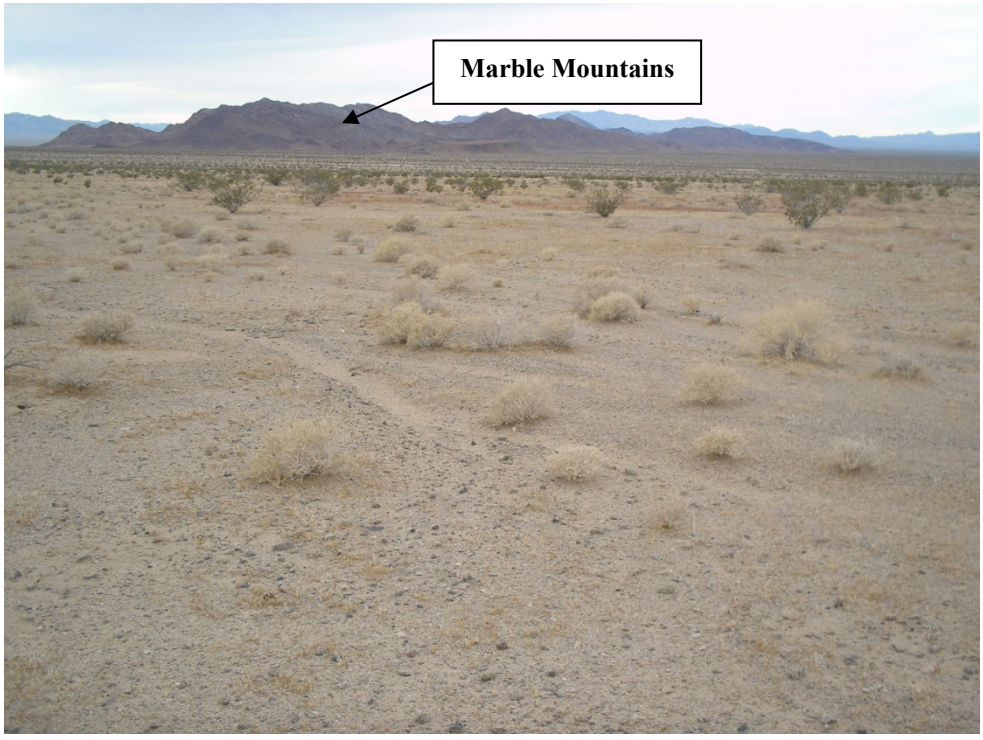


Exhibit H8. Section 18 Wellfield: View from southeast corner of Section 18, facing northwest.

Exhibit H9. Section 17 Wellfield: View from northeast corner of Section 17, facing southwest.

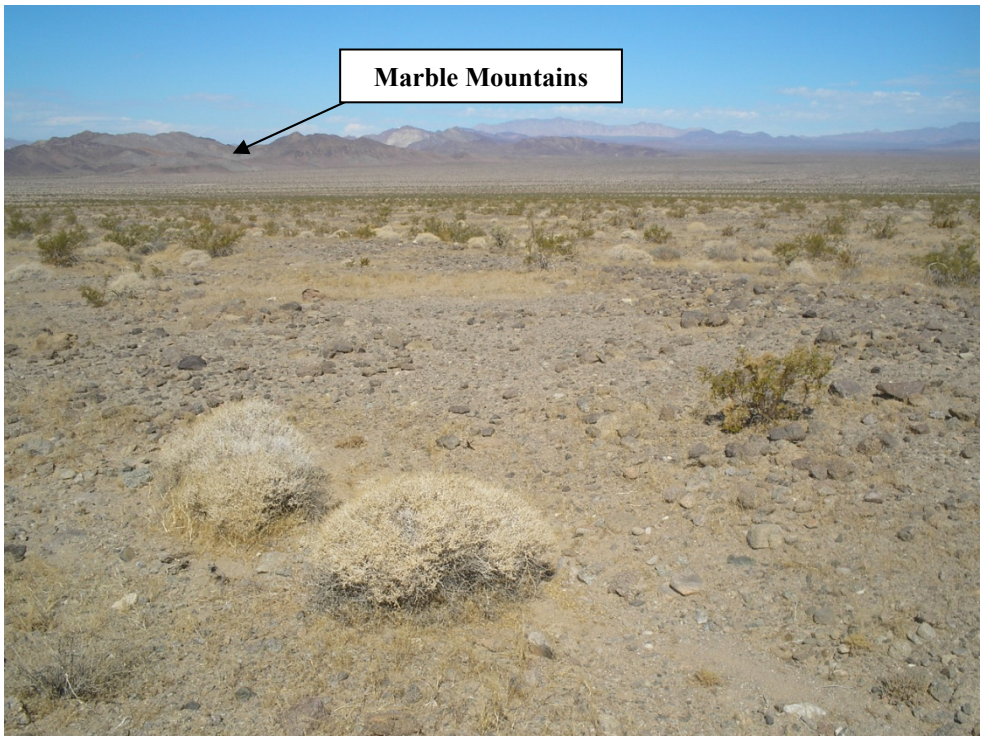


Exhibit H10. Section 17 Wellfield: View from northeast corner of Section 17, facing southwest.

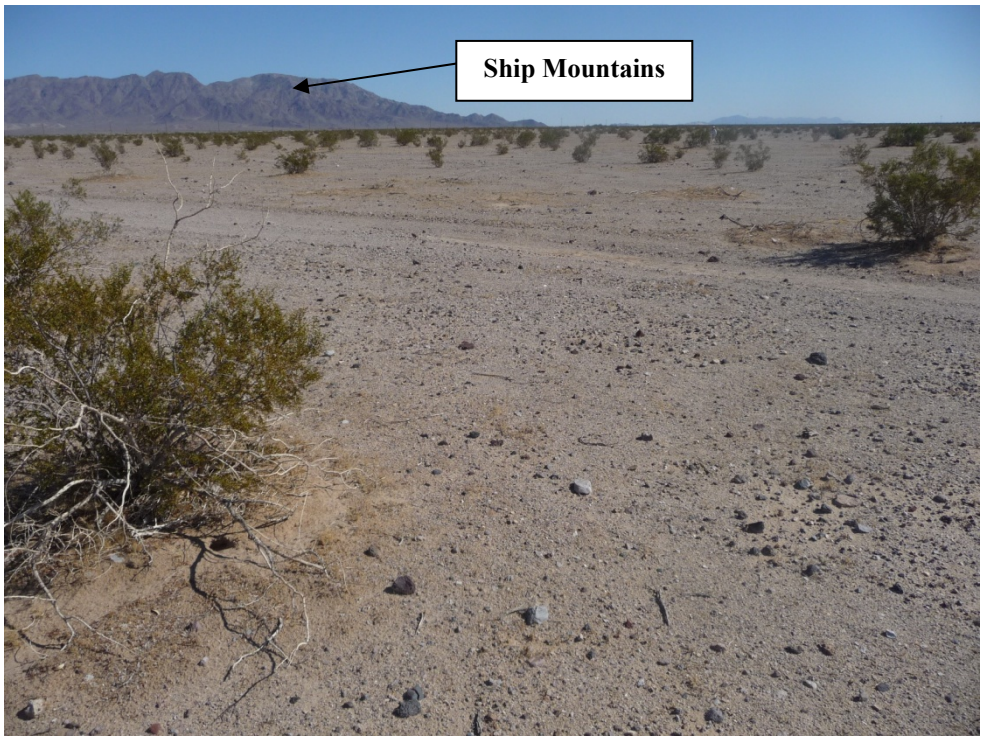


Exhibit H11. Section 22 Wellfield: View from northwest corner of Section 22, facing southeast.

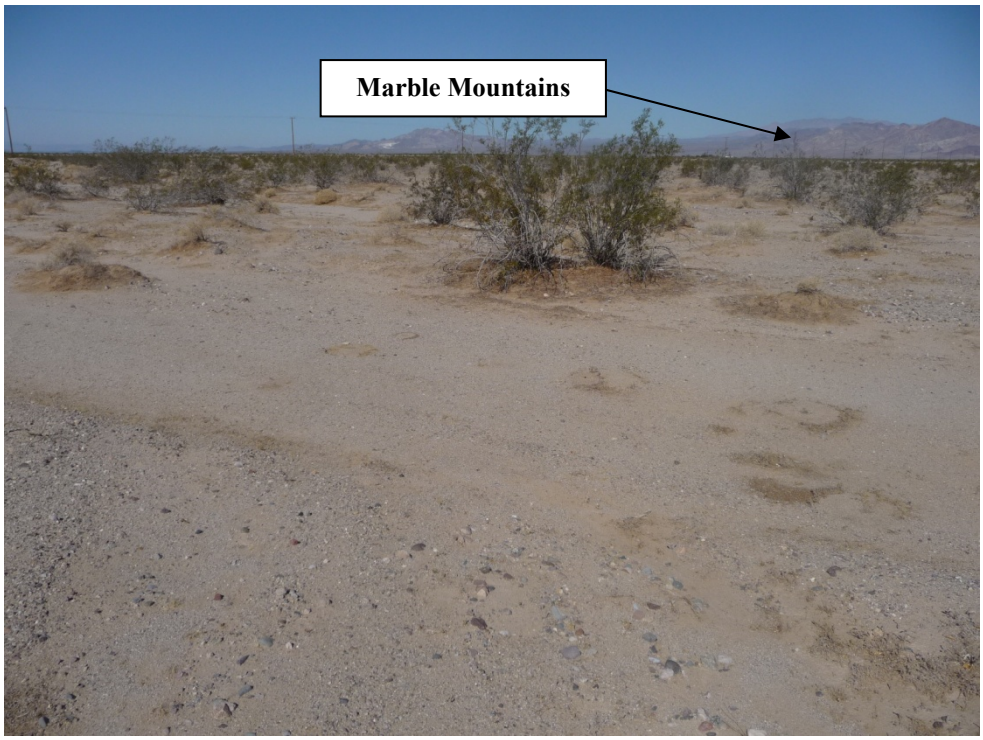


Exhibit H12. Section 22 Wellfield: View from southeast corner of Section 22, facing northwest.

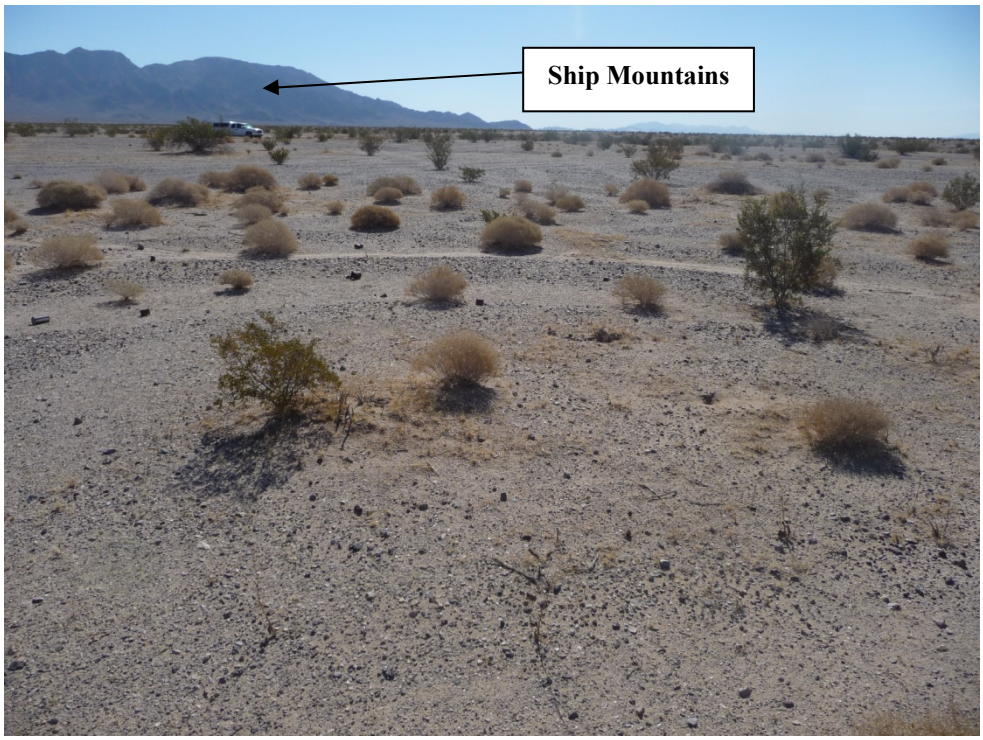


Exhibit H13. Section 23 Wellfield: View from northwest corner of Section 23, facing southeast.

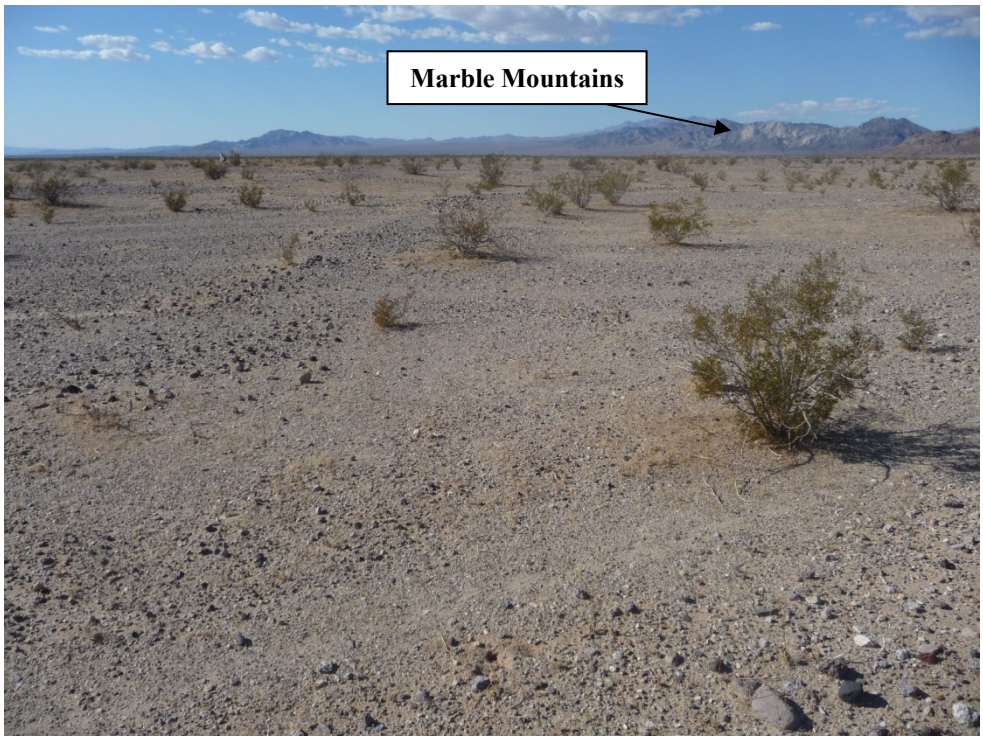


Exhibit H14. Section 23 Wellfield: View from southeast corner of Section 23, facing northwest.

Exhibit H15. Section 24 Wellfield: View from northeast corner of Section 24, facing southwest.

Exhibit H16. Section 24 Wellfield: View from southwest corner of Section 24, facing northeast.

Exhibit H17. Section 27 Wellfield: View from southwest corner of Section 27, facing northeast.

Exhibit H18. Section 27 Wellfield: View from southeast corner of Section 27, facing northwest.

Exhibit H19. Section 26 Wellfield: View from northeast corner of Section 26, facing southwest.

Exhibit H20. Section 26 Wellfield: View from southeast corner of Section 26, facing northwest.

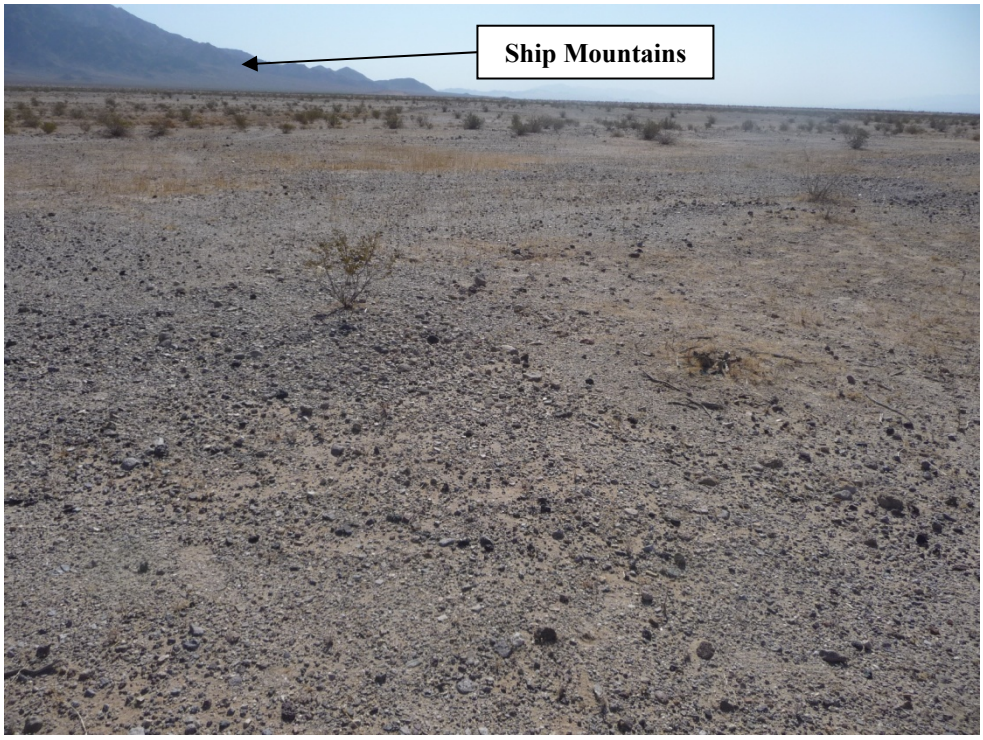


Exhibit H21. Section 25 Wellfield: View from northwest corner of Section 25, facing southeast.

Exhibit H22. Section 25 Wellfield: View from southeast corner of Section 25, facing northwest.

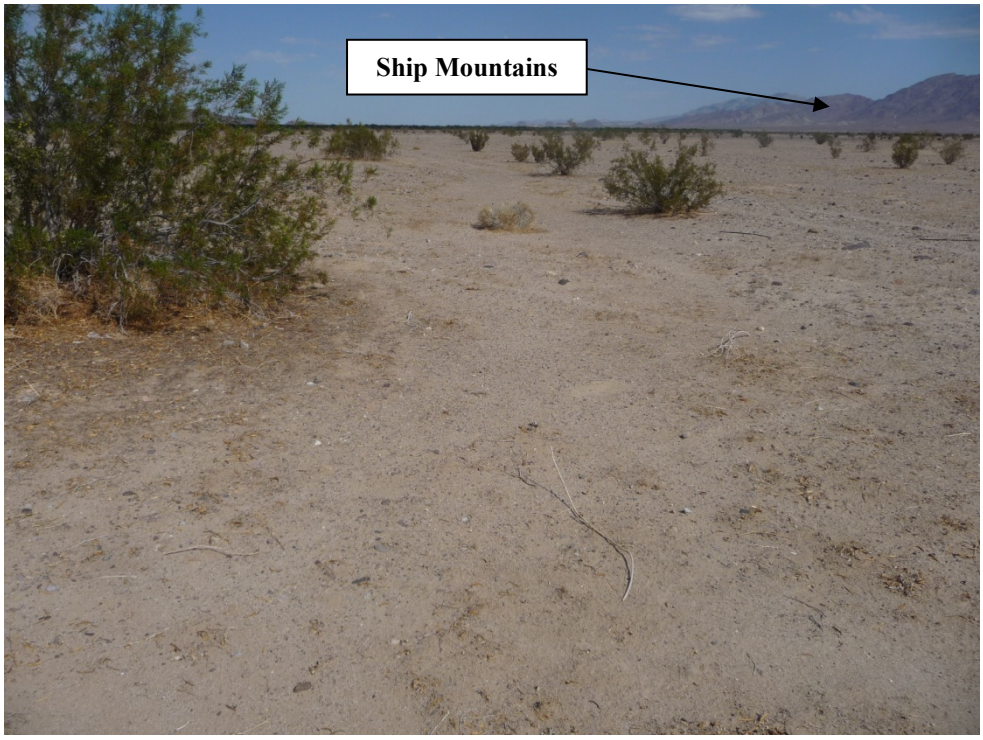


Exhibit H23. Section 34 Wellfield: View from southwest corner of Section 34, facing northeast.

Exhibit H24. Section 34 Wellfield: View from southeast corner of Section 34, facing northwest.

Exhibit H25. Section 35 Wellfield: View from southwest corner of Section 35, facing northeast.

Exhibit H26. Section 35 Wellfield: View from southeast corner of Section 35, facing northwest.

Exhibit H27. View from southeast corner of conceptual spreading basins area, facing northwest.

Exhibit H28. View from northeast corner of conceptual spreading basins area, facing southwest.

Appendix I. Photographic Exhibits of Miscellaneous Biological Resources

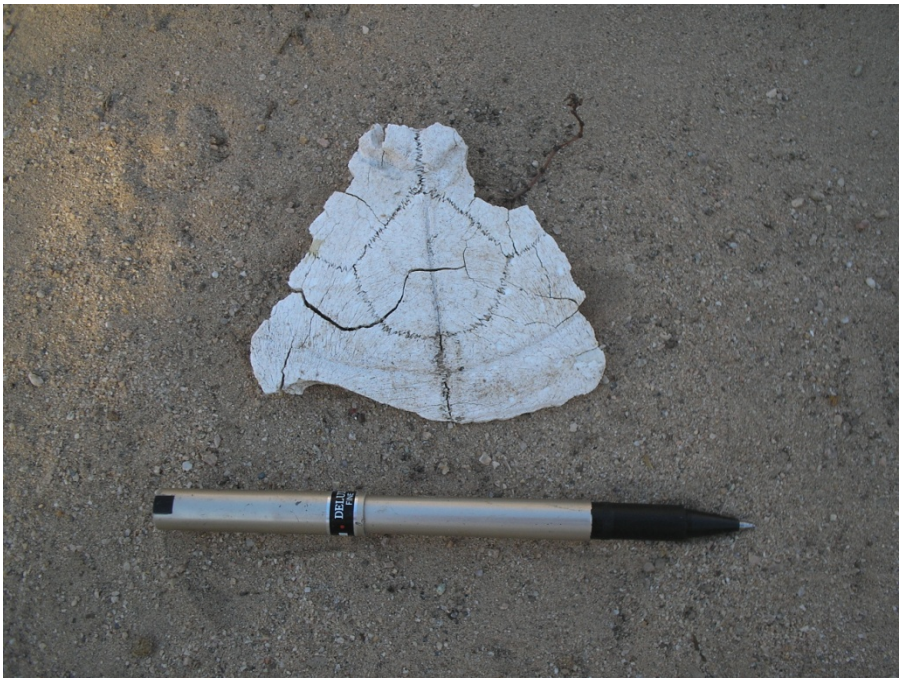


Exhibit I1. Anterior half of plastron of adult female tortoise that died more than four years ago near north end of ARZC ROW (Appendix C for location of "Adult Female Carcass, Dead > 4 Years").

Exhibit I2. Plastron pieces of a subadult tortoise that died 1-4 years ago near center of ARZC ROW (see Appendix C for location of "Subadult Carcass, Dead 1-4 Years").

Exhibit I3. Fragments of an adult tortoise that died more than four years ago on the southern half of Section 8 (see Appendix C for the location of "Adult Carcass Dead > 4 Years.").

Exhibit I4. Active tortoise burrow found near center of ARZC ROW (see Appendix C for location of "Burrow of Adult").

Exhibit I5. Fragments of adult tortoise that apparently died in the 1940's (see Appendix C for location of "Adult Carcass in Tank Tracks.")

Exhibit I6. Carcass shown above in Exhibit I5 was found in these tank tracks.

Exhibit I7. Badger dig with claw marks, burrowing owl pellets, and whitewash.

Exhibit I8. Badger dig in rodent colony with multiple burrowing owl signs (pellets, whitewash, feathers).

Exhibit I9. Burrowing owl pellets and whitewash at an unknown burrow.

Exhibit I10. Inactive kit fox den where three burrowing owl pellets were found.

Exhibit I11. Small openings in colonial burrow system that would *not* have been counted.

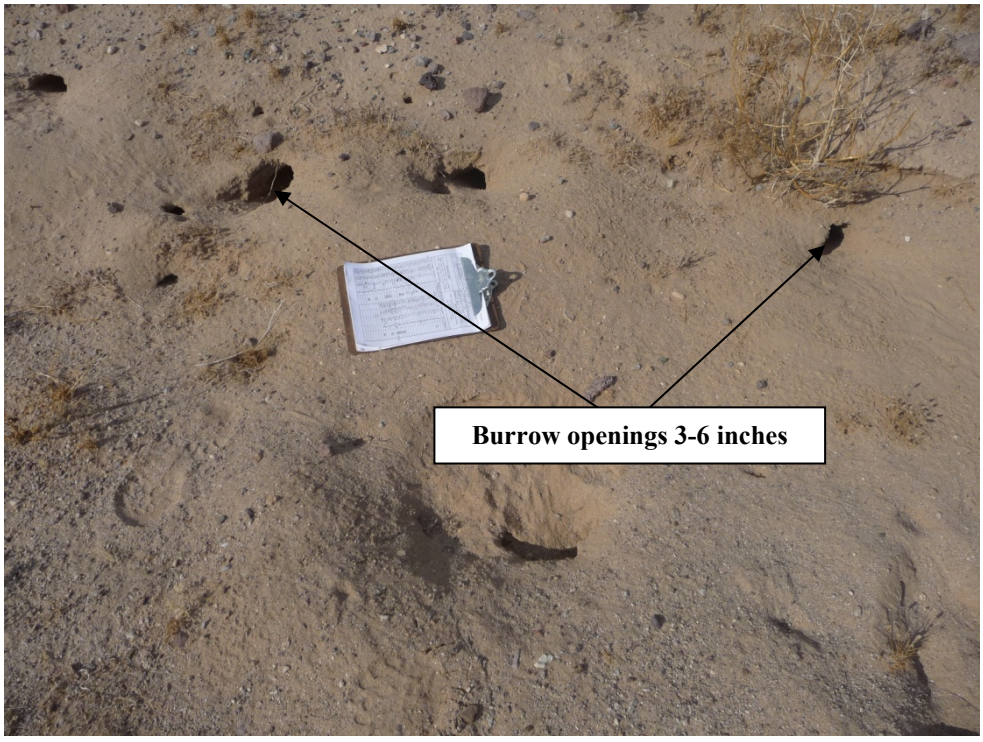


Exhibit I12. Larger openings in colonial burrow system that *would* have been counted.

Exhibit I13. Eight pallid bats found in crevice of cement trestle.

Exhibit I14. When temporarily flushed from its crevice, this pallid bat momentarily attached to cement side of train trestle.

Exhibit I15. Single pallid bat observed in the corner under a wooden train trestle.

Exhibit I16. Typical crevice under cement trestle occupied by pallid bats, with bat urine stains (?).

Exhibit I17. View of a cement trestle where pallid bats were observed in crevices in Exhibits I13 and I14, above.

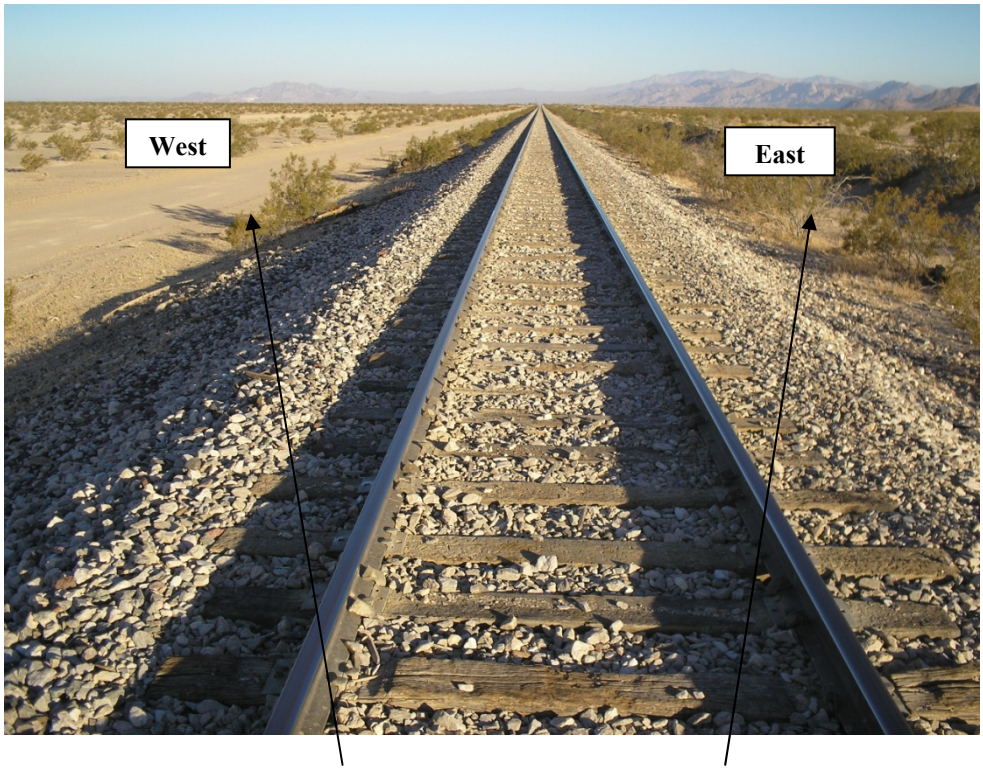


Exhibit I18. Example of degraded habitats to west versus "greenbelt" on east side of tracks.

Exhibit I19. Since water flows from east-to-west along the entire length of the ARZC ROW, washes, sometimes with extensive streamside growth, occur along the east side of the ROW.

Exhibit I20. One of a dozen well-developed drainages with smoke trees and other wash vegetation located at the north end of the proposed pipeline alignment.

Exhibit I21. 60-foot wide wash, on west side of trestle, facing west towards Chubbuck.

Exhibit I22. One of a half-dozen "washlets," with upland plant species and rocky substrates.

Exhibit I23. Skull of a recently-dead white pelican found several hundred feet west of the pilot spreading basins located in Section 13.

Exhibit I24. Common loon found between the front tires of a vehicle in Section 27.

Streambed Delineation for the
Cadiz Groundwater Conservation and Storage Project,
San Bernardino County, California

Job#: 10-030

Prepared by:

Circle Mountain Biological Consultants, Inc.
P.O. Box 3197
Wrightwood, California 92397
PH: (760) 249-4948
FAX: (760) 249-4948
Email: circlemtn@yahoo.com
Contacts: Ed LaRue, Sharon Dougherty

Prepared for:

Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, California 92688
PH: (949) 459-6400

I hereby certify that the statements furnished herein, including attached exhibits, present the data and information required for this biological evaluation, and that the facts, statements, and information presented are true and correct to the best of my knowledge and belief. Field work conducted for this assessment was performed by me or under my direct supervision. I certify that I have not signed a nondisclosure or consultant confidentiality agreement with the project applicant or applicant's representative and that I have no financial interest in the project.

_____

Circle Mountain Biological Consultants, Inc.
Author and Field Investigator: Edward L. LaRue, Jr.

April 2011

Executive Summary

There are approximately 70 streambed crossings perpendicular to the 45-linear mile± proposed Water Conveyance Pipeline and a more dense desert vegetation area running along the eastern side of the pipeline alignment that may be affected by Pipeline installation. There are two major wash systems and minor tributaries running northeast-to-southwest through the proposed wellfield and conceptual spreading basin areas that also may be affected by construction of extraction wells and associated interconnecting pipelines. Once engineering plans are finalized, the information presented herein could be used as supporting data for completion of a 1601-03 Streambed Alteration Agreement with the California Department of Fish and Game.

Table of Contents

Executive Summary i

1.0. Introduction 1

1.1. Purpose and Need for Study 1
1.2. Project Location 1

2.0. Methods 3

2.1. Field Surveys for Pipeline 3
2.2. Field Surveys for Wellfield and Conceptual Spreading Basin Areas 4

3.0. Results 7

3.1. Proposed Water Conveyance Pipeline 7
3.2. Proposed Wellfield and Conceptual Spreading Basin Areas 9

4.0. Conclusions and Recommendations 12

5.0. Literature Cited 13

List of Appendices

Appendix A. Plant Species Detected 14
Appendix B. Photographic Exhibits along Pipeline Alignment 15
Appendix C. Photographic Exhibits within Wellfield and Conceptual Spreading Basin Areas 45

List of Figures

Figure 1. Cadiz Project: Vicinity Map. 2
Figure 2. Cadiz Project: Stream Crossings along Pipeline 3
Figure 3. Transect Coverage at Wellfield Areas 5
Figure 4. Cadiz Project: Stream Crossings within Wellfield Areas 6
Figure 5. Aerial Photograph of Wellfield Areas, 24 Streambed Crossings, and Two Main Wash Systems 11
Figure 6. Cadiz Project: Exhibit Locations for Stream Crossings along Pipeline 15
Figure 7. Cadiz Project: Photographic Exhibit Locations for Wellfield Areas 45

Streambed Delineation for the
Cadiz Valley Water Conservation, Recovery, and Storage Project,
San Bernardino County, California

1.0. Introduction

1.1. Purpose and Need for Study. Circle Mountain Biological Consultants, Inc. (CMBC) was contacted by ESA Southern California Water Group (ESA) on behalf of the Santa Margarita Water District (SMWD) to perform various biological resource studies in support of the Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project) located in San Bernardino County, California (see **Figure 1**). Among other resources, CMBC collected data along all dry washes, drainages, and water courses (herein "streambeds") encountered along both the proposed water conveyance pipeline and connection to the Colorado River Aqueduct (CRA) (proposed pipeline) and in the proposed wellfield and conceptual spreading basin areas (wellfield areas), referred to as "crossings." This information could be used later, once engineering plans are finalized, as baseline data for obtaining a 1601-03 Streambed Alteration Agreement from California Department of Fish and Game (CDFG).

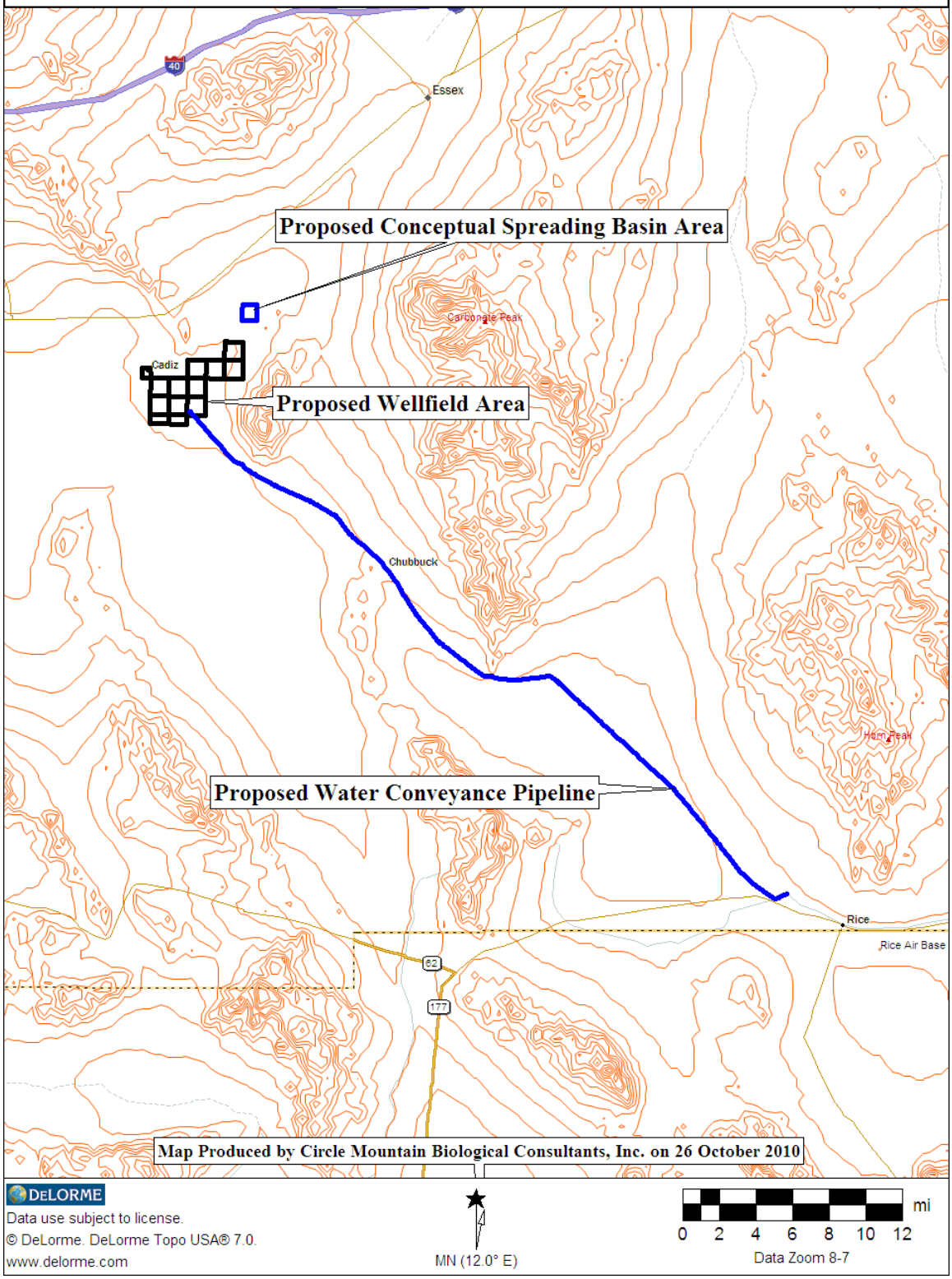
1.2. Project Location. ESA provided the following project location description for the proposed Project. The facilities to be constructed for the Project would be located at the confluence of the Fenner , Cadiz and Bristol Watersheds approximately 220 miles east of Los Angeles, 75 miles southwest of Needles, and 65 miles northeast of Twentynine Palms. The Fenner Valley is a large northeast to southwest trending valley that intersects Cadiz Valley at the Fenner Gap located between the Marble and Ship mountains (Metropolitan Water District 2001).

The Fenner groundwater basin is within a topographically closed drainage system that includes three main drainage basins: Bristol, Cadiz, and Fenner (GeoScience 2010). These basins are considered one drainage system because all surface and groundwater within these basins drains to a central lowland area (i.e. Bristol and Cadiz dry lakes). The Bristol, Cadiz, and Fenner basin system is separated from the surrounding drainage basins by topographic divides (generally mountain ranges).

The total area of the Bristol, Cadiz and Fenner groundwater basin system is approximately 2,710 square miles. Fenner Watershed is approximately 1,100 square miles. Groundwater flow within the Fenner Basin flows through Fenner Gap to the Bristol Dry Lake and Cadiz Dry Lake. The elevation of Bristol Dry Lake is approximately 600 feet above mean sea level**.** The Fenner Valley is bounded by granitic mountain ranges reaching heights over 7,500 feet. The Fenner Gap is at 900 feet.

The alluvial sediments of the valley are underlain by granites and metamorphic rocks, forming a rock-bounded basin overlain with sands and gravels several hundred feet thick. Groundwater ranges from approximately 270 feet below ground surface on the northeastern portion of the project to 140 feet below ground surface in the southwest, becoming shallower with proximity to the dry lakes (GeoScience 1999).

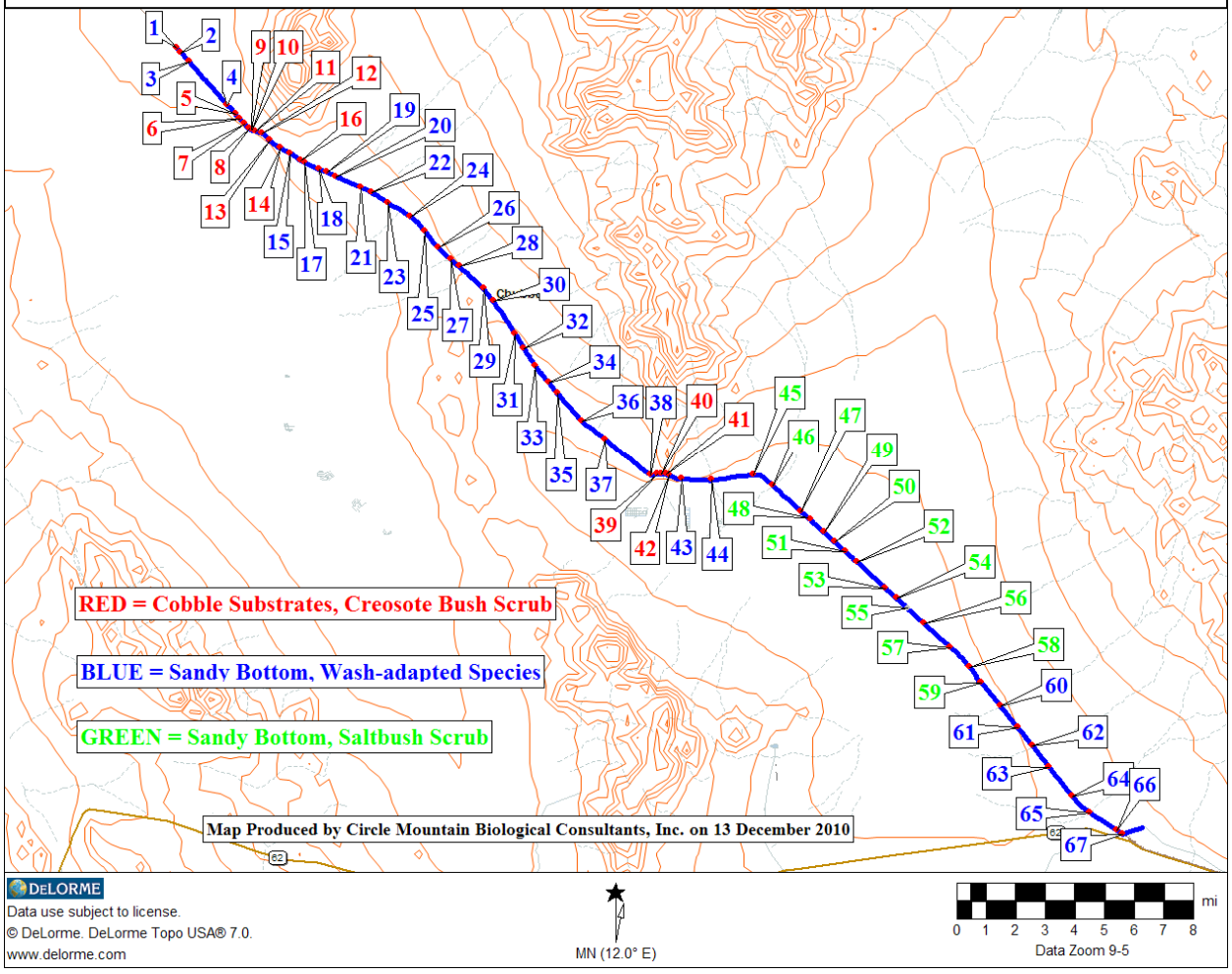
Figure 1. Cadiz Project: Vicinity Map



2.0. Methods

2.1. Field Surveys for Pipeline. Focused surveys for desert tortoise, burrowing owl, and other biological resources were performed by Ed LaRue of CMBC and seven contract biologists between 20 September and 17 October 2010, for a total of 756 hours (see Circle Mountain Biological Consultants, Inc. 2010 for full details). As streambeds were encountered, LaRue recorded the following information at each crossing: dominant perennial shrubs; estimated widths at each streambed crossing; UTM coordinates; and, in most places, photographs. The 67 streambed crossings associated with the proposed pipeline are sequentially listed from north-to-south as 1 through 67 and are mapped in **Figure 2**. These data are presented in **Table 1** on pages 6 and 7.

Figure 2. Cadiz Project: Stream Crossings along Pipeline



2.2. Field Surveys for Wellfield and Conceptual Spreading Basin Areas. Unlike the Pipeline alignment, along which transects were parallel to the Arizona and California Railroad Company (ARZC) rail line and each streambed was crossed one time, the proposed wellfield and conceptual spreading basin areas (wellfield areas) were surveyed along a series of transects spaced at 100 intervals, as depicted below in **Figure 3**. As such, streambeds were crossed at multiple locations. As with the Pipeline crossings, LaRue recorded the following information for the wellfield areas crossings mapped in **Figure 4**, which shows the 24 specific point locations where data were collected: USGS section number; dominant perennial shrubs; UTM coordinates; and photographs. These data are presented in **Table 2** on page 9.

Figure 3. Transect Coverage at Wellfield Areas

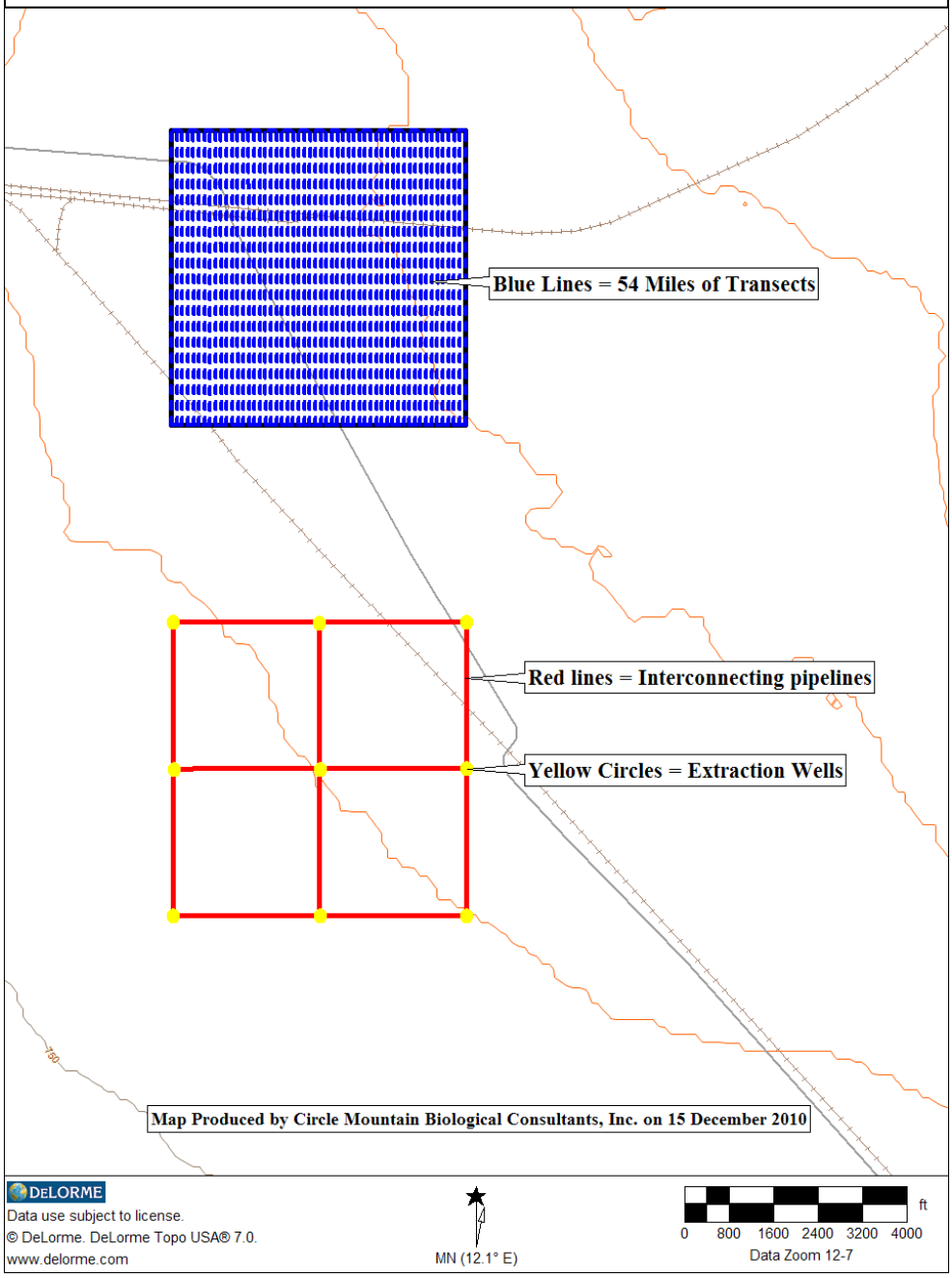
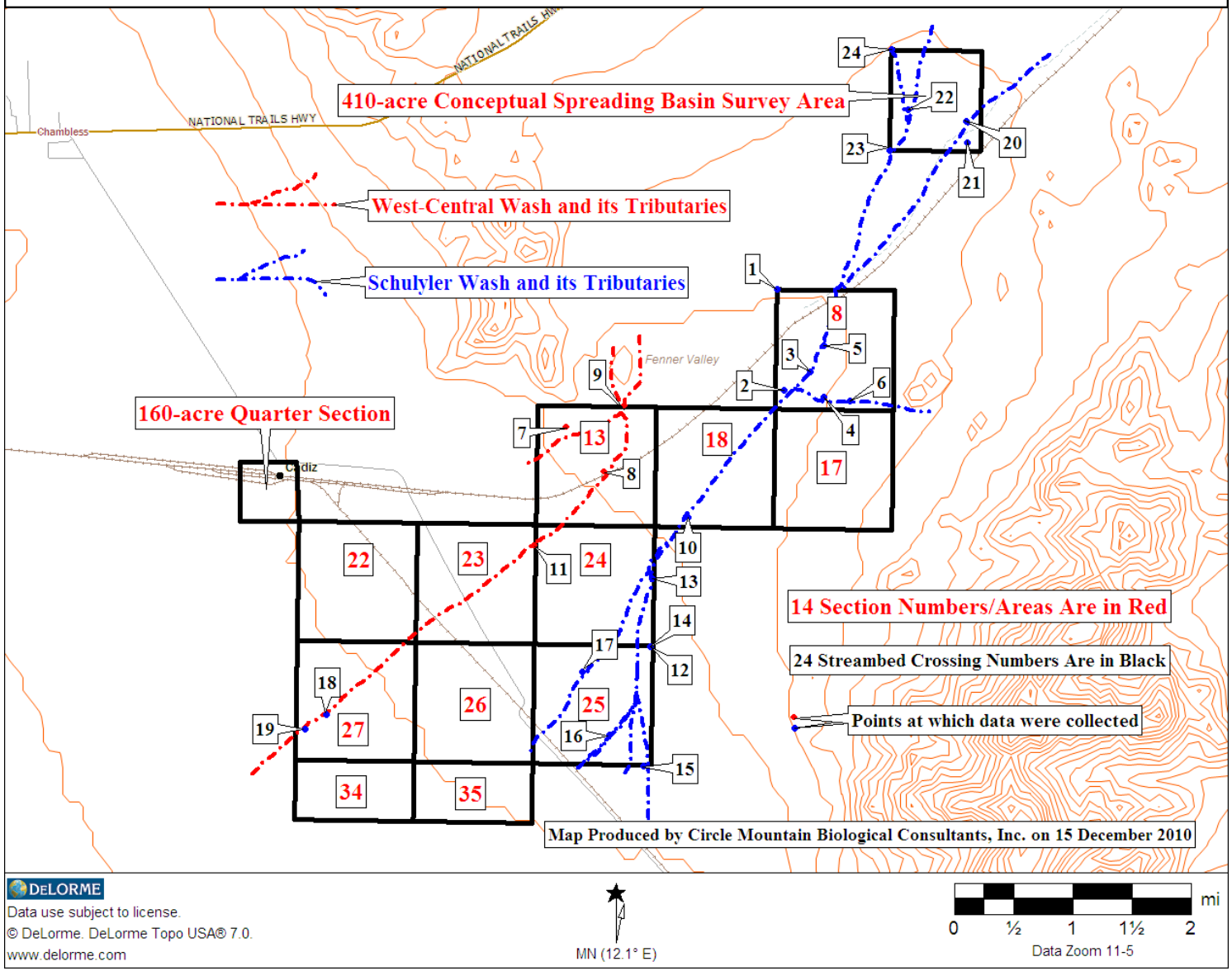


Figure 4. Cadiz Pipeline: Stream Crossings within Wellfield Areas



3.0. Results

3.1. Proposed Pipeline. CMBC identified 67 streambed crossings (e.g., No. 1 through 67 in column 1 below) along the proposed Pipeline that have the potential to be impacted by pipeline installation and project development. There may be a few other streambeds that would be affected but CMBC considers this assessment to include a majority of them and presents an accurate representation of the types of streams occurring in the Project area.

In Table 1, UTM coordinates where each streambed crosses under the ARZC rail line, which coincides with the proposed pipeline, are given in columns two and three. The two types of crossings under the ARZC rail line include bridge-like trestles (including wood, cement, and a combination of the two; see **Exhibit 51** in Appendix B) and either single- or double-holed corrugated pipes, referred to as "culvert" in Table 1 (see **Exhibits 4** and **33** in Appendix B). The estimated width at each crossing is given in column 5. The six-digit codes used to signify the two or three dominant perennial plants at each crossing are listed in the sixth column and defined in Appendix A. CMBC photographed 58 of these 67 crossings, which are mapped in **Figure 6** and included in Appendix B, with exhibit numbers given in the final column.

Table 1. Data for 67 Streambed Crossings along Proposed Pipeline

No.	UTM Coordinates (NAD 83)		Culvert Type	Wash Width (feet)	Dominant Perennials Blue = Sandy, wash-adapted species Red = Cobble, creosote bush scrub Green = Sandy, saltbush scrub	Exhibit No. App. B
	Easting	Northing				
1	640169	3817371	Trestle	60	CHR PAN, AMB DUM, PSO SPI	1
2	640521	3817064	Trestle	30	PSO SPI, ENC FRU, CHR PAN	2
3	640917	3816554	Trestle	100	CHR PAN, PSO SPI, HYM SAL	3
4	643011	3814280	Trestle	70	PSO SPI, PET THU, HYM SAL	None
5	643482	3813774	Trestle	6	HYM SAL, LAR TRI	None
6	643706	3813527	Trestle	15	HYP EMO, BEB JUN, HYM SAL	None
7	643957	3813251	Trestle	50	HYP EMO, BEB JUN, HYM SAL	None
8	644252	3813002	Culvert	6	AMB DUM, LAR TRI	None
9	644325	3812957	Culvert	5	ABM DUM, LAR TRI	4
10	644413	3812923	Culvert	4	AMB DUM, ENC ACT, BEB JUN	5
11	644571	3812878	Culvert	6	LAR TRI, AMB DUM, ENC ACT	6
12	644921	3812773	Trestle	60	HYM SAL, BEB JUN, ENC ACT	7
13	645330	3812412	Trestle	30	BEB JUN, ENC ACT, HYP EMO	8
14	645933	3811995	Trestle	40	ENC ACT, BEB JUN, LAR TRI	9
15	646476	3811705	Trestle	80	PSO SPI, BEB JUN HYM SAL	10
16	647047	3811343	Culvert	6	BEB JUN, HYM SAL, AMB DUM	11
17	647270	3811210	Trestle	15	BEB JUN, HYM SAL	12
18	648048	3810868	Culvert	10	AMB, DUM, LAR TRI	13
19	648446	3810704	Trestle	40	HYM SAL, AMB DUM, PSO SPI	14
20	648970	3810488	Trestle	50	HYM SAL, AMB DUM, LAR TRI	15
21	650345	3809914	Trestle	30	AMB DUM, LAR TRI, HYM SAL	16
22	655268	3806126	Trestle	40	AMB DUM, LAR TRI	17
23	655746	3805737	Trestle	20	HYM SAL, AMB DUM, LAR TRI	18
24	653035	3808399	Trestle	10	AMB DUM, HYM SAL, LAR TRI	19
25	653835	3807632	Trestle	15	LAR TRI, ENC ACT, HYM SAL	20

Table 1. (cont.) Data for 67 Streambed Crossings along Proposed Pipeline

No.	UTM Coordinates (NAD 83)		Culvert Type	Wash Width (feet)	Dominant Perennials Blue = Sandy, wash-adapted species Red = Cobble, creosote bush scrub Green = Sandy, saltbush scrub	Exhibit No. App. B
	Easting	Northing				
26	654583	3806760	Trestle	25	AMB DUM, LAR TRI	21
27	655281	3806135	Trestle	50	LAR TRI, AMB DUM	22
28	655754	3805743	Trestle	70	HYM SAL, PET THU, LAR TRI	23
29	657099	3804566	Trestle	20	LAR TRI, HYM SAL, PET THU	24
30	657622	3803889	Trestle	40	HYM SAL, AMB DUM, LAR TRI	25
31	658843	3802157	Trestle	45	AMB DUM, LAR TRI	None
32	659330	3801394	Trestle	60	LAR TRI, AMB DUM, HYM SAL	26
33	659943	3800440	Trestle	35	HYM SAL, AMB DUM, LAR TRI	27
34	660693	3799566	Trestle	20	HYM SAL, AMB DUM, LAR TRI	28
35	661219	3798975	Trestle	15	AMB DUM, LAR TRI	29
36	662549	3797507	Trestle	40	HYM SAL, LAR TRI, AMB DUM	30
37	663785	3796529	Trestle	10	HYM SAL, LAR TRI, AMB DUM	None
38	666318	3794638	Trestle	50	PSO SPI, HYM SAL, BEB JUN	31
39	666681	3794666	Culvert	5	BEB JUN, ENC ACT, AMB DUM	None
40	666905	3794680	Culvert	60	BEB JUN, HYM SAL, ENC ACT	32
41	667185	3794645	Culvert	15	ENC ACT, LAR TRI, BEB JUN	33
42	667312	3794607	Culvert	10	ENC ACT, HYM SAL, AMB DUM	34
43	668009	3794413	Trestle	20	PSO SPI, HYM SAL, BEB JUN	35
44	669635	3794376	Trestle	10	PSO SPI, HYM SAL, LAR TRI	36
45	671892	3794732	Trestle	35	ATR POL, HYM SAL	37
46	672950	3794169	Trestle	60	HYM SAL, ATR POL, AMB DUM	38
47	674522	3792810	Trestle	20	ATR POL, LAR TRI, HYM SAL	39
48	675055	3792355	Trestle	30	HYM SAL, AMB DUM, LAR TRI	40
49	675796	3791709	Trestle	40	HYM SAL, ATR POL, AMB DUM	41
50	676385	3791199	Trestle	15	LAR TRI, AMB DUM, HYM SAL	42
51	676995	3790673	Trestle	8	ATR POL, AMB DUM	43
52	677605	3790139	Trestle	70	ATR POL, LAR TRI, TAM RAM	44
53	679195	3788768	Trestle	15	PSO EMO, ATR CAN, AMB DUM	45
54	679835	3788220	Trestle	30	ATR POL, SUA MOQ, AMB DUM	46
55	680410	3787716	Trestle	30	ATR CAN, SUA MOQ, ATR POL	None
56	681355	3786900	Trestle	10	ATR POL, HYM SAL, AMB DUM	47
57	682812	3785645	Trestle	60	ATR POL, AMB DUM, LAR TRI	48
58	683843	3784569	Trestle	40	HYM SAL, LAR TRI, AMB DUM	49
59	684514	3783761	Trestle	60	AMB DUM, ATR POL, HYM SAL	50
60	685577	3782490	Trestle	50	HYM SAL, AMB DUM, LAR TRI	51
61	686525	3781341	Trestle	80	AMB DUM, HYM SAL, LAR TRI	52
62	687334	3780383	Trestle	90	LAR TRI, PSO SPI	53
63	688247	3779276	Trestle	80	PSO SPI, AMB DUM, LAR TRI	54
64	689566	3777697	Trestle	50	PSO SPI, HYM SAL	55
65	690550	3776865	Trestle	80	PSO SPI, HYM SAL, ASC ERO	56
66	692048	3775919	Trestle	50	PSO SPI, HYM SAL, ENC FRU	57
67	692359	3775727	Trestle	8	STE PAU, AMB DUM, ENC FRU	58

The 67 streambed crossings along the proposed pipeline may be categorized into three general types of washes based on substrates and associated plant communities. The following color codes are used in Table 1 and **Figures 2** and **6** to distinguish among these three types of washes:

There are 37 Blue Washes, which are typically wide (10 to 100+ feet), sandy-bottomed streambeds vegetated by wash-adapted species such as smoke trees (*Psorothamnus spinosus*), wash rabbitbrush (*Chrysothamnus paniculatus*), rayless encelia (*Encelia fructescens*), cheesebush (*Hymenoclea salsola*), and sandpaper plant (*Petalonyx thurberi*). As shown in Figure 2, they occur along the pipeline alignment north of Ship Mountains, between Ship and Old Woman mountains, and along the southern reaches of the proposed pipeline. With the exception of crossing #18 (**Exhibit 13**), all of these washes pass under bridge-like trestles.

There are 15 Red Washes, which are typically narrow (5 to 60 feet), with rocky-to-cobble substrates. These streambeds are typically vegetated by upland species associated with creosote bush scrub, including creosote bush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), sweetbush (*Bebbia juncea*), desert lavender (*Hyptis emoryi*), and Acton encelia (*Encelia actoni*). As shown in Figures 2 and 6, these washes are either associated with Ship Mountains or Old Woman Mountains, which are responsible for the associated cobble substrates. Most of these crossings pass through one- or two-holed corrugated pipe culverts.

Finally, there are 15 Green Washes, which are like the red washes except they have sandy bottoms and are vegetated by saltbush scrub rather than creosote bush scrub. These are intermediate in widths (10 to 70 feet) and vegetated by allscale (*Atriplex polycarpa*), four-winged saltbush (*Atriplex canescens*), Torrey's sea-blight (*Suaeda moquinii*), and indigo bush (*Psorothamnus emoryi*), among some of the same plants found along red washes. All of these streambed crossings are located east of Danby Lake, and all pass beneath trestles rather than culverts.

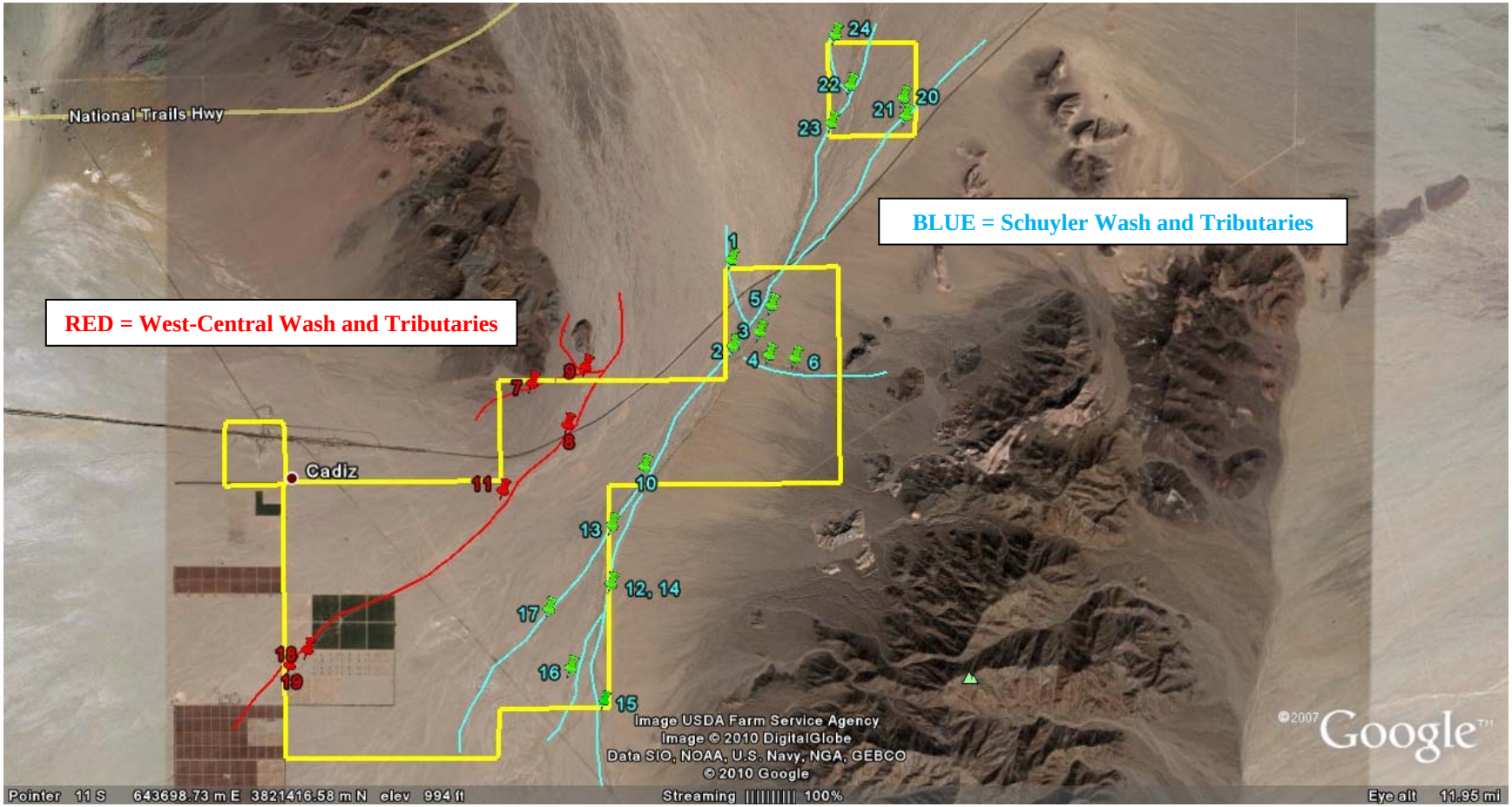
In summary, there are approximately 70 washes and drainages crossing the pipeline alignment. All of these streams flow east-to-west, and in many places have created washes and washlets along the eastern side of the ARCZ railroad. This flow of water impeded by the existing rail line has resulted in a parallel zone of more dense desert perennial plants, including many of wash-adapted species associated with the "blue washes" described above. Where these washes are associated with trestles beneath the train tracks, they serve as focal points for many common and several sensitive animal species.

3.2. Proposed Wellfield and Conceptual Spreading Basin Areas. Table 2 lists the information collected in September and October 2010 for each of 24 streambed crossings that were assessed within the wellfield and conceptual spreading basin areas (wellfield reas) and sequentially numbered 1 through 24 in the first column. USGS section numbers are given in column 2, which are also shown in Figure 4, above. UTM coordinates where data were collected are given in columns three and four. The six-digit codes used to signify the dominant perennial plants at each crossing are listed in the fifth column and defined in Appendix A. CMBC photographed each of these 24 crossings, which are mapped in Figure 4 above, included in Appendix C, with exhibit numbers given in the final column and mapped in **Figure 7** in Appendix C.

Table 2. Data for 24 Streambed Crossings within Proposed Wellfield and Conceptual Spreading Basin Areas Blue = Schulyler Wash, Red = West-Central Wash					
No.	**USGS Section No.**	**UTM Coordinates (NAD 83)**		**Dominant Perennials**	**Exhibit No. App. C**
		Easting	**Northing**		
1	8	643210	3823435	ACA GRE, PSO SPI, HYM SAL, AMB DUM	1
2	8	643323	3822074	PSO SPI, CHR PAN, ACA GRE, HYM SAL	2
3	8	643680	3822336	PSO SPI, CHR NAU, ACA GRE, HYM SAL	3
4	8	643864	3821996	PSO SPI, ENC FRU, HYM SAL, CHR NAU	4
5	8	643856	3822691	PSO SPI, CHR NAU, HYM SAL, ACA GRE	5
6	8	644225	3821946	BEB JUN, HYP EMO, PSO SPI, CHR NAU	6
7	13	640385	3821525	PSO SPI, HYM SAL, LAR TRI	7
8	13	640915	3820925	HYM SAL, BEB JUN, LAR TRI	8
9	13	641178	3821820	PSO SPI, HYM SAL, ENC FRU, LAR TRI	9
10	18	642051	3820341	CHR NAU, PSO SPI, HYM SAL, ENC FRU	10
11	23	639973	3819925	PSO SPI, HYM SAL, LAR TRI, AMB DUM	11
12	24	641566	3818600	PSO SPI, HYM SAL, AMB DUM, ACA GRE	12
13	24	641570	3819510	PSO SPI, CHI LIN, ACA GRE, ENC FRU	13
14	25	641559	3818597	PSO SPI, HYM SAL, ACA GRE, ISO ARB	14
15	25	641491	3816988	PSO SPI, HYM SAL, ACA GRE, ISO ARB	15
16	25	641030	3817395	PSO SPI, HYM SAL, ACA GRE, ISO ARB	16
17	25	640664	3818247	PSO SPI, HYM SAL, ACA GRE, ISO ARB	17
18	27	637179	3817612	PSO SPI, ENC ACT, HYM SAL, PET THU	18
19	27	636899	3817407	PSO SPI, ENC ACT, HYM SAL, PET THU	19
20	Basin	645745	3825748	PSO SPI, CHR PAN, PET THU	20
21	Basin	645758	3825465	HYM SAL, PSO SPI, CHR NAU, PET THU	21
22	Basin	644949	3825890	ACA GRE, PSO SPI	22
23	Basin	644710	3825340	ACA GRE, LAR TRI, PSO SPI	23
24	Basin	644710	3826695	PSO SPI, HYM SAL, LAR TRI	24

All of the streambed crossings in the wellfield and conceptual spreading basin areas are like those shown in blue font for the pipeline alignment, indicating they are generally well-developed drainages, with sandy bottoms, and wash-adapted plant species. The 24 streambed crossings include 18 that are associated with Schulyler Wash, which runs through the conceptual spreading basin and USGS Sections 8, 18, 24, and 25 (denoted above in blue font) and the remaining 6 crossings associated with a "West-Central" wash system passing through USGS Sections 13, 23, and 27 (denoted above in red font). **Figure 5** is an aerial photograph that schematically depicts the locations of the wellfield areas, each of the 24 crossings where data were collected, and the two major wash systems and their tributaries.

Figure 5. Aerial Photograph of Wellfield Areas, 24 Streambed Crossings, and Two Main Wash Systems



4.0. Conclusions and Recommendations

There are approximately 70 streambed crossings perpendicular to the 45-linear mile± proposed water conveyance pipeline and CRA connection and a "greenbelt" area running along the eastern side of the proposed pipeline alignment that may be affected by pipeline installation. There are two major wash systems and minor tributaries running northeast-to-southwest through the wellfield and conceptual spreading basin areas that also may be affected by construction of extraction wells and associated interconnecting pipelines (shown in Figure 3). Once engineering plans are finalized, the information presented herein could be used as supporting data for completion of a 1601-03 Streambed Alteration Agreement with the CDFG.

5.0. Literature Cited

Beauchamp, R. 1986. *A Flora of San Diego County, California.* Sweetwater River Press. National City, CA.

CH2MHill. 2010. Cadiz Groundwater Conservation and Storage Project.

Circle Mountain Biological Consultants, Inc. 2010. Focused survey for desert tortoise, habitat evaluation for burrowing owl, and general biological resource assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California. Unpublished report completed by Ed LaRue for ESA Southern California Water Group on behalf of Cadiz Inc. Job #10-030. Wrightwood, CA.

GeoScience. 2010. Geohydrologic Assessment of the Fenner Gap Area.

GeoScience Support Services Inc. 1999 Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report for Groundwater Resources, Volume I.

Hickman, J. Editor. 1993. *The Jepson Manual: Higher Plants of California.* University of California Press. Berkeley, CA.

Holland, R. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game. Sacramento, CA.

Jaeger, E. 1969. *Desert Wild Flowers.* Stanford University Press. Stanford, CA.

Metropolitan Water District of Southern California. 2001. Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Report and Final Environmental Impact Statement Volume I.

Munz, P. 1974. *A Flora of Southern California.* University of California Press. Berkeley, CA.

Sawyer, J. and T. Keeler-Wolf. 1995. *A Manual of California Vegetation.* California Native Plant Society. Sacramento, CA.

Appendix A. Plant Species Detected

Plant codes in Tables 1 and 2 correspond to the common and scientific names for dominant perennial plants listed below that characterize each streambed crossing. Those plant species that are protected by pertinent County and/or State ordinances are signified by "(SC)" following the common name.

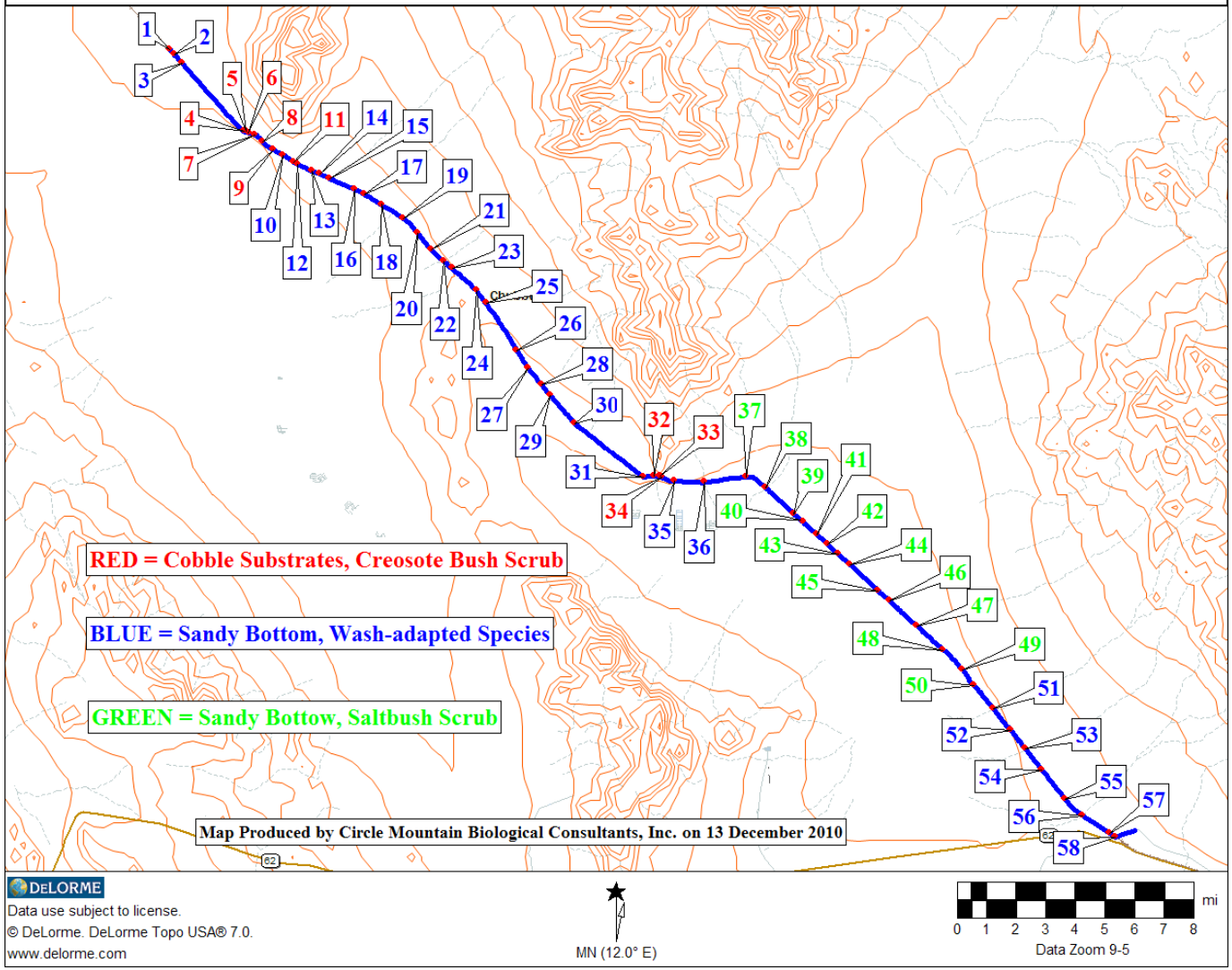
ANGIOSPERMAE: DICOTYLEDONES	DICOTS	CODES
Asclepiadaceae	**Milkweed family**	
Asclepias erosa	Milkweed	ASC ERO
Asteraceae	**Sunflower family**	
Ambrosia dumosa	Burrobush	AMB DUM
Bebbia juncea	Sweetbush	BEB JUN
Chrysothamnus paniculatus	Wash rabbitbrush	CHR PAN
Encelia actoni	Acton encelia	ENC ACT
Encelia fructescens	Rayless encelia	ENC FRU
Hymenoclea salsola	Cheesebush	HYM SAL
Stephanomeria pauciflora	Desert milk aster	STE PAU
Bignoniaceae	**Bigonia family**	
Chilopsis linearis ssp. *arcuata*	Desert willow	CHI LIN
Capparaceae	**Caper family**	
Isomerus arborea	Bladderpod	ISO ARB
Chenopodiaceae	**Goosefoot family**	
Atriplex canescens	Four-winged saltbush	ATR CAN
Atriplex polycarpa	Allscale	ATR POL
Suaeda moquinii	Torrey's sea-blight	SUA MOQ
Fabaceae	**Pea family**	
Acacia greggii	Catclaw acacia (SC)	ACA GRE
Psorothamnus (Dalea) emoryi	Indigo bush	PSO EMO
Psorothamnus spinosus	Smoke tree (SC)	PSO SPI
Lamiaceae	**Mint family**	
Hyptis emoryi	Desert lavender	HYP EMO
Loasaceae	**Stick-leaf family**	
Petalonyx thurberi	Sandpaper plant	PET THU
Tamaricaceae	**Tamarisk family**	
**Tamarix ramosissima*	Tamarisk	TAM RAM
Zygophyllaceae	**Caltrop family**	
Larrea tridentata	Creosote bush	LAR TRI

* - indicates a non-native (introduced) species.
c.f. - compares favorably to a given species when the actual species is unknown.

Some species may not have been detected because of the seasonal nature of their occurrence. Common names are taken from Beauchamp (1986), Hickman (1993), Jaeger (1969), and Munz (1974).

Appendix B. Photographic Exhibits along Proposed Pipeline Alignment

Figure 6. Cadiz Project: Exhibit Locations for Stream Crossings along Pipeline



As in the text, Figures 2 and 6, and Table 1 the following color codes are used to indicate sandy washes with wash-adapted species, sandy washes vegetated by saltbush scrub, and cobble-bottomed washes vegetated by creosote bush scrub.

Exhibit 1. Stream Crossing #1 (all photographs are facing east-to-west; see Figure 6 for locations of all exhibits).

Exhibit 2. Stream Crossing #2.

Exhibit 3. Stream Crossing #3.

Exhibit 4. Stream Crossing #9.

Exhibit 5. Stream Crossing #10.

Exhibit 6. Stream Crossing #11.

Exhibit 7. Stream Crossing #12.

Exhibit 8. Stream Crossing #13.

Exhibit 9. Stream Crossing #14.

Exhibit 10. Stream Crossing #15.

Exhibit 11. Stream Crossing #16.

Exhibit 12. Stream Crossing #17.

Exhibit 13. Stream Crossing #18.

Exhibit 14. Stream Crossing #19.

Exhibit 15. Stream Crossing #20.

Exhibit 16. Stream Crossing #21.

Exhibit 17. Stream Crossing #22.

Exhibit 18. Stream Crossing #23.

Exhibit 19. Stream Crossing #24.

Exhibit 20. Stream Crossing #25.

Exhibit 21. Stream Crossing #26.

Exhibit 22. Stream Crossing #27.

Exhibit 23. Stream Crossing #28.

Exhibit 24. Stream Crossing #29.

Exhibit 25. Stream Crossing #30.

Exhibit 26. Stream Crossing #32.

Exhibit 27. Stream Crossing #33.

Exhibit 28. Stream Crossing #34.

Exhibit 29. Stream Crossing #35.

Exhibit 30. Stream Crossing #36.

Exhibit 31. Stream Crossing #38.

Exhibit 32. Stream Crossing #40.

Exhibit 33. Stream Crossing #41.

Exhibit 34. Stream Crossing #42.

Exhibit 35. Stream Crossing #43.

Exhibit 36. Stream Crossing #44.

Exhibit 37. Stream Crossing #45.

Exhibit 38. Stream Crossing #46.

Exhibit 39. Stream Crossing #47.

Exhibit 40. Stream Crossing #48.

Exhibit 41. Stream Crossing #49.

Exhibit 42. Stream Crossing #50.

Exhibit 43. Stream Crossing #51.

Exhibit 44. Stream Crossing #52.

Exhibit 45. Stream Crossing #53.

Exhibit 46. Stream Crossing #54.

Exhibit 47. Stream Crossing #56.

Exhibit 48. Stream Crossing #57.

Exhibit 49. Stream Crossing #58.

Exhibit 50. Stream Crossing #59.

Exhibit 51. Stream Crossing #60.

Exhibit 52. Stream Crossing #61.

Exhibit 53. Stream Crossing #62.

Exhibit 54. Stream Crossing #63.

Exhibit 55. Stream Crossing #64.

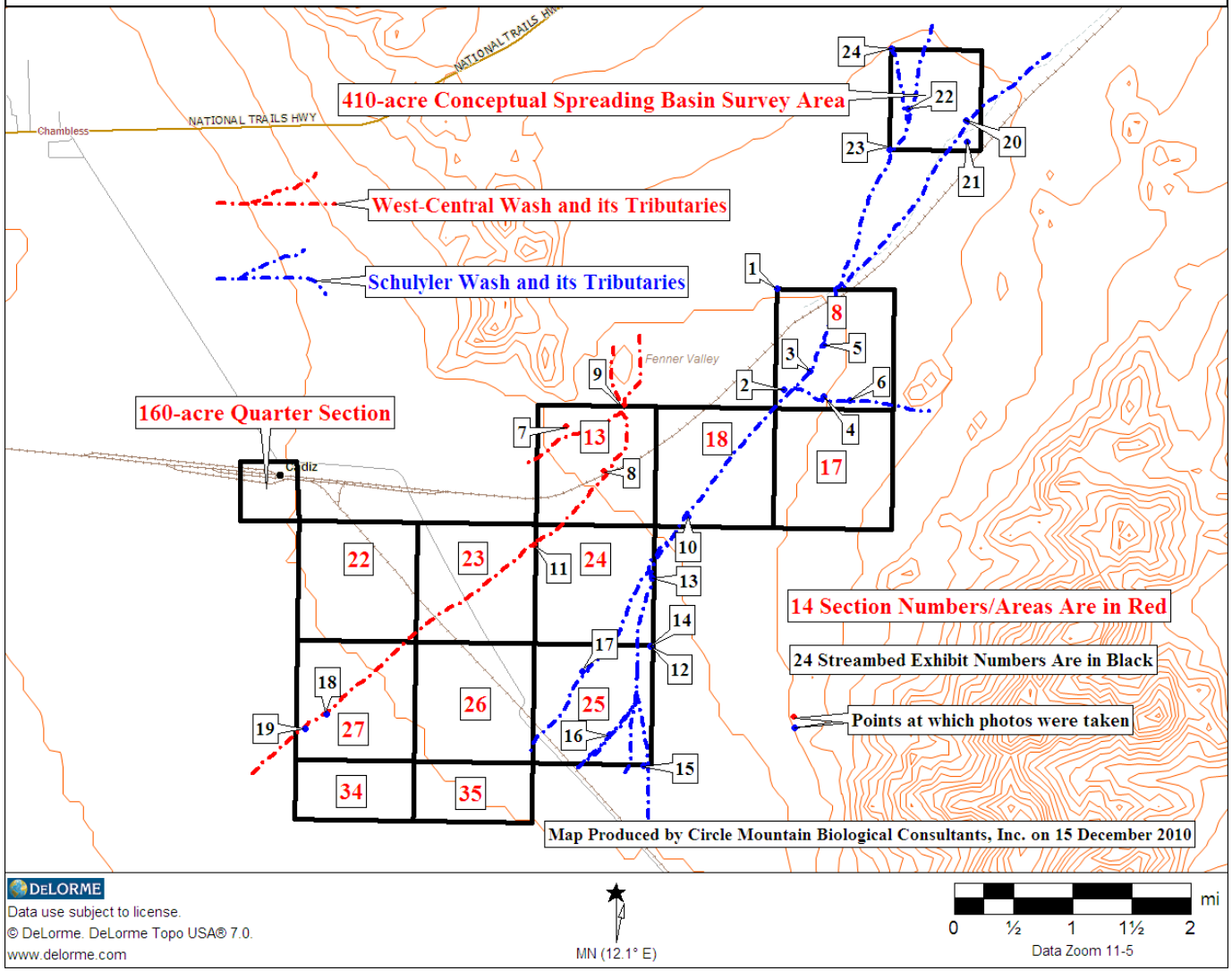
Exhibit 56. Stream Crossing #65.

Exhibit 57. Stream Crossing #66.

Exhibit 58. Stream Crossing #67.

Appendix C. Photographic Exhibits within Wellfield and Conceptual Spreading Basin Areas

Figure 7. Photographic Exhibit Locations for Wellfield Areas



As in the text, Figures 4 and 7, and Table 2 blue font is used to indicate those photograph exhibits in and along Schulyler Wash and red font is used to indicate those exhibits taken along the West-Central wash system.

Exhibit 1. Stream Crossing #1 in Section 8, facing northwest to southeast (see Figure 7 for locations of all exhibits).

Exhibit 2. Stream Crossing #2 in Section 8, facing south to north.

Exhibit 3. Stream Crossing #3 in Section 8, facing south to north.

Exhibit 4. Stream Crossing #4 in Section 8, facing northwest to southeast.

Exhibit 5. Stream Crossing #5 in Section 8, facing southwest to northeast.

Exhibit 6. Stream Crossing #6 in Section 8, facing southeast to northwest.

Exhibit 7. Stream Crossing #7 in Section 13, facing southwest to northeast.

Exhibit 8. Stream Crossing #8 in Section 13, facing south to north.

Exhibit 9. Stream Crossing #9 in Section 13, facing north to south.

Exhibit 10. Stream Crossing #10 in Section 18, facing south to north.

Exhibit 11. Stream Crossing #11 in Section 23, facing northeast to southwest.

Exhibit 12. Stream Crossing #12 in Section 24, facing south to north.

Exhibit 13. Stream Crossing #13 in Section 24, facing north to south.

Exhibit 14. Stream Crossing #14 in Section 25, facing northeast to southwest.

Exhibit 15. Stream Crossing #15 in Section 25, facing south to north.

Exhibit 16. Stream Crossing #16 in Section 25, facing south to north.

Exhibit 17. Stream Crossing #17 in Section 25, facing northeast to southwest.

Exhibit 18. Stream Crossing #18 in Section 27, facing northeast to southwest.

Exhibit 19. Stream Crossing #19 in Section 27, facing southwest to northeast.

Exhibit 20. Stream Crossing #20 at Spreading Basin, facing east to west.

Exhibit 21. Stream Crossing #21 at Spreading Basin, facing east to west.

Exhibit 22. Stream Crossing #22 at Spreading Basin, facing northeast to southwest.

Exhibit 23. Stream Crossing #23 at Spreading Basin, facing southwest to northeast.

Exhibit 24. Stream Crossing #24 at Spreading Basin, facing northwest to southeast.

Draft

CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Rare Plant Survey Report

Prepared for
Santa Margarita Water District

May 2011

Draft

CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Rare Plant Survey Report

Prepared for
Santa Margarita Water District

May 2011

626 Wilshire Boulevard
Suite 1100
Los Angeles, CA 90017
213.599.4300
www.esassoc.com

Oakland

Olympia

Petaluma

Portland

Sacramento

San Diego

San Francisco

Seattle

Tampa

Woodland Hills

D210324

TABLE OF CONTENTS

Cadiz Valley Water Conservation, Recovery, and Storage Project: Rare Plant Survey Report

Page

Summary 1

Introduction 2
- Objective 2
- Project Location and Description 2

Setting 5
- Climate 5
- Topography and Soils 5
- Vegetation 6
- Special-status Plant Species 10

Methods 10

Survey Results 11
- Assessment of Potential Impacts on Special-status Plants and Natural Communities 12
- Recommendations 12

Report Authors and References 13
- Report Authors 13
- References 13

Appendix 1: Plant Species Considered / Plant Species Observed within the Rare Plant Study Area A-1

Tables
1. Plant Species Considered A-1
2. Plant Species Observed within the Rare Plant Study Area A-3

Figures
1. Project Location 3
2. Rare Plant Survey Area 4
3. Photo – Mojave Creosote Bush Scrub 8
4. Photo – Mojave Creosote Bush Scrub 8
5. Photo – Mojave Wash Scrub 9
6. Photo – Mojave Wash Scrub 9

Summary

Environmental Science Associates (ESA) botanists conducted a rare plant survey for the Cadiz Valley Water Conservation, Recovery, and Storage Project (Project) in April of 2011. The 2011 rare plant surveys were concentrated within the proposed pipeline route and …… This area is referred to as the "study area" throughout this report. <See comment gca3>

Vegetation, particularly the herbaceous layers, has been disturbed to varying degrees throughout the study area, particularly within the southeastern region of the study site in areas adjacent to the access road running along the Danby Dry Lake and south toward the Colorado River Aqueduct. Throughout the study site, shrub diversity is relatively low owing to both the low diversity of habitats encountered within the site and the high level of previous disturbance. The desert habitat communities encountered consisted of creosote bush scrub, desert wash scrub, and desert pavement regions, each of which varied with level of disturbance. The diversity of herbaceous vegetation along the access road was similarly low and appears to have been impacted considerably by dirt movement associated with road grading, off-highway vehicle impacts. In addition, the preceding four years have been drought years for the state of California, resulting in an overall lower yield of annuals. However, precipitation for the 2009-2010 water-year was above average in the Project region and precipitation for Southern California overall for 2011 wet season was above average; therefore, floristic survey results in the spring of 2011 were anticipated to be by and large representative of the flora of the study area.

A total of 21 special-status plant species were determined to have potential to occur within the rare plant study area. None of those plant species are federal- or state-listed as threatened or endangered and therefore have no designated status or protection under federal or state endangered species legislation. However, 8 of those species are recognized as "rare or endangered, or potentially at risk of becoming so" by the California Native Plant Society (CNPS). Consideration of impacts to those species during CEQA review is warranted.

No special-status plant species were found within the rare plant study area. Based on the results of this 2011 survey, a 2010 survey, and the levels of past disturbance throughout the study area, special-status plant species are absent from the study site. Therefore, it is our professional opinion that construction related activities for Cadiz Valley Water Conservation, Recovery, and Storage Project and usage of associated access roads will have no impacts on special-status plants.

Introduction

Objective

This Rare Plant Survey Report was conducted in order to determine the presence and/or absence of special-status plant species within the proposed pipeline route of the Project, so that impacts to special-status plants can be analysis in the proposed project's Draft Environmental Impact Report

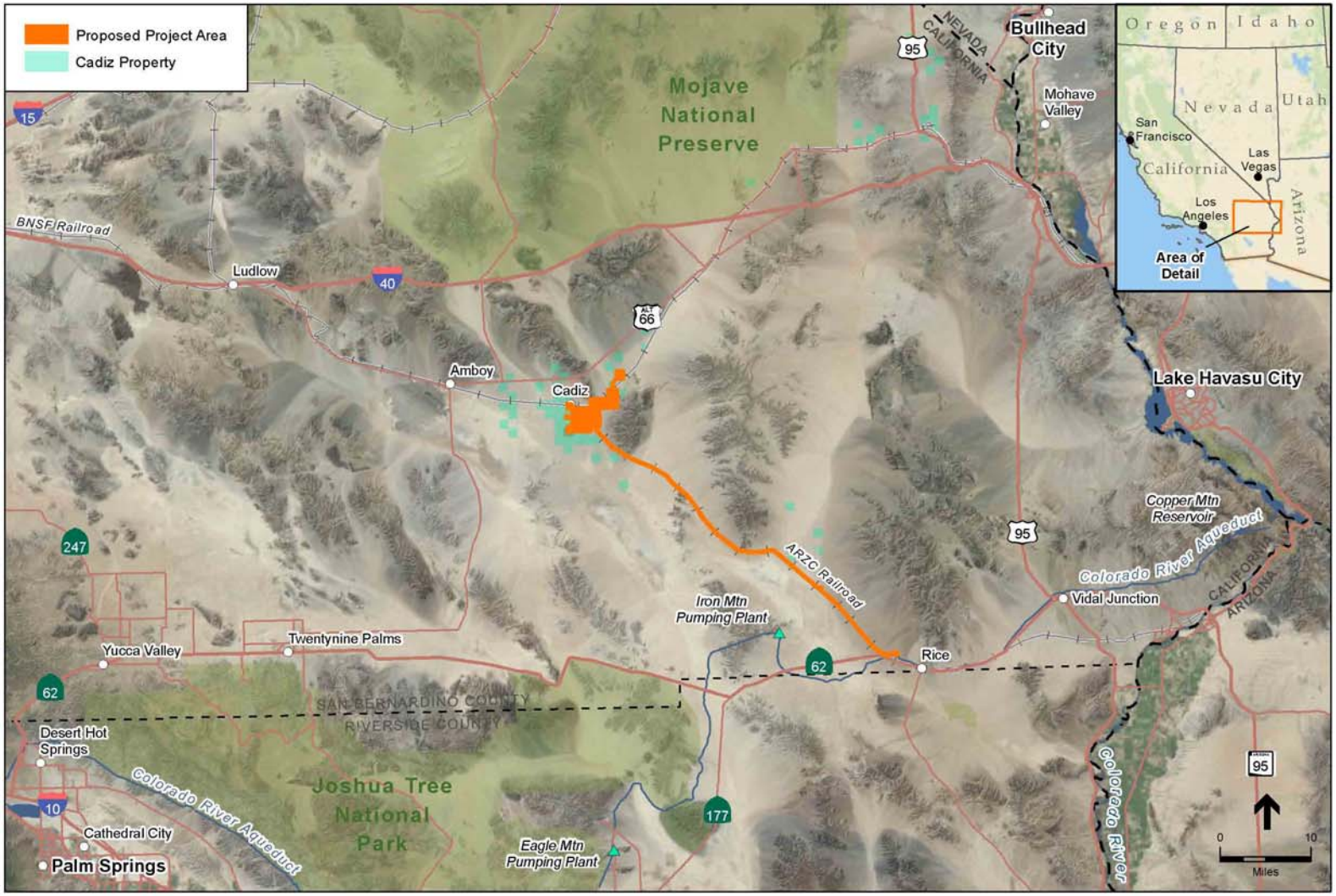
Project Location and Description

Project Location

The study area is located within the Fenner Watershed in the eastern Mojave Desert of San Bernardino County, California, approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms. The Fenner Valley is a large northeast to southwest trending valley that intersects Cadiz Valley at the Fenner Gap located between the Marble and Ship mountains (Metropolitan Water District 2001).

Project Description

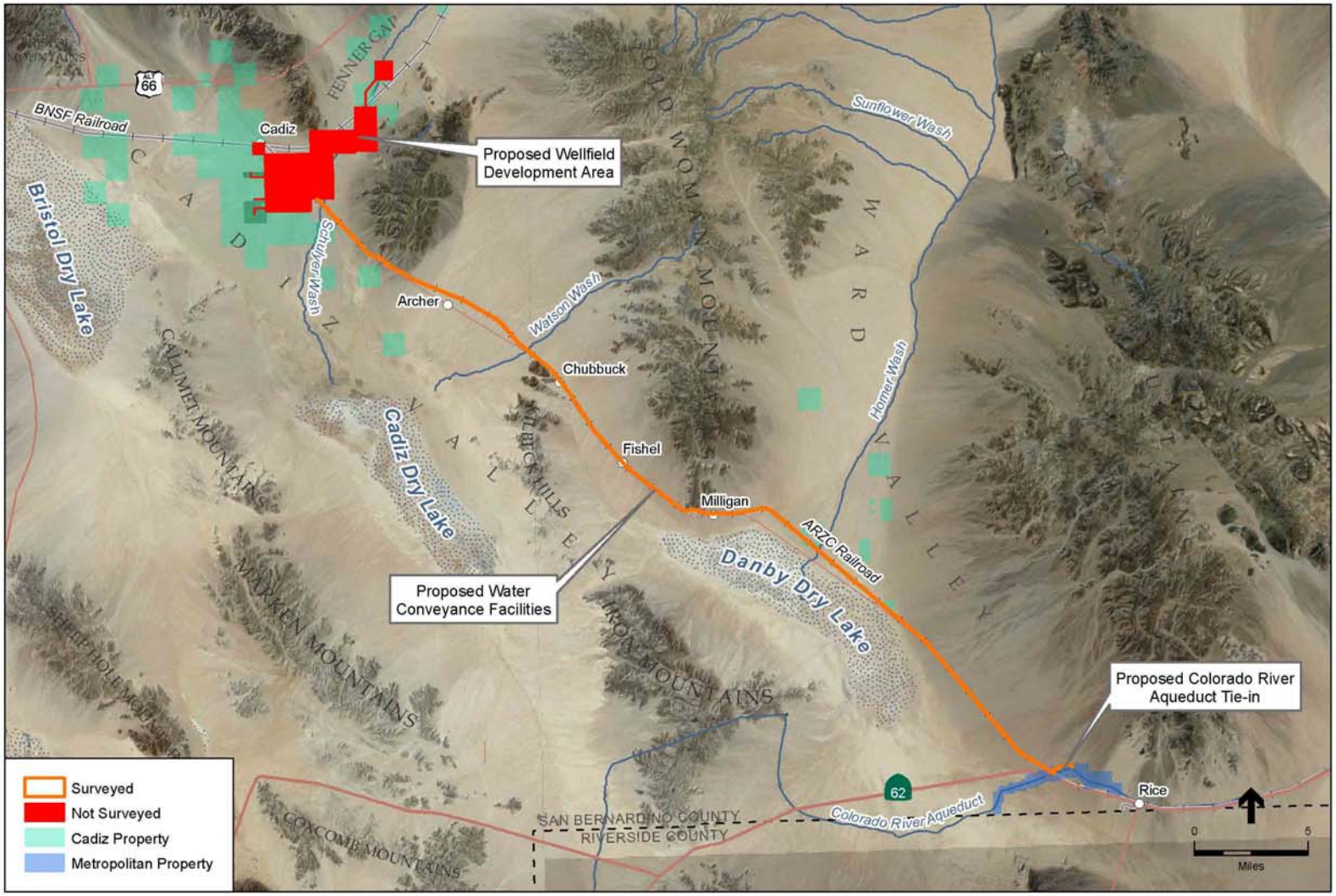
The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. The Project would be operated by Cadiz, which owns 34,000 acres in the Cadiz and Fenner valleys of the eastern Mojave Desert in San Bernardino County, California.



SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project Rare Plant Survey . 210324

Figure 1
Regional Location



SOURCE: Bing Maps, 2010; BLM, 2009; ESRI, 2010; Cadiz Inc., 2010; and ESA, 2010

Cadiz Valley Water Conservation, Recovery, and Storage Project Rare Plant Survey . 210324

Figure 2
Survey Areas

Setting

Climate

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower temperatures and higher precipitation at higher altitudes. Average annual precipitation varies from about 4 inches in Bristol Valley to more than 12 inches in the New York Mountains.[1]

Topography and Soils

Elevations along the pipeline right-of-way range from approximately 830 feet at the north end down to 640 feet east of Danby Lake back up to 950 feet where the pipeline terminates at the CRA.[2]

The groundwater recharge and storage study conducted in 2010 included acquiring input for the soil types and properties within the watershed.[3] Areas of low topographic relief consist of the Carrizo-Rositas-Gunsight soil series and are typically described as light colored, red, desert alluvial, sandy soils. Areas along the mountain slopes adjacent to the proposed water conveyance facilities consist of the Gunsight-Rillito-Chuckwalla soil series and are typically described as alluvium, colluvium, and residuum from granite, gneiss, quartzite and limestone formations.[4] The majority of the Project footprint consists of the Carrizo-Rositas-Gunsight soil units.

The Carrizo soils include floodplains, alluvial fans, and associated formations formed in mixed alluvium, with slopes ranging from 0 to 15 percent. Typical profiles range from extremely gravelly sand to very gravelly course sand, with low shrink-swell capacity, rapid to very rapid drainage, and negligible to low runoff potential.

The Rositas soils consist of sand sheets to dunes formed of eolian material, with slopes ranging up to 30 percent in dune areas. Typical profiles include sand depths of about 60 inches, with less than 15 percent course to very course sand. These soils have rapid permeability, low shrink-swell capacity, and negligible to low runoff potential.

The Gunsight and Rillito soils consist of mixed alluvium with mostly moderate slopes but isolated areas up to 60 percent, gravelly sandy loam to extremely gravelly sandy loam, somewhat excessively drained, with low shrink-swell capacity, and runoff potential from very low to high.

---

1 CH2MHill, Cadiz Groundwater Conservation and Storage Project, July 2010, page 2-3; see also www.prism.oregonstate.edu

2 Circle Mountain Biological Consultants, Inc. (CMBC), *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Groundwater Conservation and Storage Project*. November 2010, page 15.

3 CH2M Hill, July 2010, *Cadiz Groundwater Conservation and Storage Project*, Pages 2-7 and 4-6, Table 4-3

4 Metropolitan Water District of Southern California (Metropolitan) and Cadiz, September 2001. *Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Cadiz Groundwater Storage and Dry-Year Supply Program*. Pages 5-34 and 5-35

Other associations that could be intersected in proportionally small amounts include Tecopa Rock Outcrop-Lithic Torriorthents (Tecopa formation comprises very shallow soils of recently weathered material, on low hills and low mountain slopes with 15 to 75 percent slope, as well as rock outcrops and torriorthents), along the northwestern edge of the wellfield development area and the southern tip of the Old Woman Mountains along the pipeline; and the Rillito-Gunsight association (mixed alluvium with mostly moderate slopes but isolated areas up to 60%, gravelly sandy loam to extremely gravelly sandy loam, somewhat excessively drained, and runoff potential from very low to high) along the pipeline to the southeast of the wellfield area, and where the pipeline approaches the Old Woman Mountains.

Plant Communities

Plant communities observed within the study site were compared to the Holland Code of Terrestrial Natural Communities of California (1986). The study site was generally dominated by Mojave Creosote Bush Scrub. This habitat varied slightly between areas within the study site but was consistently dominated by creosote bush (*Larrea tridentata*) with few other species, occasionally forming a monoculture of creosote bush. Various small washes run through the study site usually in a north-south direction, but the vegetation compositions of most of those washes differed only slightly from the surrounding habitat and were observed as generally containing the same principal species composition as the surrounding (creosote bush) scrub. A small amount of those washes displayed slightly higher plant diversity than the surrounding scrub and fit the description for Mojave Wash Scrub. Additionally, various portions of the study site that have been subjected to prior human disturbances (e.g., off highway vehicle (OHV) disturbance or grading) contained mainly non-native, weedy annuals or bare ground and most closely could be described as disturbed habitat, which were typically observed directly along the railroad and access roads but that occasionally accounted for up to or beyond 100 feet on either side from center.

Vegetation, particularly the herbaceous layers, has been disturbed to varying degrees throughout the study area, particularly along the region south and east of Browns Wash, along the Kilbeck Hills, where the site runs along the north side of Danby Dry Lake and in the southeastern most area of the site closest to the Colorado River Aqueduct. The rate of recovery in desert habitats that have been impacted by human activities depends on the intensity and duration of the impacts, as well as climatic factors. Lovige and Bainbridge (1999) state that, "Recovery to predisturbance plant cover and biomass may take 50–300 years, while complete ecosystem recovery may require over 3000 years." Their further review of impacts to, and recovery rates for, desert vegetation cites several studies showing that a) shrub cover is greater in areas that have never been grazed than in grazed areas, b) plots protected from grazing for ten years showed no difference from heavily grazed areas, suggesting generally slow rates of recovery and c) exclusion of grazing for 14–19 years was not sufficient time for recovery of native perennial grasses in southeastern Arizona. In addition, Lovige and Bainbridge suggest that degradation of arid lands does not necessarily stop following cessation of human activities and that drought, combined with erosion and sand encroachment precipitated by disturbance, can continue to degrade areas already impacted for many years (Lovige and Bainbridge, 1999). While vegetation within the study site exhibits shrub species composition that is generally consistent with Mojave creosote bush scrub,

the diversity of herbaceous vegetation appears to have been impacted to a considerable degree by human activities within the study site.

Mojave Creosote Bush Scrub (Holland Code 34100)

Mojave creosote bush scrub is an open community dominated by the perennial creosote bush and often by white bursage (*Ambrosia dumosa*), typically with abundant bare ground space between shrubs. Soils are generally well drained, have a low water holding capacity, and occur on bajadas, slopes, fans, and relatively flat valley floors. Throughout most of the study site, creosote bush was the predominant species and in some areas was the only shrub species visible for up to or more than 100 feet from the centerline of the site. Much of this habitat also included smaller shrub associates such as white bursage, littleleaf rattany (*Krameria erecta*), and rabbitbrush (*Hymenoclea salsola*). Less frequently, the smaller shrubs also included Mormon tea (*Ephedra nevadensis*), and where the study site occurred within a mile of Danby Dry Lake, the shrub associates often included four-winged saltbush (*Atriplex canescens*) and tamarisk (*Tamarix rammossissima*), especially close to where small washes intersected the study site. Within the study area, this community supports a generally low diversity and numbers of native annual herbaceous species. Most of the creosote scrub within the study site lacked a consistent herbaceous layer; however, where it occurred, the herbaceous layer most commonly contained such annuals as pebble pincushion (*Cheanactus carphoclinia*), spiny-herb (*Chorizanthe rigida*), chia (*Salvia columbariae*), and occasionally desert trumpet (*Eriogonum inflatum*).

Mojave Wash Scrub (Holland Code 34250)

Mojave wash scrub occurs in desert washes generally and normally contains many of the perennial plant species found in the surrounding scrub habitat with the addition of species that are specific to desert wash parameters; sandy bottoms of wide canyons, incised arroyos of upper bajadas, and sandy or rocky braided washes of lower bajadas below approximately 5,000 feet in elevation. Within the study site, Mojave wash scrub contained many of the same dominant shrubs as found in creosote bush scrub with the additions of smoke tree (*Psorothamnus spinosa*) and catclaw acacia (*Acacia greggii*) and to a much lesser extent with palo verde (*Cercidium floridum*). Mojave wash scrub was also observed to contain annuals and biennials not observed in the surrounding upland scrub, such as desert milkweed (*Asclepias erosa*), ajamete (*Asclepias subulata*), and Mojave lupine (*Lupinus sparsiflorus*).

Disturbed Habitat (Holland Code 13000)

Disturbed habitat is any land on which the native vegetation has been significantly altered by agriculture, construction, or other land-clearing activities, and the species composition. Within the survey site, disturbed habitat occurred generally along both sides of the railroad tracks and access roads and within all other previously disturbed areas, including the areas immediately surrounding the Colorado River Aqueduct. The amount of disturbed habitat varied from several feet to more than 50 feet from the centerline of the survey area. Vegetation typically consisted of weedy, introduced annuals such as wild mustard (*Brassica* sp.), redstem filaree and Mediterranean schismus.

Figure 3: Mojave Creosote Bush Scrub

A relatively average and undisturbed portion of Mojave creosote bush scrub.

Figure 4: Disturbed Mojave Creosote Bush Scrub

Example of disturbed Mojave creosote bush scrub located at the southern end of the survey site adjacent to the Colorado River Aqueduct. This area consists of spaced shrubs and sparse herbaceous layer.

Figure 5: Mojave Wash Scrub

An example of a Mojave wash scrub dominated with creosote bush scrub species..

Figure 6: Mojave Wash Scrub with additional species

Mojave scrub wash dominated with smoke tree (*Dalea spinosa*), white bursage, and mormon tea, with Mojave creosote scrub in the background

Special-status Plant Species

A total of 21 special-status[5] plant species have the potential to occur in the project area based on the proximity of the project to previously recorded occurrences in the region, on-site vegetation and habitat quality, topography, elevation, soils, surrounding land uses, habitat preferences, and geographic ranges of special-status plant species known to occur in the region.

One of these plant species, Trelease's beavertail pricklypear (*Opuntia basilaris* var. *treleasei*), is federally and state listed as endangered. The remaining have no designated status or protection under federal or state endangered species legislation but are recognized as rare or endangered, or potentially at risk of becoming so, by the California Native Plant Society (CNPS). CNPS List 1B species are rare throughout their range, with the majority of them endemic to California. Most of the plants of List 1B have declined significantly over the last century. List 2 species are considered to be rare and endangered in California but are more common elsewhere. List 3 species are those for which CNPS lacks the necessary information to assign them to one of the other lists or to reject them. List 4 species are of limited distribution or infrequent throughout a broader area in California and their overall vulnerability or susceptibility to threat is considered relatively low at this time. While these plants are not considered "rare" from a statewide perspective, they are uncommon enough that their status should be monitored regularly. In addition, CNPS added a 'threat rank' to their listings. This is an extension added onto the CNPS List and designates the level of endangerment by a 1 to 3 ranking, with 1 being the most endangered and 3 being the least endangered. The threat ranks are defined as follows:

- 0.1-Seriously threatened in California (high degree/immediacy of threat)
- 0.2-Fairly threatened in California (moderate degree/immediacy of threat)
- 0.3-Not very threatened in California (low degree/immediacy of threats or no current threats known).

Impacts to CNPS List 1 and 2 species are generally considered significant under CEQA. Impacts to List 3 species are not generally considered as this is primarily an advisory list. Impacts to List 4 species are generally not presumed significant, due to the wider distribution of these species, but may be considered significant should conditions warrant it (e.g. a species' habitat is being converted at a rapid pace due to local development pressure).

Methods

The survey area consisted of 100 feet on both sides of the Arizona and California Railroad Company's (ARZC) railroad tracks.

In preparation for the field surveys the California Natural Diversity Database (CNDDB) (CDFG, 2011) and the CNPS online database (CNPS, 2011) were queried to develop a list of special-status and rare plant species that have been previously recorded in the Project region. Data were

[5] Special-status plants are those listed as rare, threatened, or endangered by the State or federal government or by organizations with recognized expertise, such as the California Native Plant Society.

queried for San Bernardino County and for the following USGS 7.5 minute topographic quadrangles that contained the Project survey area: Cadiz Lake NW, Cadiz Lake NE, Chubbuck, Milligan, Danby Lake, and Africa Mountains. Field surveys were then focused on the resulting 21 plant species identified through the database search results (Appendix A). Of those species, 8 had a moderate potential to occur within the survey area; the remaining 11 species were considered as having low potential to occur based mainly on lack of suitable habitat parameters, such as substrate or elevation specificity.

Field surveys were conducted within the study area on April 19, 20, and 21, 2011, by a four person botanical survey team that included Darren Burton and Jon West of Environmental Science Associates, and Jeremiah George, Ph.D. and Youssef Attalla, Ph.D., of Environmental Intelligence, LLC. The survey dates were chosen to encompass the maximum chance of observing the blooming periods of the annual species (note: perennial species, such as cactuses, can be located and positively identified outside of their respective blooming periods). Due to the low growing nature and scarcity of the herbaceous vegetation and generally widely spaced character and flat topography of creosote bush scrub, visual coverage of the study area was very comprehensive and effectively complete.

The length of the study site was first assessed by driving access roads that occurred along the length of the Project to identify habitats with a moderate potential to support target species based on habitat conditions and suitability. Selected segments that were observed to contain moderate habitat suitability, which was generally based on shrub diversity and presence of annuals, were surveyed on foot. Disturbed areas with low plant growth were methodically scanned from a vehicle driven at very slow speeds and randomly assessed by foot where plant growth and some marginal habitat was present. Plant communities were characterized according to Holland (1986) along the entire length of the survey site and all plant species observed were identified to the appropriate level needed to determine rarity.

Survey Results

No special-status plant species were observed within the study area. The rare plant survey was timed during the typical blooming period of the target species to allow for certainty of taxonomic identification Most of the plant species encountered were in bloom and easily identifiable by their flowers or infructescences; some species were past or near the end of their blooming periods. Nonetheless, all species were positively identified by either vegetative parts, fruit, or identifiable reproductive structures (i.e., flower parts).

Table 2 (in Appendix A) lists all plant species observed within the study area. A few herbaceous annuals were widespread throughout the study area, including red-stem filaree (*Erodium cicutarium*), and desert pincushion (*Chaenactis stevioides*). Various other annuals were scattered sparsely throughout the site and found in concentrated areas, such as bright green buckwheat (*Eriogonum viridescens*), desert calico (*Loeseliastrum matthewsii*), and chia (*Salvia columbariae*). The greatest species diversity was concentrated in the western portion of the study area, with the eastern portion dominated by <name of plant community here> almost exclusively by just a few species such as **<or just say creosote if it's creosote scrub>_____**. In general, the

annual plant cover of the survey site was considered moderate to low and species diversity was typically low throughout.

Most plants were recognizable to species or subspecies level; those that were not immediately recognized or comparable to published photograph from a field guide were identified using the Desert Jepson Manual (Baldwin et al, 2002). Those species that resembled special-status taxa were able to be excluded due to known distributions or one or more recognizable distinguishing morphological characteristics that distinguished it from a target species. For example, *Opuntia basilaris* var. *basilaris* was observed at the eastern end of the site and was determined not be *O. b.* var. *brachyclada*, a taxon listed by the CNPS as rare, threatened or endangered in California and elsewhere, based on range and morphological differences in spine architecture. Also, two *Cryptantha* species of limited distribution have been documented as occurring in eastern San Bernardino County and within Mojave creosote bush scrub; however, the two *Cryptantha* species that were observed (in bloom) were identified as commonly occurring species and not special-status due to leaf and nutlet morphology. *Eschscholzia minutiflora* was found on in limited spots within the survey site. However, the special-status subspecies, *E. m.* ssp. *twisselmanii*, is not known to occur anywhere near the survey vicinity; it is currently only found in very limited regions of Kern County.

In our professional opinion, these three species do not occur at the Project site and no additional or late season floristic surveys are warranted.

Assessment of Potential Impacts on Special-status Plants and Natural Communities

No special-status plant species were found within the study area during the survey. Given the results of this 2011 survey and the history of past habitat degradation throughout the study area, the potential for special-status species to occur is low. Therefore, it is the professional opinion of ESA that Project-related construction and usage of associated access roads associated with the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project will have no impacts on special-status plants and mitigation to special-status plant species will not be required.

Recommendations

No special-status plants were found within the study area. It is our professional opinion that the surveys conducted in April 2011 were adequate to allow determination of a low likelihood of special-status plants being impacted by the proposed Project. No further surveys are recommended and no mitigation for impacts to special-status plants will be required under CEQA.

Report Authors and References

Report Authors

ESA
9191 Towne Centre Dr., Suite 340
Oakland, CA 92122
(858) 638-0900

Project Director:	Greg Ainsworth
Field Surveyors:	Darren Burton, Jon West, Jeremiah George, Youssef Atalla
Report Preparation:	Darren Burton
Graphics:	ESA

References

Baldwin, B.G., Boyd, S., Ertter, B.J., Patterson, R.W., Rosatti, T.J, Wilken, D.H., eds. *The Jepson Desert Manual: Vascular Plants of Southeastern California*, Berkeley, CA: University of California Press, 2002.

Calflora (online). Berkeley, CA. http://www.calflora.org/.

California Native Plant Society (CNPS). 2011. Inventory of Rare and Endangered Plants (online edition, v7-10a). California Native Plant Society. Sacramento, CA. http://www.cnps.org/inventory.

California Department of Fish and Game(CDFG) California Natural Diversity Database. 2011. Electronic database of rare plant and animal species reported to The State Resources Agency, Natural Heritage Division, California Natural Diversity Data Base. Sacramento, CA.

LaRue, Edward L., Jr.**.** *Focused Survey for Desert Tortoise, Habitat Evaluation for Burrowing Owl, and General Biological Resource Assessment for the Cadiz Groundwater Conservation and Storage Project, San Bernardino County, California***.** Circle Mountain Biological Consultants, Inc. Prepared for ESA Southern California Water Group. November, 2010.

Holland, R.F. *Preliminary Descriptions of the Terrestrial Natural Communities of California*, Department of Fish and Game, Sacramento, CA, 156 p., 1986.

Jepsen – The Book and what ever other keys were used that were mentioned in the document.

Jepson Flora Project, *Jepson Online Interchange*, http://ucjeps.berkeley.edu/interchange.html. Copyright@ Regents of the University of California, accessed 7/13/10.

Lovich, J.E. and Banbridge, D., *Anthropogenic Degradation of the Southern California Desert Ecosystem and Prospects for Natural Recovery and Restoration*, Environmental Management Vol. 24, No. 3, p. 309–326, 1999.

U.S. Department of Agriculture (USDA), National Resources Conservation Service (NRCS), 2010. *Web Soil Survey*, data request for Aero Windswept Lower West Project site, web application available at: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx , accessed 07/07/10.

Western Regional Climate Center (WRCC, 2010a), Period of Record (01/01/1904-12/31/2009) Monthly Climate Summary, Mojave, California (045756), available online: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5756, accessed 07/13/10.

WRCC (2010b), Period of Record (01/01/1893-06/30/2007) Monthly Climate Summary, Tehachapi, California (048826), available online: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8826.

WRCC (2010c), California Climate Tracker, Precipitation Percent of Normal (Oct-Jun 2009-2010), web application available at: http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html.

APPENDIX A: TABLE 1

Listed/Protected Plant Species with Potential to Occur within the Rare Plant Study Area

Scientific Name	Common Name	Listing Status	Potential to Occur Onsite
Androstephium breviflorum	Small-flowered androstephium	List 2.2	**Moderate.** Creosote bush scrub and desert dunes between 840 and 4,960 feet; found west of Iron Mountains in 1995; suitable habitat throughout Project area.
Arctomecon merriamii	White bear poppy	List 2.2	**Low.** Rocky soils in creosote bush scrub between 1,520 and 4,910 feet; not found in 1995 or 1999; site is outside range and elevations are too low.
Astragalus insularis var. *harwoodii*	Harwood's milk-vetch	List 2.2	**Moderate.** Sandy or gravelly desert dunes, desert scrub below 930 feet; 300+ plants between Danby Lake and Cadiz Road in 2010; suitable habitats and elevations along ARZC ROW and western wellfields.
Astragalus lentiginosus var. *borreganus*	Borrego milk-vetch	List 4.3	**Moderate.** Sandy soils in creosote bush scrub between 90 and 840 feet; observed in 1995 east of Iron Mountain pumping plant and Cadiz Lake in sand field areas; suitable habitats and elevations in western wellfields and sandy areas along ARZC ROW particularly near Danby Lake.
Castela emoryi	Crucifixion thorn	List 2.3	**Low.** Deciduous shrub along gravelly washes, slopes, and plains in creosote bush scrub between 280 and 1,890 feet; not found in 1995 or 1999; as a large shrub occurring in washes, this plant would have been found if present within the ARZC ROW.
Colubrina californica	Las animas colubrina	List 2.3	**Low**. Evergreen shrub in creosote bush scrub between 30 and 3,100 feet; not found in 1995 or 1999; as a large shrub occurring in washes, this plant would have been found if present within the ARZC ROW.
Coryphantha alversonii	Alverson's foxtail cactus	List 4.3	**Moderate.** Rocky to cobbly soils in creosote bush scrub between 230 and 4,730 feet; found west of Iron Mountain in 1995; suitable habitats in Section 17 and where Ship and Old Woman Mountains approach ARZC ROW.
Cryptantha costata	Ribbed cryptantha	List 4.3	**Moderate.** Sandy soils in creosote bush scrub between 180 and 1,550 feet; found in 1995 at Cadiz Lake and in areas of stabilized dunes, but not along Cadiz Road; suitable habitats east of Danby Lake.
Cryptantha holoptera	Winged cryptantha	List 4.3	**Moderate.** Sandy to rocky soils in creosote bush scrub between 310 and 3,720 feet; not found in 1995 or 1999; suitable habitats throughout.
Cynanchum utahense	Utah vine milkweed	List 4.2	**Moderate.** Dry sandy, gravelly soil in creosote bush scrub between 465 and 4,400 feet; not found in 1995 or 1999; suitable habitats throughout.

Scientific Name	Common Name	Listing Status	Potential to Occur Onsite
Echinocereus engelmannii var. howeii	Howe's hedgehog cactus	List 1B.1	**Low.** In creosote bush scrub between 1,333 and 2,400 feet; not found in 1995 or 1999; elevations too low to be suitable.
Linanthus maculatus	Little San Bernardino Mountains linanthus	List 1B.2	**Low.** Sandy soils in creosote bush scrub between 604 to 6,030; not observed in 1995 or 1999; found in the vicinity of Joshua Tree, the Project area is well outside the known range of the species.
Matelea parvifolia	Spear-leaf matelea	List 2.3	**Low.** Dry rocky soils in creosote bush scrub between 1,360 and 3,390 feet; not found in 1995 or 1999; elevations too low to be suitable
Monardella robisonii	Robison's monardella	List 1B.3	**Low.** Pinyon-juniper woodland between 1,890 and 4,650; not found in 1995 or 1999; site is outside range and elevations are too low; suitable habitat not present within survey area.
Nemacaulis denudate var. *gracilis*	Slender cottonheads	List 2.2	**Moderate.** Sandy slopes above drainage at 1,560 feet; found in Arica Mountains in 2010; suitable habitats and elevations along ARZC ROW and western wellfields.
Opuntia basilaris var. *brachyclada*	Short-joint beavertail cactus	List 1B.2	**Low.** Creosote bush scrub between 1,320 and 5,580 feet; not found in 1995 or 1999; site is outside range and elevations are too low.
Penstemon albomarginatus	White-margined beardtongue	List 1B.1	**Low.** Sandy soils, stabilized dunes, roadside washes in creosote bush scrub between 1,980 and 3,300 feet; elevations too low to be suitable.
Penstemon stephensii	Stephen's beardtongue	List 1B.3	**Low.** Carbonate or rocky soils in creosote bush scrub between 3,500 and 5,720 feet; not found in 1995 or 1999; elevations too low to be suitable.
Physalis lobata	Lobed ground-cherry	List 2.3	**Low.** Decomposed granite in creosote bush scrub between 1,550 and 2,480 feet; not found in 1995 or 1999; elevations too low to be suitable; suitable substrates not observed within survey area.
Salvia greatae	Orocopia sage	List 1B.3	**Low.** Broad alluvial bajadas and fans beside washes in creosote bush scrub between 120 and 2,500 feet; found in Marble Mountains in 1978; potentially suitable habitats in Section 17 and where Ship and Old Woman Mountains approach ARZC ROW.
Sphaeralcea rusbyi var. *eremicola*	Rusby's desert-mallow	List 1B.2	**Low.** Creosote bush scrub between 3,020 and 4,650; not observed in 1995 or 1999; elevations too low to be suitable.

APPENDIX A: TABLE 2

Plant Species Observed within the Rare Plant Study Area

Scientific Name	Common Name
Nonflowering Plants	
Ephedraceae	**Joint-fir Family**
Ephedra nevadensis	Nevada joint-fir
Flowering Plants	
Eudicots	
Amaranthaceae	**Amaranth Family**
Atriplex canescens	four-winged saltbush
Atriplex hymenelytra	desert holly
Atriplex polycarpa	allscale
*Salsola tragus**	Russian thistle
Suaeda moquinii	Torrey's sea-blight
Tidestromia oblongifolia	honeysweet
Asclepiadaceae	**Milkweed Family**
Asclepias erosa	desert milkweed
Asclepias subulata	ajamete
Sarcostemma hirtellum	hairy milkweed
Asteraceae	**Sunflower Family**
Ambrosia dumosa	burrobush
Baileya multiradiata	woolly marigold
Bebbia juncea	sweetbush
Calycoseris wrightii	white tackstem
Chaenactis stevioides	desert pincushion
Chrysothamnus paniculatus	wash rabbitbrush
Dicoria canescens	dicoria
Encelia farinosa	brittlebush
Encelia fructescens	rayless encelia
Eriophyllum wallacei	Wallace's woolly daisy
Ericameria cooperi	Cooper's goldenbush
Geraea canescens	desert sunflower
Hymenoclea salsola	cheesebush
Malacothrix glabrata	desert dandelion
Monoptilon bellioides	gray desert star

Scientific Name	Common Name
Palafoxia arida	desert Spanish-needles
Pectis papposa	chinch weed
Perityle emoryi	Emory's rock daisy
Porophyllum gracile	odora
Psathyrotes ramosissima	velvet rosettes
Stephanomeria exigua	milk aster
Stephanomeria pauciflora	desert milk aster
Bignoniaceae	**Bigonia Family**
Chilopsis linearis	desert willow
Boraginaceae	**Borage Family**
Amsinckia tessellata	fiddleneck
Cryptantha barbigera	fuzzy forget-me-not
Cryptantha nevadensis	Nevada forget-me-not
Pectocarya heterocarpa	combseed
Pholisma arenarium	dune food
Tiquilia plicata	plicate coldenia
Brassicaceae	**Mustard Family**
*Brassica tournefortii**	Saharan mustard
*Descurainia pinnata**	tansy
*Descurainia sophia**	flixweed
Guillenia lasiophylla	California mustard
Lepidium flavum	peppergrass
Lepidium lasiocarpum	sand peppergrass
*Sisymbrium irio**	London rocket
Cactaceae	**Cactus Family**
Opuntia basilaris	beavertail cactus
Opuntia echinocarpa	silver cholla
Capparaceae	**Caper Family**
Isomerus arborea	bladderpod
Cuscutaceae	**Dodder Family**
Cuscuta sp.	dodder
Euphorbiaceae	**Spurge Family**
Euphorbia setiloba	Yuma sandmat
Stillingia spinulosa	toothleaf
Fabaceae	**Pea/Bean Family**
Acacia greggii	catclaw acacia
Cercidium floridum	palo verde
Dalea mollissima	soft prairie clover
Lupinus sparsiflorus	Mojave lupine
Psorothamnus emoryi	indigo bush

Scientific Name	Common Name
Psorothamnus spinosus	smoke tree
Senna armata	desert senna
Geraneaceae	**Geranium Family**
*Erodium cicutarium**	red-stemmed filaree
Hydrophyllaceae	**Water-leaf Family**
Nama demissum	purple mat
Phacelia crenulata	notchleaf hacelia
Krameriaceae	**Krameria Family**
Krameria erecta	littleleaf rhatany
Lamiaceae	**Mint Family**
Hyptis emoryi	desert lavender
Salvia columbariae	chia
Loasaceae	**Stick-leaf Family**
Mentzelia albicaulis	little blazing star
Petalonyx thurberi	sandpaper plant
Malvaceae	**Mallow Family**
Eremalche rotundifolia	desert fivespot
Nyctaginaceae	**Four o'clock Family**
Mirabilis bigelovii	desert wishbone plant
Onagraceae	**Evening-primrose Family**
Camissonia boothii	red primrose
Camissonia brevipes	yellow cups
Camissonia claviformis	brown-eyed primrose
Oenothera deltoides	devil's lantern
Orobanchaceae	**Broom-rape Family**
Orobanche cooperi	desert broomrape
Papaveraceae	**Poppy Family**
Eschscholzia minutiflora	pygmy poppy
Plantaginaceae	**Plantain Family**
Plantago ovata	plantain
Polemoniaceae	**Phlox Family**
Gilia sp.	gilia
Langloisia setosissima	lilac sunbonnets
Loeseliastrum matthewsii	desert calico
Loeseliastrum schottii	Schott's calico
Polygonaceae	**Buckwheat Family**
Chorizanthe brevicornu	brittle spineflower
Chorizanthe rigida	rigid spineflower
Eriogonum inflatum	desert trumpet
Eriogonum thomasii	Thomas's buckwheat

Scientific Name	Common Name
Eriogonum viridescens	bright green buckwheat
Resedaceae	**Mignonette Family**
Oligomeris linifolia	narrowleaf oligomeris
Solanaceae	**Nightshade Family**
Datura wrightii	jimsonweed
Tamaricaceae	**Salt-cedar Family**
*Tamarix ramosissima**	tamarisk
Viscaceae	**Mistletoe Family**
Phorodendron californicum	mesquite mistletoe
Zygophyllaceae	**Caltrop Family**
Fagonia laevis	California fagonbush
Larrea tridentata	creosote bush
*Tribulus terrestris**	puncture vine
Monocots	
Agavaceae	**Agave Family**
Agave deserti	desert agave
Hesperocallis undulata	desert lily
Melanthiaceae	**Starfruit Family**
Zigadenus curvibracteatus	desert camas
Poaceae	**Grass Family**
Pleuraphis rigida	Big galleta
*Schismus barbatus**	Mediterranean schismus
Vulpia octoflora	sixweeks fescue

*=species not native to California

HydroBio
Advanced Remote Sensing

September 1, 2011

Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California

Executive Summary

Vegetation provides stabilization of soils against the action of wind erosion, particularly in desert environments such as the Cadiz Valley region of proposed groundwater pumping for export. Such pumping has the potential to induce localized declines in water tables that would affect any vegetation that is partially reliant upon groundwater.

This analysis was conducted by locating the most likely vegetation in the area potentially affected by the planned groundwater pumping. This "most likely" cover was identified by its higher activity (denser growth, larger plants) than all other locations around the Bristol Playa. Observations of the Cadiz Playa indicated that this region could be eliminated from concern because the vegetation around the playa is generally no more verdant than the surrounding area, hence obviously receiving no promotion from groundwater.

A curve for depth to water (DTW) versus elevation was reconstructed from hydrographic data collected in the region of the Cadiz Ranch. A DTW point was added on the Bristol Playa that was reconstructed using photogrammetry. Together, these points describe a highly linear relationship of DTW versus elevation above sea level (r2 = 99.9%). With this robust and accurate relationship, predicted DTW at the lowermost edge of the higher vegetation cover was 65 feet, about 40 feet deeper than the highest recorded rooting depths for four wing saltbush. The promotional effect of periodic surface flows from the upstream catchments is hypothesized for the apparent promotion of this vegetation.

In summary, there is no connection of vegetation with groundwater in the region of Cadiz and Bristol Playas, hence, no vegetation will be affected by changes in water table elevation.

Section		Page
1.	Introduction	1
2.	Vegetation Analysis	3
3.	Depth to Groundwater Analysis	5
4.	Estimating Depth to Groundwater—Bristol Playa	7
5.	Conclusions	7
6.	References	7

1220 Cerro Gordo Road • Santa Fe • New Mexico • 87501 • 505-992-0234 • www.HydroBioARS.com

1. Introduction

Phreatophyte is a term for plants that use groundwater. Especially in an arid climate such as exists in the region of Cadiz , phreatophytic vegetation will tend to be much greener than other vegetation that receives only rain. There are three shrub species that grow around the Bristol Playa: creosote bush [*Larrea tridentata*], cattle saltbush [*Atriplex polycarpa*] and four wing saltbush [*Atriplex canescens*]. Creosote bush and cattle saltbush are not phreatophytes. Four-wing saltbush is a facultative phreatophyte, meaning it can benefit from but does not require shallow groundwater (DOE, 1998). It would be this species that would have connection with the groundwater, if such a connection exists.

Vegetation Sensitivity to declines in water table elevations due to groundwater pumping is well known (Munoz-Reinoso, 2001; Cooper et al., 2006; Patten et al., 2008). The region adjacent to the Bristol Playa was evaluated to determine whether the vegetation is phreatophytic and could, therefore be impacted by export pumping from the Cadiz Groundwater Conservation, Recovery, and Storage Project (Project). This zone had both elevated vegetation cover and nearby DTW measurements.

The area identified for this analysis includes the Bristol Playa extending up the Orange Blossom and Fenner Gap washes (Figure 1). The Orange Blossom and Fenner Gap are a source of water supply that drains by gravity, either surface or subsurface down gradient toward the Bristol Playa. This report identifies the vegetation and DTW patterns associated with these features, and investigates the potential interactions between groundwater and vegetation.

The magnitude of the groundwater supply for phreatophytes determines their sensitivity in the event of a decrease in supply due to water table decline. Thus, in order to understand the functional connection of vegetation with the water table, the region of the highest native vegetation cover in the region of Cadiz and Bristol Playas was selected for comparing the depth to water (DTW) at the lowest elevation boundary for the high vegetation cover—this location corresponds with edge of the promoted vegetation along the margin of the playa.

Water tables were reconstructed using hydrograph data from the wells indicated on Figure 2. Elevation contours were reconstructed using digital elevation model (DEM) data (USGS 2010). The hydrographs were contained in GSSI (2009).

The analysis began after observations of both Cadiz and Bristol playas on air photos and by aircraft. The Cadiz Playa lacks any indication of verdant cover except for Russian thistle in the dunes around the north through northeast portions of the play where it may receive discharge from distributaries of the Fenner Wash or ran upon the dunes that this plant has colonized.

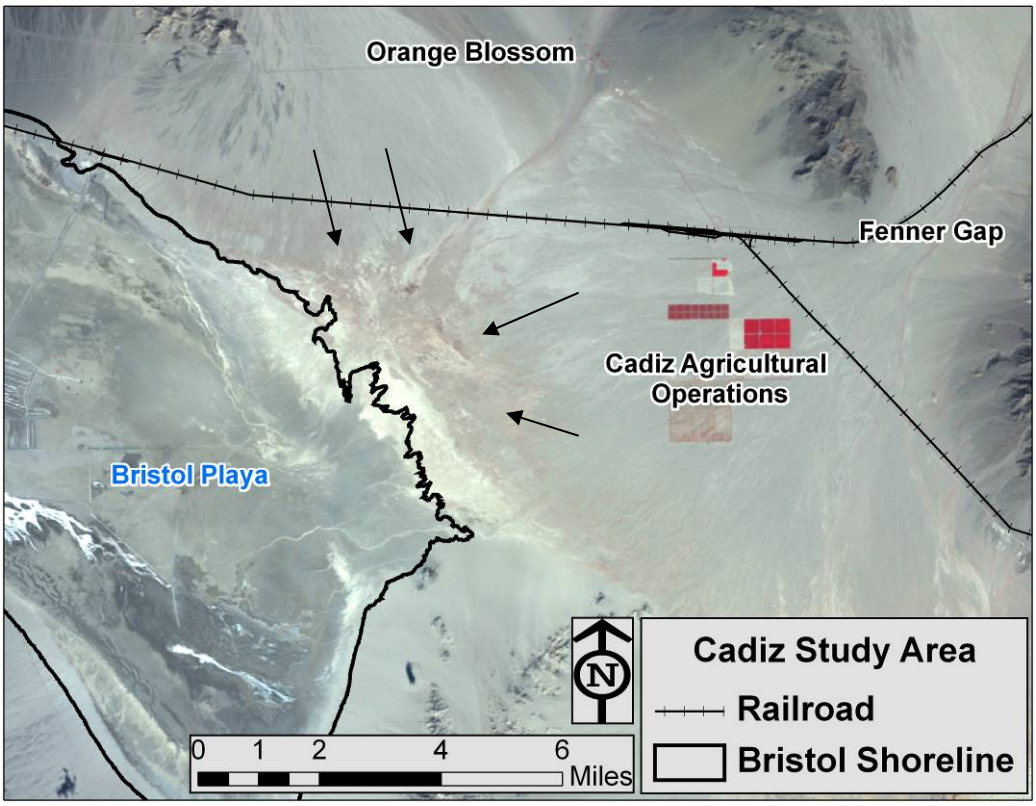


Figure 1. The location of key landmarks and the generally extent of the study area. The region north of the Bristol Playa margin is the logical for to look for phreatophyte vegetation and groundwater interaction because the most verdant native vegetation is located there—this appears as the pinkish region of the Orange Blossom Wash in this false color portrayal.

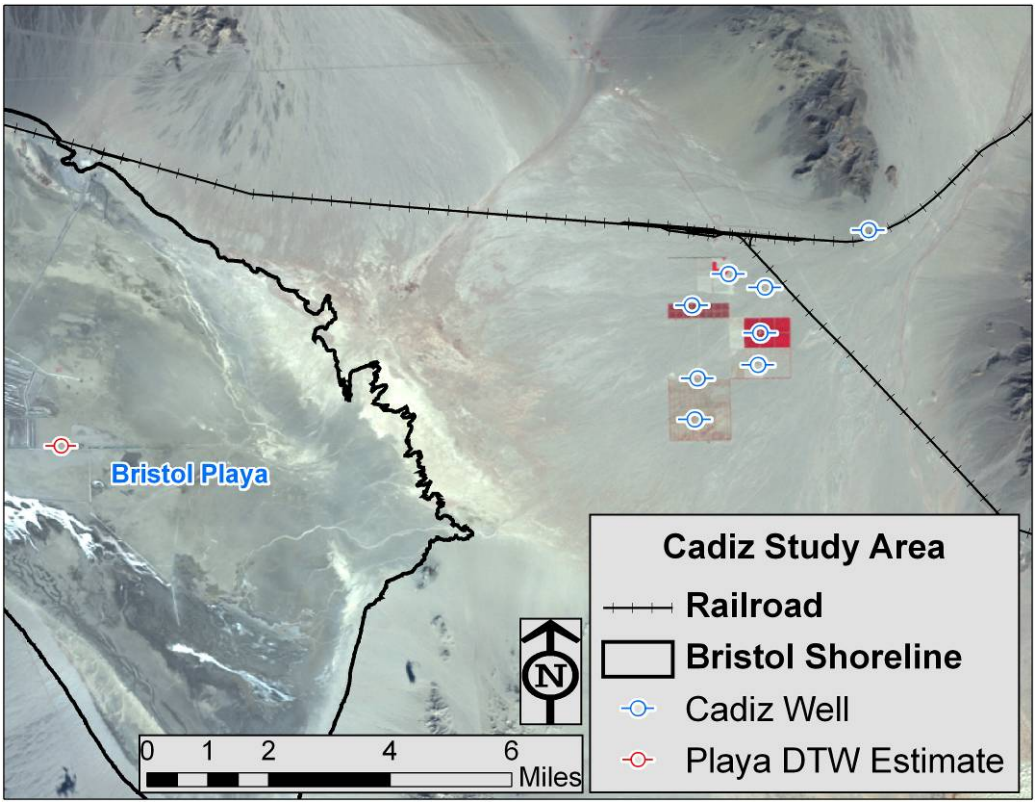


Figure 2: Location map with Bristol Playa margin indicated and location of test wells relative to the land surface contours.

2. Vegetation Analysis

Water is the most limiting factor for vegetation growth in arid environments and so any vegetation that receives water in excess of the small amount of precipitation in this arid climate should contrast by having a higher greenness from the surrounding low vegetation activity in the adjacent desert. The native vegetation with the highest vegetation vigor was identified using remote sensing. A Landsat TM image was processed to reflectance and converted to normalized difference vegetation index (NDVI) that displays the greenness of the vegetation. The area of the highest natural vegetation cover in the study region was identified in contrast to the vegetation of the surrounding desert (Figure 3). This area corresponds to the Orange Blossom wash and a region along the northern margin of the Bristol Playa. No such areas were found around the remainder of Bristol Playa and were also lacking from the region around Cadiz Playa.

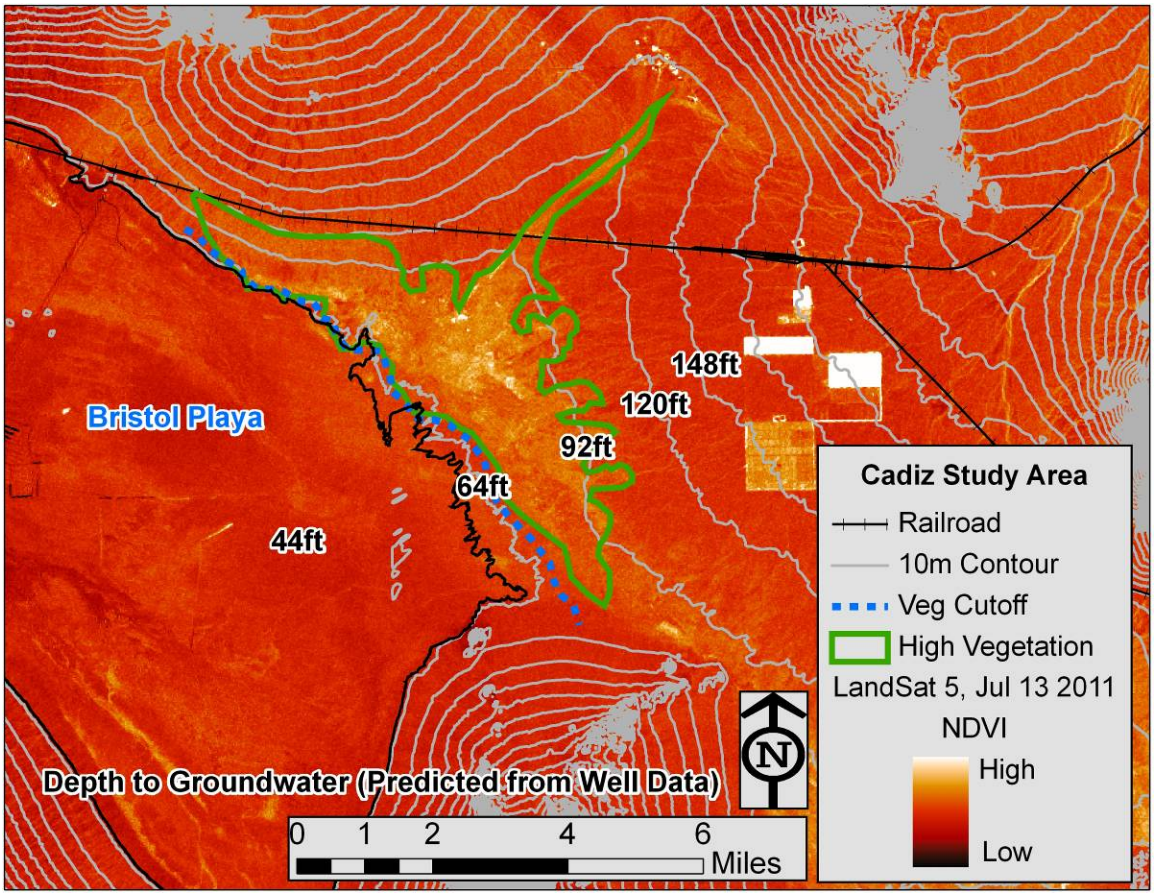


Figure 3. NDVI vegetation density acquired from LandSat 5 TM imagery. There is little evidence suggesting DTW influences vegetation density surrounding the Cadiz Agricultural Operations corner of the Bristol playa. The highest cover of vegetation corresponds to the verdant agriculture at the Cadiz Ranch. The dashed line shows the position of the edge of the higher vegetation vigor to be compared to DTW reconstruction.

Figure 4 shows an aerial view of the zone of higher vegetation vigor. Ground visits indicated that the vegetation cover there consists of all three species mentioned above.

Figure 4. An aerial oblique perspective from the Bristol Playa shoreline looking north. The zone of high vegetation visible in this image is delineated in Figure 3. If this vegetation is phreatophytic then groundwater must be within reach of plant roots

3. Depth to Water Analysis

DTW was reconstructed along an elevation gradient between the Cadiz Agricultural Operations and the Bristol Playa (contours shown on Figure 3). Depth to groundwater data were obtained from the Eleventh Annual Groundwater Monitoring Roport January – December 2008 produced by Cadiz Valley Agricultural Development (GSSI, 2009). DTW, reference elevation, and groundwater elevation are available in tabular format in the report. In the absence of precise well location data, the location map included in GSSI (2009) was used, along with aerial and satellite imagery and a digital elevation model, to locate wells precisely as possible (generally within about 200 feet) that are described in the report. Uncertainty on exact location had no bearing on the interpretation since the elevation and depth to water of each well could be calculated directly from the GSSI (2009) data.

All available DTW data were plotted on Figure 5. DTW points were available for areas in proximity to the Cadiz Agricultural operations (Pink points in Figure 5) but were not available for elevations approaching or on the Playa. DTW was estimated on the playa using oblique aerial photography of known locations as reference points on the ground (Blue point in Figure 5, calculations in next section). To interpolate between these points, a linear regression was applied to the measured and estimated DTW points. The relationship is extremely strong (r^2 = 99.9%), and allows interpolation of DTW at the position of the lower elevational boundary elevation of the higher vigor shrub area shown in Figure 3, likely within a couple feet of actual.

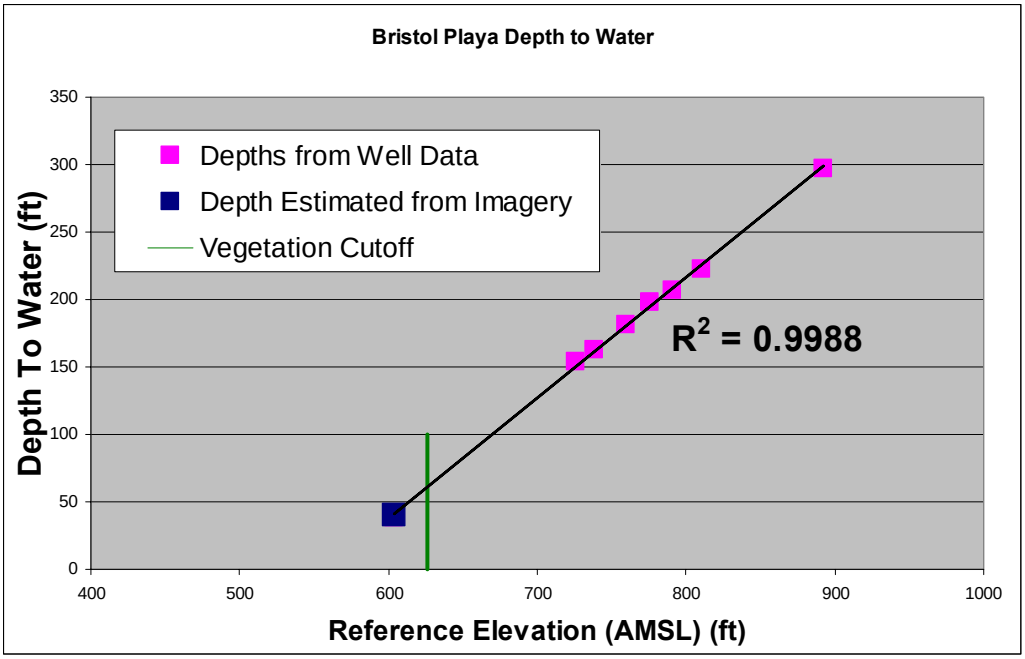


Figure 5. DTW data acquired from GSSI (2009) are displayed in pink, and DTW estimated from oblique aerial imagery is displayed in blue. The strong linear relationship supports interpolation between measured points.

4. Estimated Depth to Groundwater—Bristol Playa

To interpolate DTW values between the Cadiz Agricultural Operations and the Bristol Playa, a data point on the Bristol Playa was required (far more robust than extrapolation). In the absence of available DTW records on or immediately surrounding the Bristol Playa, we chose to estimate DTW using oblique aerial imagery that was obtained on August 23, 2011. The occurrence of groundwater was visible at several points on the Bristol Playa where pits are excavated for saltworks operations.

Many pits exist near the saltworks facility on Bristol Playa and these were not chosen for analysis because watertables may have been influenced by local operations. A pit excavated in the lakebed away from the operations was chosen that intersected the groundwater surface (Figures 6 and 7). No evidence of pumping infrastructure, or influence of local operations was apparent in the area which suggests the water level in the pit represented the actual water table surface.

Figure 5. Google Earth image of a pit on Bristol playa. Imagery is used to establish scale and base the math for estimation.

Figure 6. Oblique air photo captured on August 23, 2011 to estimate angle of pit wall and confirm water table.

An oblique aerial image coupled with Google Earth imagery was used to estimate the angle of the pit wall and to confirm the water table. A scene from Google Earth (nadir or near nadir) was used to measure the horizontal run of the pit face slope. Analysis of the aerial oblique imagery suggested the slope of the pit face was about 60˚. Correcting for the run of the pit face slope with a tangent function yielded a depth of 35 feet at a known elevation. This point was added to the measured well data (Figure 5). With the strong linear relationship obtained, DTW was confidently interpolated at the lower boundary of the higher vegetated area (dotted line in Figure 3): 65 feet.

5. Conclusions

DTW at the lowermost ecotone of the higher shrub zone was 65 feet—because it is on the down gradient boundary, this is the potential minimum estimated DTW beneath the region identified with higher vegetation activity that appeared to have the highest potential for groundwater connection. Root excavations of four wing saltbush have been measured to reach a maximum of 25 feet only rare occasions when soils and hydrology permit but average about 13 feet (Foxx 1984). Based on measured and estimated DTW, the shallowest watertable position is 40 feet below the record rooting depth for the only species that could be potentially affected by groundwater decline. The higher vegetation in the wash is likely the result of periodic resupply by surface flows from Orange Blossom Wash and other similar wadis.

6. References

Cooper, DC, Sanderson, JS, Stannard, DI, and Groeneveld, DP. 2006. Effects of long-term water table drawdown on evapotranspiration and vegetation in an arid region phreatophyte community. Journal of Hydrology, 325: 21-34.

DOE. 1998. Monument Valley Ground Water Remediation Work Plan: Native Plant Farming and Phytoremediation Pilot Study. US Department of Energy Project Number UGW–511–0015–10–000. Document Number U0029501. *<www.lm.doe.gov/MonValley/umon00000165.pdf>*

Foxx, T. S., G. D. Tierney, and J. M. Williams, 1984. Rooting Depths of Plants on Low-Level Waste Disposal Sites, LA–10253–MS, Los Alamos National Laboratory, Los Alamos, New Mexico.
<http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/16/057/16057804.pdf>

GSSI.. 2009. 11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development, June 2009. Geoscience Support Services, Inc.

Munoz-Reinoso, JC. 2001. Vegetation changes and groundwater abstraction in SW Donana, Spain. Journal of Hydrology. 242: 197-209.

Patten, DT, Rouse, L, Stromberg, JC. 2008. Isolated Spring Wetlands in the Great Basin and Mojave Deserts, USA: Potential Response of Vegetation to Groundwater Withdrawal. Environmental Management. 41: 398-413.

United States Geological Survey, EROS Data Center. National Elevation Dataset 30 Meter. San Bernardino County. Accessed November 2010. http://datagateway.nrcs.usda.gov/.

CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Phase I Cultural Resources Assessment

Prepared for
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

November 2011

ESA

CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Phase I Cultural Resources Assessment

Prepared for
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

November 2011

Prepared By:
ESA
626 Wilshire Blvd. Suite 1100
Los Angeles, CA 90017

Project site location: Cadiz, Cadiz Summit, Cadiz Lake NW, Cadiz Lake NE, Calumet Mine, Chubbuck, Milligan, East of Milligan, Danby Lake, Sablon, and Arica Mountains (CA) USGS 7.5' Topographic Maps T1S R19E, 20E; T1N R18E, 19E; T2N R17E, 18E; 3N R16E, 17E; 4N R15E, 16E; 5N R14E, 15E

Principal Investigator: Monica Strauss, M.A.

Report Authors: Madeleine Bray, M.A, Candace Ehringer, M.A., Brian S. Marks, Ph.D.

Keywords: San Bernardino County, Cadiz, Milligan, Archer, Freda, Chubbuck, Ward, Siam, Saltmarsh, Sablon, Fishel, Atchison Topeka and Santa Fe Railroad, Parker Cutoff, General George Patton Desert Training Center, Railroad Siding, Archaeological Survey

626 Wilshire Boulevard
Suite 1100
Los Angeles, CA 90017
213.599.4300
www.esassoc.com

Oakland

Olympia

Orlando

Palm Springs

Petaluma

Portland

Sacramento

San Diego

San Francisco

Seattle

Tampa

Woodland Hills

210324

TABLE OF CONTENTS

Cadiz Valley Water Conservation, Recovery, and Storage Project

Phase I Cultural Resources Assessment

Page

Executive Summary.....1

Introduction.....1
Project Location.....1
Project Description.....1

Setting.....4
Natural Setting.....4
Prehistoric Setting.....5
Ethnographic Setting.....8
Historic Setting.....9

Methodology and Results.....14
Archival Research.....14
Native American Contact.....25
Field Survey.....26

Evaluation of Cultural Resources.....68
Regulatory Framework.....68
Significance Evaluation of Cultural Resources.....73

Conclusions and Recommendations.....79

References.....82

List of Figures

Figure 1 Regional Location Map.....2
Figure 2 Project Location Map.....3
Figure 3 Survey Areas.....28
Figure 4 Cultural Resources Location Map.....Appendix D
Figure 5 Photos: CA-SBR-3233H (Milligan).....31
Figure 6 Photos: CA-SBR-3235H (Saltmarsh).....35
Figure 7 Photos: CA-SBR-3282H (Archer).....37
Figure 8 Photos: CA-SBR-3283H (Chubbuck).....39
Figure 9 Photos: CA-SBR-SBR-9849H and -9851H.....41
Figure 10 Photos: CA-SBR-9853H (ATSF Parker Cutoff).....43
Figure 11 Photos: CA-SBR-9856H and -9858H.....44
Figure 12 Photos: CA-SBR-10646H (Sablon).....46

List of Figures (cont.)

Figure 13 Photos: Newly Recorded Cutlural Resources 49
Figure 14 Photos: Newly Recorded Cutlural Resources 50
Figure 15 Photos: Newly Recorded Cutlural Resources 52
Figure 16 Photos: Newly Recorded Cutlural Resources 54
Figure 17 Photos: Newly Recorded Cutlural Resources 55
Figure 18 Photos: Newly Recorded Cutlural Resources 56
Figure 19 Photos: Newly Recorded Cutlural Resources 58
Figure 20 Photos: Newly Recorded Cutlural Resources 59
Figure 21 Photos: Newly Recorded Cutlural Resources 60
Figure 22 Photos: Newly Recorded Cutlural Resources 62
Figure 23 Photos: Newly Recorded Cutlural Resources 64
Figure 24 Photos: Newly Recorded Cutlural Resources 66
Figure 25 Photos: Newly Recorded Cutlural Resources 67

List of Tables

Table 1 Cultural Complexes 5
Table 2 Previous Cultural Resources Investigations Conducted within 0.5 Mile of the Project Area 15
Table 3 Previously Recorded Cultural Resources within 0.5 Mile of the Project Area 17
Table 4 Cultral Resources Recorded or Updated during Survey 28
Table 5 Significant Cultural Resources 74

Appendices

Appendix A: Personnel Qualifications

Appendix B: Native American Contact

Appendix C: Survey Coverage on USGS Topographic Maps (1:24000)

Appendix D: Cultural Resources Location Map (Figure 4)
(Confidential – bound under separate cover)

Appendix E: DPR Forms
(Confidential – bound under separate cover)

EXECUTIVE SUMMARY

Cadiz Valley Water Conservation, Recovery, and Storage Project
Phase I Cultural Resources Assessment

Pursuant to the California Environmental Quality Act (CEQA), ESA is preparing an Environmental Impact Report (EIR) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). The Santa Margarita Water District (SMWD) is acting as Lead Agency as the first public agency with a discretionary decision regarding the Project and because the Project will be owned in part and operated by SMWD. The Project, located on private lands in the unincorporated portion of southeast San Bernardino County, would develop a new reliable water supply and storage facility for SMWD and other participants.

The proposed Project would be executed in two phases: 1) Groundwater Conservation and Recovery Component and 2) Imported Water Storage Component. The first phase involves the conservation and recovery of native groundwater that is now lost due to evaporation. Facilities that would be constructed under the first phase include a wellfield and manifold system, water conveyance facilities, a tie-in to the Colorado River Aqueduct (CRA), access roads, and power supply and distribution facilities. In accordance with *CEQA Guidelines* §15378(a), the Conservation and Recovery Component is being analyzed at a project level in the Draft EIR.

The second phase includes an expanded wellfield, an extension of the water conveyance facilities, spreading basins, a CRA diversion structure and pump station, access roads (if necessary), and expansion of the power supply and distribution facilities. Where possible, the Imported Water Storage Component is also analyzed at a project level, but because certain elements of the design are still under conceptual development, phase two of the proposed Project will be analyzed at an overall programmatic level in the Draft EIR.

This report provides a cultural resource study for phase one facilities associated with the Groundwater Conservation and Recovery Component. For the purposes of this study, the Project area has been divided into two portions: 1) the proposed wellfield area located in the northern portion of the Project area and related portion of the water conveyance pipeline; and 2) the proposed water conveyance pipeline that would be installed within the Arizona California Railroad Company (ARZC) railroad right-of-way (ROW) that connects the Project wellfield in the north to the Colorado River Aqueduct (CRA) in the south and the proposed CRA tie-in Option 1.

A Project-specific cultural resources literature and records search was conducted at the California Historical Resources Information System (CHRIS) San Bernardino Archaeological Information Center (SBAIC) on September 22, 2010. The records search study area included the Project wellfield area, water conveyance facilities (pipeline), the CRA tie-in, and a half-mile buffer. The

records search indicated that 50 cultural resources have been previously recorded within the records search study area. The 50 resources include eight prehistoric archaeological sites, 35 historic-era resources, one site with both prehistoric and historic-era components, and six isolated artifacts. Of the 50 previously recorded cultural resources, 16 are located within or immediately adjacent to the wellfield portion of the Project area. Eighteen cultural resources are located within or immediately adjacent to the pipeline portion of the Project area.

A Sacred Lands File search with the Native American Heritage Commission (NAHC) was requested on November 8, 2010. Search results prepared by the NAHC on November 12, 2010, indicated the presence of Native American cultural resources within one-half mile of the Project area. Contact letters to all individuals and groups indicated by the NAHC as having affiliation with the Project area were prepared and mailed on November 17, 2010. To date, two responses have been received.

Field surveys were conducted between October 18 and 26, 2010. The survey area for the proposed pipeline portion of the Project area included 42.5 miles of the 200-foot-wide ARZC railroad ROW (100 feet on either side of the center line), from the proposed wellfield in the north to the CRA tie-in in the south; and an area from the ARZC railroad ROW east to the Freda Siphon, including the CRA tie-in Option 1. (CRA tie-in Options 2a and 2b and the wellfield portion of the proposed Project area were not surveyed since the precise location of the wells, forebays, and access roads were not yet finalized.)

A total of 43 cultural resources were recorded or updated during the field surveys of the proposed pipeline portion of the Project area, including 15 previously recorded resources and 28 newly recorded resources. Two of the 15 resources that were previously recorded within the proposed pipeline portion of the Project area could not be relocated and are presumed to have been destroyed; therefore a total of 41 resources are currently known to exist within the proposed pipeline portion of the Project area. All 41 of these resources consist of historic-era archaeological sites. All resources were updated on California Department of Parks and Recreation (DPR) 523 forms, which will be filed at the SBAIC. No prehistoric resources or artifacts were observed during the survey and no isolated artifacts were recorded.

Of the 41 resources located within the proposed pipeline portion of the Project area, 10 are recommended eligible for listing in the California Register of Historical Resources (CRHR) and should be considered significant resources under CEQA. The remaining 31 resources are recommended not eligible for listing in the CRHR and are therefore not considered significant resources under CEQA. Avoidance is the preferred method of mitigation for significant resources. However, if the Project will impact any of the 10 recommended-eligible resources, a treatment plan that identifies procedures to reduce impacts to these resources should be developed by a qualified archaeologist and implemented prior to the issuance of Project permits. The remaining 31 resources do not require further work as part of this Project. In addition, prior to the issuance of Project permits, any areas that were not surveyed as part of this study, including the proposed wellfield and any new areas added to the Project area after the completion of this study, should be surveyed by a qualified archaeologist for the purposes of identifying eligible resources. Any resources identified as eligible should be avoided, where feasible, and appropriate treatment procedures implemented where avoidance is not possible.

PHASE I CULTURAL RESOURCES ASSESSMENT

Cadiz Valley Water Conservation, Recovery, and Storage Project

Introduction

Pursuant to the California Environmental Quality Act (CEQA), ESA is preparing an Environmental Impact Report (EIR) for the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project (Project). The Santa Margarita Water District (SMWD) is acting as Lead Agency as the first public agency with a discretionary decision regarding the Project and because the Project will be owned in part and operated by SMWD.

ESA personnel involved in the preparation of this Phase 1 cultural resources assessment are as follows: Monica Straus, M.A., RPA., principal investigator; Madeleine Bray, M.A., R.P.A., surveyor and report author; Candace Ehringer, M.A., R.P.A, surveyor and report author; Brian Marks, Ph.D., R.P.A., report co-author; Jason Nielsen, GIS specialist; and Linda Uehara, graphic artist. Resumes of key personnel are attached as Appendix A.

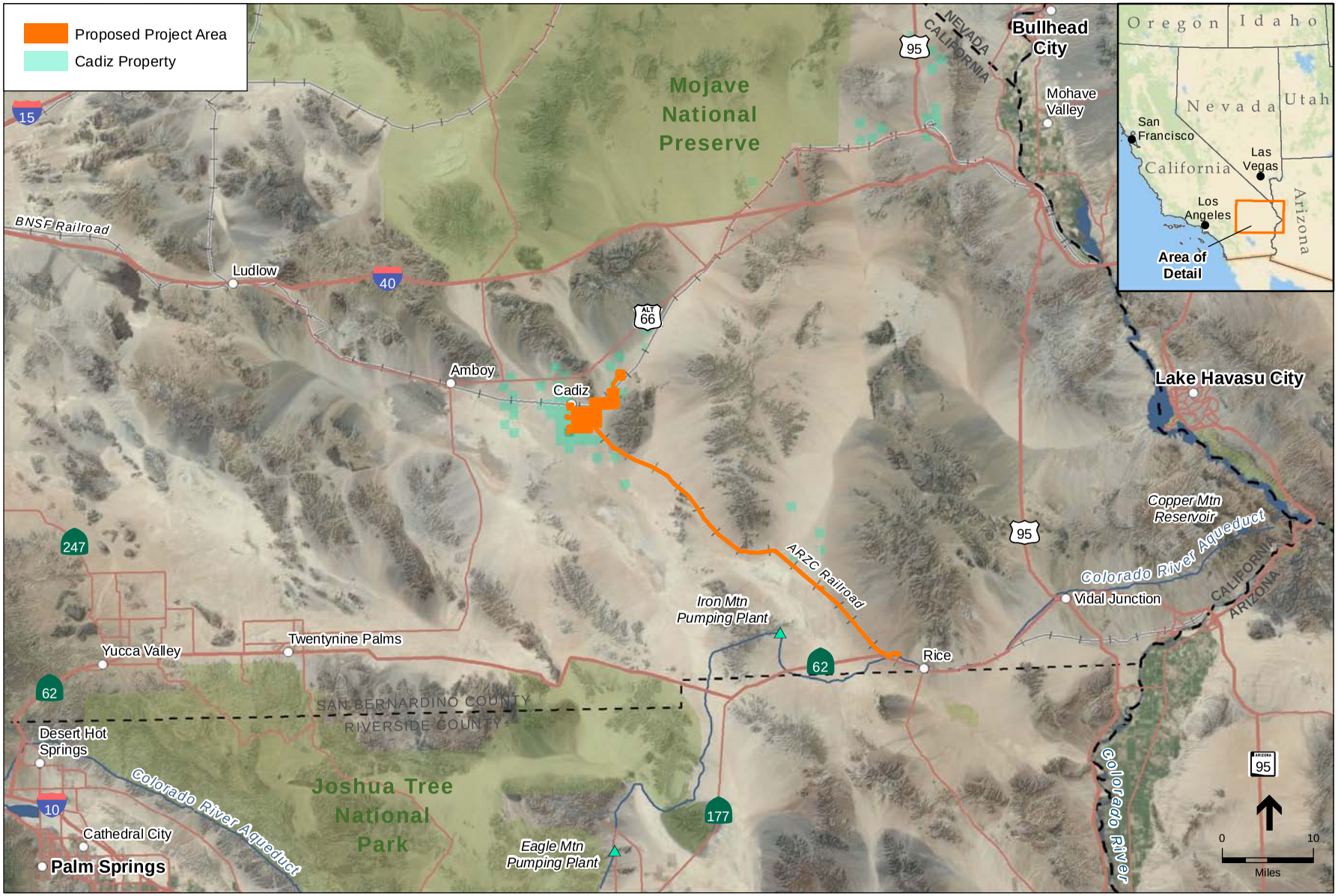
Project Location

The Project is located in the unincorporated portion of southeast San Bernardino County, between the towns of Cadiz and Freda along the Arizona California Railroad Company (ARZC) railroad line (**Figure 1**). The Project is 220 miles east of Los Angeles, 75 miles southwest of Needles, and 65 miles northeast of Twentynine Palms (**Figure 2**).

Project Description

Cadiz Inc., in partnership with the SMWD and other participants, has developed this Project to implement a comprehensive, long-term groundwater management program that would allow for both beneficial use of some of the groundwater and storage of imported surface water in the groundwater basin. The Project would provide a new, reliable water supply source local to the southern California region and provide local water storage, both contributing to improved water supply reliability for the region..

The Project would be implemented in two phases. The first phase, referred to as the Groundwater Conservation and Recovery Component, involves the conservation and recovery of native groundwater that is now lost due to evaporation. Facilities that would be constructed under the first phase include a Project wellfield and manifold system, water conveyance facilities, a tie-in to the Colorado River Aqueduct (CRA), access roads, and power supply and distribution facilities. In accordance with *CEQA Guidelines* §15378(a), the Conservation and Recovery Component is

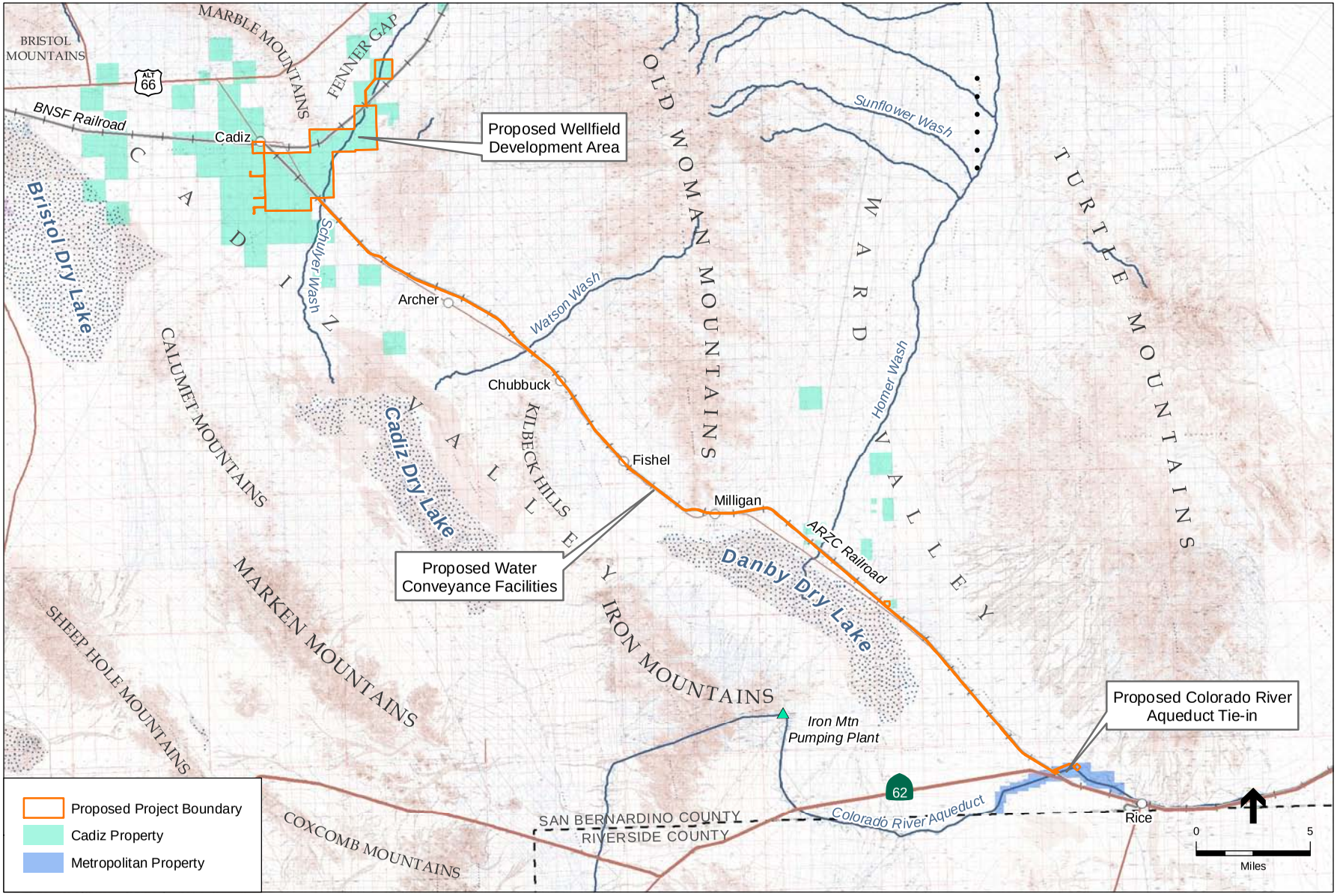


SOURCE: Bing Maps, 2011; ESRI, 2010; DeLorme, 2011; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 1

Regional Location



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 2

Project Location

being analyzed at a project level in the Draft EIR. This report provides a cultural resource study for phase one facilities associated with the Groundwater Conservation and Recovery Component.

The second phase of the Project is referred to as the Imported Water Storage Component. Facilities that would be constructed under the second phase include an expanded Project wellfield, an extension of the water conveyance facilities, spreading basins, a CRA diversion structure and pump station, access roads (if necessary), and expansion of the power supply and distribution facilities. Where possible, the Imported Water Storage Component is also analyzed at a project level, but because certain elements of the design are still under conceptual development, including the potential quantity and schedule for spreading, storage, and extraction, phase two of the proposed Project will be analyzed at an overall programmatic level in the Draft EIR. This report provides a cultural resource study for phase one only.

For the purposes of this study, the Project area has been divided into two portions: 1) the proposed wellfield area (approx. 7198 acres at the time of this study) located in the northern portion of the Project area (Sections 8, 17, 18, 13, 16, 24, 23, 22, 25, 26, 27, 35, 34, and 33 of USGS quads Cadiz, Cadiz Summit, Cadiz Lake NW, and Calumet Mine) and related portion of the water conveyance pipeline (referred to hereafter as "wellfield portion of the project area" or "wellfield"); and 2) the proposed water conveyance pipeline that would be installed in the ARZC railroad right-of-way (ROW) from the proposed wellfield in the north to the Colorado River Aqueduct (CRA) tie-in in the south (approx. 42.5 miles) and the proposed CRA tie-in Option 1 (approx. 24 acres) (referred to hereafter as "pipeline portion of the Project area" or "pipeline"). The portion of the pipeline in the wellfield area is not included in this report. The ARZC railroad is referred to as such when describing its current state; however, historically the same railroad was known as the Atchison, Topeka, and Santa Fe (ATSF) Railroad, Parker Cutoff, and is referred to by the designation "ATSF Parker Cutoff" when referring to the railroad's history.

Setting

The following section provides the natural environment and cultural context for the Project area.

Natural Setting

The Project area is located in the Mojave Desert, which is situated within the southern Basin-and-Range geomorphic province. The terrain consists of a series of broad, shallow southeast-trending valleys. Several playas, or closed basin sinks, exist on the valley floors. North-south trending weathered mountain ranges, rarely exceeding 4,000 feet in elevation, surround the valleys. The elevation of the Project area ranges from 600 feet above mean sea level (amsl) at Bristol Dry Lake to over 900 feet amsl at the Fenner Gap. However, the New York Mountains at the northern edge of the Fenner Watershed are over 7,500 feet in elevation.

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower

temperatures and higher precipitation at higher altitudes. Average annual precipitation varies from about 4 inches in Bristol Valley to more than 12 inches in the New York Mountains (CH2MHill, 2010:2-3).

The primary plant community in the Mojave Desert is the creosote scrub community, which is dominated by creosote bush and white bursage. Other plant communities include the cactus scrub community, which includes barrel cactus, calico cactus, and ocotillo, and the saltbrush series, which includes saltbrush, mesquite, arrowweed, and goldenbrush. Common animals include desert cottontail, jackrabbit, kangaroo rat, packrat, chuckwalla iguana, desert tortoise, and desert quail.

The area provided many sources of food for its prehistoric inhabitants. Rodents, jackrabbits and cottontails, and occasionally deer and waterfowl would have been hunted. Mesquite, pinon nuts, live oak acorns, and Manzanita berries were all important plant food sources (Bean and Vane, 2002).

Prehistoric Setting

The prehistory of the Mojave is generally described in terms of cultural "complexes." A complex is a specific archaeological manifestation of a general mode of life, characterized archaeologically by technology, particular artifacts, economic systems, trade, burial practices, and other aspects of culture. Complexes are typically associated with particular chronological periods (**Table 1**).

TABLE 1
CULTURAL COMPLEXES

Time Period	Complex	Dates
Pleistocene	Paleo-Indian	10,000 – 8,000 B.C.
Early Holocene	Lake Mojave	8,000 – 6,000 B.C.
	Deadman Lake	7,500 – 5,200 B.C.
Middle Holocene	Pinto	6,000 – 3,000 B.C.
Late Holocene	Gypsum	2,000 B.C. – A.D. 200
	Rose Spring	A.D. 200 – 1100
	Late Prehistoric	A.D. 1100 to contact

SOURCE: Sutton et al., 2007: 236

Paleo-Indian (10000 to 8000 B.C.)

The Paleo-Indian period is sparsely represented in the Mojave, but is characterized primarily by large, fluted Clovis Projectile points. This limited evidence suggests that early human occupants of the Mojave probably lived in small, mobile groups in temporary camps on permanent water sources (Sutton et al., 2007: 233-234).

Lake Mojave Complex (8000 to 6000 B.C.)

Lake Mojave sites have been found primarily around Fort Irwin, Lake Mojave, Lake China, Rosamond Lake, and Twentynine Palms, located near extinct water sources with the margins of pluvial lakes being the preferred settlement area. Subsistence and settlement patters are likely to have been a direct response to climatic fluctuations occurring during the Pleistocene to Holocene transition. High mobility designed to exploit ever-changing resource bases, coupled with a reliance on more permanent resources (water sources), was likely. In particular, the Lake China basin, located about 150 miles northeast of the Project area, seems to have been a preferred resource location. Lake Mojave populations were organized into relatively small, mobile groups and practiced a forager-like subsistence strategy. Sites appear to have been repeatedly occupied, with artifact assemblages from both large and small sites being functionally identical (Sutton et al., 2007: 234-237).

In terms of material culture, the Lake Mojave Complex is typified by stone tools such as Lake Mojave and Silver Lake projectile points, bifaces, steep-edged unifaces, crescents, and some ground stone implements. The use of heavy projectile points, bifaces, and scrapers would suggest exploitation of large game. However, faunal assemblages and protein residue analyses from Fort Irwin represent heavy reliance on small game, such as rodents, reptiles, and lagomorphs (hares/rabbits/pikas). Ground stone wear is generally light, which suggests minor use of hard seeds. Marine shell beads and non-local lithic materials indicate trade and/or long-distance foraging. Heavily battered cobble tools are often recovered, but the nature of their use is unclear (Sutton et al., 2007: 234-237).

Deadman Lake Complex (ca. 7500 to ca. 5200 B.C)

This complex is a newly proposed complex that has yet to be fully defined and recognized. Thus far, sites from the Deadman Lake Complex are geographically restricted to Twentynine Palms in the southeastern Mojave Desert and appear to overlap with the Paleo-Indian and Pinto complexes (Sutton et al., 2007: 239). Artifact types include small- to medium-size contracting-stemmed or lozenge-shaped points, battered cobbles and core tools, bifaces, flaked tools, and milling equipment. Similar projectile points have been recovered from Ventana Cave in Arizona. Lithic materials include large quantities of coarse- to fine-grained igneous rock and smaller amounts of both local and exotic obsidian. *Olivella* shell beads are present, with both *O. biplicata* from the Pacific coast and *O. dama* from the Sea of Cortez represented.

The Pinto Complex (6000 to 3000 B.C.)

Archaeological deposits dating from the Pinto Period suggest that Pinto settlement patterns consisted of seasonal occupation by small, semi-sedentary groups that were dependent upon a combination of big and small-game hunting and collection strategies, which could include the exploitation of stream or water resources. Typically, sites of this period are found along lakeshores and streams or springs, some of which are now dry, and in upland areas. Larger sites tend to be near well-watered locations, with smaller sites in other areas. In comparison to smaller sites, larger sites exhibit substantial midden deposits and greater variation in artifact types. These larger sites were probably centralized locations from which foraging parties journeyed to seasonal resources (Sutton et al., 2007: 238).

The extent of regional mobility at this time is uncertain. A lack of lithic material diversity might indicate that foraging activities were not as expansive as in the previous complex (Sutton et al., 2007: 238). However, *Olivella* shell beads are still present, which indicates at least some degree of contact with coastal groups.

Material culture representative of this period include roughly formed projectile points, "heavy-keeled" scrapers, choppers, and a greater prevalence of flat millingstones and manos (Warren, 1984: 410-414). Pinto series projectile points appear to have been frequently reworked, suggesting they were used primarily as spear tips and not darts (Sutton et al., 2007: 238).

Faunal assemblages are similar to those of the Lake Mojave Complex, with a slight increase in small fauna taxa coupled with a decrease in artiodactyls (Sutton et al., 2007: 239). The rise of millingstones and manos indicates a more intensive use and processing of plant resources and site placement may have been in part based on access to plant resources. New dates indicate that intensive plant exploitation was occurring by ca. 7000 B.C., which is contemporaneous with coastal California groups (Sutton et al., 2007: 238-239).

At the end of the Middle Holocene, around 3000 B.C., environmental conditions became much drier and hotter, and few sites in the Mojave date to the period between 3000 and 2000 B.C., suggesting that the area may have been largely abandoned during this period of unfavorable climate (Sutton et al., 2007: 241).

Gypsum Complex (ca. 2000 B.C. to A.D. 200)

The Late Holocene was characterized by a wetter and cooler climate than the Middle Holocene. Settlement patterns suggest small, temporary camps concentrated near streams. At the same time, we see more evidence of inter-tribal trade, particularly between the desert and the coast, and increasing social complexity (Sutton et al., 2007: 241). The artifact assemblage associated with this period includes an increase in the prevalence of millingstones and manos, and it is believed that it was during this period that the pestle and mortar were introduced. These technological developments may point to the increased consumption of seeds and mesquite (Warren, 1984: 416). Other artifacts associated with the Gypsum Period include Elko corner-notched series, concave base Humboldt series, and contracting-stemmed Gypsum series projectile points. Ritual activities are indicated by the presence of quartz crystals, paint, and rock art (Sutton et al., 2007: 241). Towards the end of the Gypsum period, there is evidence for the use of the bow and arrow (Warren, 1984: 415). Interestingly, there is a scarcity of Gypsum periods sites in the southern and eastern extent of the Mojave Desert (Sutton et al., 2007: 241).

Rose Spring Complex (ca. A.D. 200 to 1200)

The general cultural pattern for this period is a continuation of that of the preceding Gypsum Period. The increase in cultural complexity continued into this period and the archaeological record attests to established trade routes between desert and coastal populations by way of shell beads and steatite, as well as an introduction of Anasazi influence from the eastern Great Plains as evidenced by the appearance of turquoise and pottery (Warren. 1984: 421-422).

Archaeological sites from this period are more numerous and contain more well-developed middens, indicating an increase in population and a more permanent settlement pattern (Sutton et al., 2007: 241). Additionally, evidence of structures such as wickiups and pit houses also supports more permanent settlements. Sites tend to be located near springs, washes, and lakeshores (Sutton et al., 2007: 241).

Material culture related to this period includes large quantities of obsidian artifacts, Rose Spring and Eastgate series projectile points, knives, drills, pipes, bone awls, millingstones, manos, mortars and pestles, marine shell ornaments, slate pendants, and incised stones (Sutton et al., 2007: 241-242; Warren, 1984). The bow and arrow continued in use.

The Late Prehistoric Period (A.D. 1100 to European Contact)

By the Late Prehistoric period, an extensive network of established trade routes wound their way through the desert, routing quality goods to populations throughout the Mojave Region. It is also believed that these trade routes encouraged or were the motivating factors for "increasingly complex socioeconomic and sociopolitical organization" within Late Prehistoric peoples in Southern California. Housepit village sites are prevalent during this period, as are the presence of Desert series and Cottonwood projectile points, brownware and buffware ceramics, steatite shaft straighteners, painted millingstones, and, to a lesser degree, coastal shell beads. By the end of this period, however, a decline in trade occurred and well-established village sites were abandoned, perhaps as a result of rising temperatures (known as the Medieval Climatic Anomaly) (Sutton et al., 2007: 242; Warren, 1984: 424-428).

Ethnographic Setting

Mojave oral tradition, supported by archaeological evidence, suggests that the Yuman-speaking Mojave Indians were also among the earliest residents in the Mojave Desert. They moved from the area approximately 500 years ago to the Colorado River where they were documented by Father Francisco Garcés, a Spanish explorer, in 1776. Another Spanish explorer, Juan de Onate, may have observed this group as early as 1604 based on his descriptions of the "Mojave" people along the Colorado River (Kroeber 1925:3).

However, at the time of European contact the Project area was occupied by the ethnohistoric Desert Chemehuevi group of the Southern Paiute. This group comprised the Southern Numic portion of the Uto-Aztecan language family (Kroeber 1925:593). The Chemehuevi inhabited the area between Needles, Blythe, Twentynine Palms, and the Colorado River, which contained the primary settlements. However, the Project is located in an area that was utilized for seasonal resource exploitation or for specific resources, such as salt.

The oral tradition of the Chemehuevi suggests that they migrated from the north and engaged the Mojave group in a long war that drove the Mojave east to the Colorado River (Kroeber 1925:3). Archaeological evidence indicates that the war ended between 250 and 500 years ago (King and Casebier 1976:17-18)

The harsh desert environment typical of the Project area could support only the smallest groups comprised of nuclear families joined by kinship ties. These small hunter-gatherer groups moved in response to local food and water availability, typically seasonally or more frequently. The lack of resources of the area created a very diverse hunting economy where small game were important protein sources. Pronghorn sheep, mountain sheep, deer, rabbits, squirrels, desert chipmunks, and wood rats were important mammals in the local diet along with reptiles, such as desert tortoises, snakes, and lizards, and birds, eggs and insects. Agriculture was introduced to the Chemehuevi by their eastern neighbors and they cultivated crops of various types of maize and corn, squash, gourds, wheat, and potatoes along the Colorado River (Kelly and Fowler 1986:371).

The Chemehuevi utilized the paddle-and-anvil technique for their pottery, which included cooking pots, storage jars, spoons, scoops, and large vessels (Kelly and Fowler 1986:377). They also utilized twining techniques for their basketry, which were used for transporting items, winnowing and parching, seed beating, boiling water, and storage. Other artifacts associated with the Chemehuevi included the mano and millingstone (metate), mortar and pestle, digging sticks, and the sinew-backed bow with arrows of cane or willow. In addition to locally consumed trade goods, the Chemehuevi acted as "middle-men" in the long distance trade networks from groups to the west and the Pacific Coast and the Central Valley to the groups in the Southwest and along the Colorado River.

Following the Civil War, the traditional Native subsistence base was threatened by the influx of settlers and accompanying livestock. With these resources unavailable, the Chemehuevi were employed on ranches, building railroads, and in the newly opened mines.

The Chemehuevi were divided into two moieties (kinship group) represented by two songs, the Mountain Sheep Song and the Deer Song, which were each associated with different hunting areas. They generally lived in bands of two or three families, each band having a leader. The Chemehuevi were occupying the oasis of Mara (Twentynine Palms) when permanent settlement of the area by Europeans and Americans began. Livestock depleted natural resources and Euro-American settlers began to claim large pieces of land and water rights. In 1890, 160 acres were set aside for a reservation for the Chemehuevi. In 1910, 640 acres adjacent to the existing Cabazon reservation in Coachella was given jointly to the Cahuilla and the Chemehuevi, and those who remained on the Twentynine Palms reservation were encouraged to move there. Some went, some stayed, and others chose to settle elsewhere in California (Bean and Vane, 2002).

Historic Setting

Several major trails crossed the Mojave before and at the time of Spanish contact, and continued to be used not only by the native peoples but by Euro-American explorers as well. The Yuma-Needles Trail ran from south of Yuma up the western side of the Colorado River to the Needles area. The Mojave Trail ran from Needles west across the desert to the coast. The Cocomaricopa Trail ran from Arizona through the Salton Sink and then northwest to meet the Mojave Trail near San Bernardino (Greene, 1983:11).

The first Europeans known to have visited the Mojave were Pedro Fages in 1772 and Juan Bautista de Anza and Father Francisco Garcés in 1774 (Greene, 1983:4). In 1775, Father Garcés separated from de Anza and crossed the Mojave along the ancient Mojave Trail from Needles west to the San Gabriel Mission.

The Spanish missions that dotted the California coast never spread inland to the Mojave, and the desert remained relatively unexplored and unsettled by Europeans for much of the next century. The Romero-Estudillo Expedition of 1823-24 was an attempt by the Spanish to establish a secure route between the California Coast and Tucson; however, despite two attempts, the expedition never managed to make it as far as the Colorado River (Greene, 1983:6).

The first recorded American visitors to the Mojave were the party of Jedediah Smith, who crossed the Mojave along the Mojave Trail in 1826. Ewing Young and Kit Carson followed his route in the 1820s and 1830s. Several American and Mexican military expeditions were conducted in the 1840s and 1850s. American involvement in the region was limited during the early 19th century, but certain figures and events made lasting impressions on the landscape. In the 1850s, Pauline Weaver, a cattleman, trapper, and guide, created a private thoroughfare through the Morongo Basin by which he herded cattle from the Cajon Pass to Arizona (Greene, 1983:18).

California became an American state in 1850. However, little settlement occurred near the Project area during the American period due to the lack of water and other resources. What settlement did occur was related to mining or the railroads.

Railroads

In the 1850s, after California achieved statehood, numerous railroad surveys were conducted in the Mojave (Greene, 1983:19). The California Southern Railroad Company, which was organized in 1880 and became a subsidiary of the Atchison, Topeka, & Santa Fe (ATSF) Railway in 1884, constructed a line from Cadiz, California, to Matthie, Arizona in 1910. On July 1, 1910 the 83-mile ATSF Parker Cutoff, as this line was known, was completed (Myrick 1963:792). In 1916, due to the need for a rail line in closer proximity to mining sites north of Blythe, they began constructing a railroad from Rice to Blythe. A spur track was laid from Rice to Ripley in 1920, with operations beginning the next year. The Cadiz to Matthie line was purchased by the ARZC in 1991 (Anon., 2008:13).

The network of railroads throughout the desert created new travel corridors. Wagon trains and later automobile roads tended to parallel railroad lines, in order to take advantage of the regularly spaced watering stations and railroad maintenance crew camps (Warren et al., 1981:90).

Mining

In 1848 gold was discovered by James W. Marshall at Coloma, some 400 miles to the north on the American River. The gold rush began and immigrants flooded into California. Investors began seeking the construction of a transcontinental railroad to facilitate transportation to the gold-rich region. The discovery of the Comstock Lode in Nevada in 1859 shifted attention from gold to silver, and miners began to focus on the desert regions (Vredenburgh, 2005). Some of the early exploration and settlement near the survey area was related to mining prospects.

The 1880s were fairly prosperous for mining in the Mojave Desert, and operations at that time were dominated by gold mining. In the 20th century, mining operations were beginning to bring out borax, zinc, and silver and they began to rework old deposits in the 1910s. Productivity fell off in the 1920s due to increased inflation, but was revived during the Great Depression and accelerated in the early 1940s to meet war-time demands. By 1956, the declining gold prices caused most small gold operations to close (Vredenburgh et al., 1981: 127-132). The Old Woman Mountains, to the east and north of the Project area, were the site of the primary mining and prospecting efforts in the vicinity. Several mines and mining settlements were set up in the area, and in the early 20th century ATSF Parker Cutoff serviced many of these locations, including Cadiz, Chubbuck, Milligan, Fishel, and Freda (Vredenburgh et al., 1981: 127-132). All of these settlements are within or adjacent to the Project area.

Mining and Railroad Settlements

During the early 20th century, a number of railroad siding camps and mining settlements sprung up along the railroad route. Those within the Project area include Siam, Cadiz, McCoy, Archer, Chubbuck, Kilbeck, Fishel, Milligan, Saltmarsh, and Sablon. These camps or small settlements, often located where railroad sidings occurred, primarily provided a place for people involved in local mining activities or the operation of the ATSF Parker Cutoff to live. In general, these settlements remained inhabited until about mid-20th century when they were abandoned. The abandonment was most likely related to the switch from steam-powered engines to the use of diesel fuel, because of which the regularly spaced water supply points at the sidings were no longer necessary.

Historic maps document the inception of these settlements along the railroad corridor in the early 20th century. The "Relief Map of Part of Mohave Desert Region, California (Showing Desert Watering Places)," surveyed by Thompson in 1917-1918, shows the completed ATSF Railroad, the Parker Cutoff ("Parker-Phoenix Branch"), and paralleling roads. The settlements or sidings of Siam and Cadiz are shown on the map in the wellfield portion of the Project area. The settlements or sidings of McCoy, Archer, Kilbeck, Fishel, Milligan, Ward (Saltmarsh?), and Sablon are depicted in the pipeline portion of the Project area. The settlement of Arica (Freda?) is shown but is located just southeast of the pipeline portion of the Project area. The 1925 "Map of San Bernardino County, California Showing Roads, Railroads, Springs, and Mining Districts of the Desert Portion" by J. Kremmerer shows the ATSF Railroad, including the Parker Cutoff, parallel roads, and the same settlements as the earlier map. The CRA, ATSF Railroad (including the Parker Cutoff), and the settlements of Cadiz, Archer, Fishel, Milligan, Saltmarsh, Sablon, and Freda are shown on the 1943 US Army 15' Milligan and 1944 US Army 15' Rice quadrangles, as well as the 1956 USGS 15' quadrangles (Cadiz:, Cadiz Lake; Iron Mountain; and Milligan). The 1954 USGS 15' Rice quadrangle map shows rail sidings at Archer, Fishel, Milligan, Sablon and Saltmarsh.

Historical information was available for Siam, Cadiz, Archer, Chubbuck, Milligan, and Sablon and these six locations are discussed in more detail below. No information could be obtained for McCoy, Kilbeck, Fishel, or Saltmarsh and these locations are not covered below.

Siam

Very little is known about Siam, other than that it was a railroad siding established in 1897 on the ATSF main line between Old Danby and Cadiz. No settlement is known to have been established at Siam and it may never have been more than a watering stop. It is unknown when Siam was abandoned and no structural remains or foundations are extant at Siam (de Kehoe, 2007: 83).

Cadiz

Cadiz was first named by an engineer for the Atlantic and Pacific Railroad in 1883 (Gudde 1969: 9, 45). Originally, Cadiz was a siding with four section houses built by the Southern Pacific (de Kehoe, 2007: 44). Cadiz rose in prominence when the ATSF Parker Cutoff was connected to the main track at Cadiz on July 1, 1910. Prior to that time, water was imported from Newberry Spring. In August 1910, a well was drilled at Cadiz. Tamarisk trees, planted on either side of the tracks, served as a windbreak and helped control drifting sand (de Kehoe, 2007: 51).

The population of Cadiz was never large, but at least at one point included 50 residents (de Kehoe, 2007: 45). Residents consisted of railroad workers and their families.

In the 1940s and 1950s, Frank McConnell served as the Santa Fe telegrapher and depot agent at Cadiz. Trains passing through would have a three hour layover in Cadiz. No tourist facilities were available, so Mr. McConnell sold candy bars and bottled soda from an ice chest at the depot (de Kehoe, 2007: 49-51).

The depot at Cadiz was an important stop for the Santa Fe railroad until the 1950s. Almost all trains stopped to refuel or take on water, and all freight trains were inspected at Cadiz. It was closed in 1967 (de Kehoe, 2007: 44).

Archer

Archer was a small siding located about 10 miles southeast of Cadiz on the ATSF Parker Cutoff. The site served as a watering station for steam locomotives on the line and was probably first occupied when the water well was drilled in 1910 (de Kehoe, 2007: 98). When the railroad switched to diesel locomotives in the 1950s, the site was abandoned (de Kehoe, 2007: 96). The community was comprised primarily of Mexican laborers and their families, but never included more than about 20 people at any given point in time (de Kehoe, 2007: 96-97).

Chubbuck

Chubbuck was established in the early to mid-1920s as a mining settlement, about one mile south of the Kilbeck siding, though it was initially used as a railroad siding as early as 1911 (Applied Earthworks, Inc.,1999: 43). However, Chubbuck was not a railroad settlement and was unique among settlements along the ATSF Parker Cutoff in that it primarily housed mine workers and their families (de Kehoe, 2007: 109). Charles Inglis Chubbuck, manufacturer of products used in cement and masonry, purchased a 1600-acre mining claim from Marcus Pluth and Tom Schofield in 1922. The claim contained a white limestone outcrop, perfect for cement manufacture. The claim was located about one-half mile west of the ATSF Parker Cutoff, facilitating shipment to market. Mr. Chubbuck built the primary crusher at the limestone quarry and kilns adjacent to the

railroad tracks. The crushed ore was transported to the kilns via a narrow gauge railroad. Ore carts were pushed back and forth by hand (de Kehoe, 2007: 111-115). Lime from Chubbuck was used in the construction of the CRA ca. 1937 to 1938 (Vredenburgh, 1981).

Over 40 buildings were located at Chubbuck, including a company store, school (1932), post office (1938), and residential structures. The company store reportedly sold great quantities of Eastside Beer, manufactured and distributed by the Los Angeles Brewing Company (Vredenburgh, 1981; Rustycans.com, 2005). Occupants at Chubbuck were primarily Mexican laborers and their families. The mill ceased operation in 1951 and the railroad siding at Chubbuck was removed from 1975 to 1976 when the ATSF Parker Cutoff was re-laid (Vredenburgh, 1981).

Milligan

Like the other sidings, Milligan was established in 1910 when the ATSF Parker Cutoff was constructed. A well was drilled in 1910, with water being pumped up to a tank located 16 feet above ground. Milligan included several section houses, a foreman's house, a bunkhouse for workers, and a cemetery. A line of tamarisk trees was planted adjacent to the tracks as a windbreak and for shade. The trees were surrounded by concrete and cobble water catchments. Milligan was abandoned around 1955 (de Kehoe, 2007: 175-176).

Sablon

Sablon was established on the ATSF Parker Cutoff in 1909. At that time, the station was called Randolph. The name was changed to Sablon, which means 'gravel' in Spanish, in 1912 (Gudde, 1969: 275).

Colorado River Aqueduct

The CRA was constructed in the 1930s by the Metropolitan Water District of Southern California in order to transport water from the Colorado River to the Los Angeles metropolitan area. The aqueduct stretches from Lake Havasu on the Colorado River to Lake Matthews, south of Riverside (Neves and Goodman, 2000). Construction of the aqueduct began in 1933 and the first delivery of water occurred in 1941. Approximately 3,500 men and women were employed constructing the CRA during the Depression era. The completed aqueduct crosses 242 miles of desert and delivers approximately one billion gallons of water a day. Related projects included roads and electrical power transmission lines. Most project-related work was conducted out of temporary camps; however, permanent structures, such as the Iron Mountain pumping station, supported a higher number of longer-lasting settlements. The CRA is still in use.

Desert Training Center – California-Arizona Maneuver Area (DTC-CAMA)

In 1942, General George S. Patton, Jr., and the US Army created the Desert Training Center, later called the California-Arizona Maneuver Area (DTC-CAMA), which encompassed over 30,000 square miles of California, Arizona, and Nevada, as a training ground for military personnel who would be fighting overseas. Originally intended as a training ground that would simulate the harsh conditions of the North African deserts, the training center was operational for two years. At the height of its two-year period of operation in July, 1943, over 190,000 armed

forces personnel were stationed within the DTC-CAMA (Bischoff, 2000:30). Fourteen divisional camps, along with airfields, bivouacs, hospitals, and numerous other supporting facilities were constructed during the DTC-CAMA's two-year period of operation. Much of the land outside of the camps was used as maneuver areas for training exercises; evidence of these exercises, such as foxholes, tank tracks, debris scatters, and aircraft landing strips, can still be found. In April, 1944, the Desert Training Center was closed and land returned to private use. The area was again used for military training in the 1960s for "Operation Desert Strike."

Because of certain logistical considerations, such as the need for electricity, water, and transportation routes, the operation of the DTC-CAMA resulted in some improvements in infrastructure in the remote desert. The need for a route leading from Twentynine Palms to Parker Dam resulted in the creation of what is now Highway 62, although the road was not completely paved until 1959 (Bischoff, 2000:22).

Camp Iron Mountain was located at the CRA pumping station and was the closest base camp to the Project area. The ATSF, including the ATSF Parker Cutoff, were instrumental in supplying goods and equipment for the training center (Applied Earthworks, Inc., 1999:55).

Methodology and Results

Archival Research

A Project-specific cultural resources literature and records search was conducted at the California Historical Resources Information System (CHRIS) San Bernardino Archaeological Information Center (SBAIC) on September 22, 2010. The records search study area included the wellfield and pipeline portions of the proposed Project plus a half-mile buffer. The records search provided a summary of previous cultural resources surveys and reports and known cultural resources in the Project area and half-mile buffer. Other sources reviewed include the California Points of Historical Interest (PHI), the California Historical Landmarks (CHL), the California Register of Historical Resources (CRHR), the National Register of Historic Places (NRHP), the California State Historic Resources Inventory (HRI), and historic maps.

Previous Cultural Resources Investigations

The records search revealed that a total of 22 cultural resources investigations were previously conducted within the records search study area (**Table 2**). Of these 22 previous investigations, 14 involved surveys covering approximately 10 to 20 percent of the wellfield portion of the Project area and less than 10 percent of the pipeline portion of the Project area. The remaining eight investigations were identified by the SBAIC as pertaining to the Project area, but did not involve surveys of any portion of the Project area.

TABLE 2
PREVIOUS CULTURAL RESOURCES INVESTIGATIONS CONDUCTED WITHIN 0.5 MILE OF THE PROJECT AREA

Author	Report # (106-)	Title/Description	Date	Project Component
Bureau of Land Management	**0558	Environmental Assessment Record for Interim Critical Management, Program Area No. 37, Cadiz Valley/Danby Lake.	1977	Pipeline
Barker, James P., Carol H. Rector, and Philip J. Wilke	**0874	An Archaeological Sampling of the Proposed Allen-Warner Valley Energy System, Western Transmission Line Corridors, Mojave Desert, Los Angeles and San Bernardino Counties, California and Clark County, Nevada.	1979	Wellfield
Leonard, Joanne C.	**1092	A Cultural Resources Evaluation of Eight Proposed Earth and Gravel Borrow Sites, San Bernardino County, California.	1981	Pipeline
Taylor, Thomas T. and David R.M. White	**1418	Archaeological Survey of the Solar Salt Pond Project Facilities, Danby Dry Lake, San Bernardino County, California.	1983	Pipeline
Weil, Edward B., Jill Weisbord, and E.R. Blakley	**1449	Cultural Resources Literature Search, Records Check and Sample Field Survey for the California Portion of the Celeron/All American Pipeline Project.	1984	Wellfield and Pipeline
Lerch, Michael K.	**1548	Class II Archaeological Survey of Eighteen Sections of Land Near Cadiz, San Bernardino, California	1986	Wellfield and Pipeline
New Mexico State University	**1979	Cultural Resources Report for the All American Pipeline Project: Santa Barbara, California to McCamey, Texas and Additional Areas to the East Along the Central Pipeline Route in Texas.	1989	Well filed and Pipeline
Westec Services, Inc.	**2255	Class II Cultural Resource Inventory: Turtle Mountains, Bristol/Cadiz, Palen Planning Units.	1973	Wellfield and Pipeline
Buffington, Kevin and Michael Macko	**3298	A Class III Intensive Survey for Cadiz Land Company's Seismic Reflection Survey Line in Cadiz Valley, San Bernardino County, CA.	1995	Wellfield
Horne, Melinda, Colleen Hamilton, and Michael Rodarte	**3840	Cultural Resources Survey for the Cadiz Groundwater Survey for the Cadiz Groundwater Storage and Dry-Year Supply Program, San Bernardino County, CA.	1999	Wellfield and Pipeline
Duke, Curt	**3894	Cultural Resource Assessment for the PBMS Facility CM 660-01, County of San Bernardino, CA.	1999	Wellfield
Underwood, Jackson	**5636	Cultural Resources Survey of the Cadiz Lateral/Interconnect, A Potential Future Facility of the Line 1903 Project, San Bernardino County, California	2004	Wellfield and Pipeline
Underwood, Jackson and Carrie Gregory	**5637	Cultural Resources Evaluation of the Cadiz Lateral, Line 1903 Project: CA-SBR-11,582H (a 1964 Military Camp at Cadiz) and a Segment of CA-SBR-2910H, the National Old Trails Highway, San Bernardino County, California	2004	Wellfield
Higgins, Howard C., Deann Muller, David M. Smith, and Christopher E. Drover	**6518	A Class III Cultural Resources Inventory for 10 Proposed Microwave Tower Sites, County of San Bernardino, California	2005	Wellfield
King, Chester and Dennis G. Casebier	0290	Background to Historic and Prehistoric Resources of the East Mojave Desert Region. Bureau of Land Management, Riverside, CA.	1976	Overview Report

Author	Report # (106-)	Title/Description	Date	Project Component
King, Chester	0291	Part 1: Background to Prehistoric Resources of the East Mojave Desert Region. In *Background to Historic and Prehistoric Resources of the East Mojave Desert Region*. Bureau of Land Management, Riverside, CA.	1976	Overview Report
Casebier, Dennis G.	0292	Part 2: Historical Sketch of the East Mojave Planning Unit. In *Background to Historic and Prehistoric Resources of the East Mojave Desert Region*. Bureau of Land Management, Riverside, CA.	1976	Overview Report
Gallegos, Dennis, Emma Lou Davis, Gary Lowe, Frank Norris, and Jay Thesken	0892	Cultural Resources Inventory of the Central Mojave and Colorado Desert Regions, California. Bureau of Land Management, Riverside, CA.	1980	Overview Report
Warren, Elizabeth Von Till, Robert H. Crabtree, Claude N. Warren, Martha Knack, and Richard McCarthy	1069	A Cultural Resources Overview of the Colorado Desert Planning Units. Bureau of Land Management, Riverside, CA.	1981	Overview Report
Jenkins, Richard Charles	2017	A Study of Aboriginal Land Use: Southern Paiute Subsistence in the Eastern Mojave Desert. M.A. Thesis, UC Riverside.	1982	Overview Report
Ludwig, Verle E.	2256	US Marines at Twentynine Palms, California. US Marine Corps, Washington, DC.	1989	Overview Report
Hanks, Herrick E. (ed.)	2555	East Mojave Planning Unit Resource Analysis: Cultural Resources. Bureau of Land Management	1976	Overview Report

**Indicates investigation covering a portion of the Project Area
SOURCE: SBAIC, 2010

Previously Recorded Resources

The records search indicated that 50 cultural resources have been previously recorded within the records search study area (**Table 3**). The 50 resources include eight prehistoric archaeological sites, 26 historic-era archaeological sites, one multi-component archaeological site with both prehistoric and historic-era elements, nine historic-era built architectural/engineering resources, and six isolated artifacts.

Of the 50 previously recorded cultural resources, 16 are located within the wellfield portion of the Project area (CA-SBR-3243, -3281H, -693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-020149, -060315, -060319, -060922, and -064132).

Fifteen previously recorded cultural resources are located within the pipeline portion of the Project area (CA-SBR-3233H, -3235H, -3282H, -3283H, -5606/H, -5819H, -9849H, -9850H, -9851H, -9853H, -9856H, -9858H, -10521H, -10646H, and -11583H). Three previously recorded cultural resources are located immediately adjacent to the pipeline portion of the Project area (CA-SBR-9852, -10525H, and -10645H).

Portions of resources CA-SBR-9853H and CA-SBR-11583H overlap both the wellfield and pipeline portions of the Project area. All sites within the actual Project areas are described below.

TABLE 3
PREVIOUSLY RECORDED CULTURAL RESOURCES WITHIN 0.5 MILE OF THE PROJECT AREA

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
003233	**3233H	TU-219(11)	"Milligan" RR section camp remains; concrete debris, low rock wall, and introduced vegetation	9-20-78	No	Pipeline
003235	**3235H	TU-222(14)	"Saltmarsh"- Wooden and brick structural remains & debris alongside ATSF tracks	9-21-78	No	Pipeline
003243	**3243	BC-6	Lithic scatter- primarily chert and chalcedony cores	8-10-78	No	Wellfield
003254	3254	BC-17	Lithic scatter- small workshop area; chert debitage	9-19-78	No	Pipeline
003280	3280H	BC-219(7)	"Cadiz" RR section camp- east portion including modern buildings and 1920s-era stucco row houses	9-20-78	No	Wellfield
003281	**3281H	BC-220(8)	"Cadiz" RR section camp- west portion including wood frame buildings ca. 1920s	9-20-78	No	Wellfield
003282	**3282H	BC-221(9)	"Archer" RR section camp remains (concrete foundation, debris) and cemetery	9-20-78	Yes - Eligible for NRHP	Pipeline
003283	**3283H	BC-222(10)	"Chubbuck" mill and settlement; Desert Butte Mine District. Extant structures and widely scattered debris	9-20-78; updated 4-22-99 and 2-27-2001	Yes-Eligible for NRHP under Criteria A and D	Pipeline
005472	5472H	Navajo #1	Dugout depression with wooden timbers, fire-cracked rock in arroyo; described as remnant Navajo sweathouse	11-27-85	No	Wellfield
005606	**5606/H	-	Lithic (flaked- and ground-stone tools; debitage) and historic (metal can) scatter	3-16-77 thru 4-19-77; updated 3-5-01	No	Pipeline
005815	5815	AAP 039-001/IO-AAP 039-002	Rock ring with flaked- and ground-stone artifacts; not relocated during update	11-21-85; updated 2-28-01	No	Wellfield
005816	5816	AAP 043-001	Lithic scatter with flaked-stone tools and debitage; groundstone tools & fragments	10-30-85; updated 2-28-01	No	Pipeline
005817	5817H	AAP 043-002/IO-AAp 043-002	Historic debris scatter; 100% collected in AAP right-of-way; no cultural materials found during update	11-20-85; updated 2-28-01	No	Pipeline
005819	**5819H	AAP 045-001/IO-AAP 045-003	Historic debris scatter (metal, glass, porcelain); 100% collected	11-20-85	No	Pipeline
006693	**6693H	-	ATSF RR- determined eligible to NRHP under Criterion A, 3-31-94	5-30-90; numerous updates	Yes - Eligible for NRHP under Criterion A	Wellfield

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
006694	**6694H	HS-10 (ML-12)	Historic unpaved road and telephone pole line	5-30-90	Yes - Not eligible for NRHP	Wellfield
009848	**9848	AE-CAD-1	Lithic scatter- small workshop area; agate chert debitage	4-8-99	Yes - Not significant	Wellfield
009849	**9849H	AE-CAD-2H	Historic debris scatter (glass, metal, ceramics, buttons)	4-14-99	Yes - Not significant	Pipeline
009850	**9850H	AE-CAD-3H	Historic debris scatter (glass, metal, crockery, buttons, insulated wire, burned faunal bone)	4-14-99	Yes - Not significant	Pipeline
009851	**9851H	AE-CAD-4H	Historic debris scatter (whiteware, glass, metal)	4-15-99	Yes - Not significant	Pipeline
009852	*9852	AE-CAD-5	Lithic scatter- debitage and tools of obsidian, chert, chalcedony	4-27-99	Yes - Not significant	Pipeline
009853	**9853H	AE-CAD-6H	ATSF RR – Parker Cutoff	5-7-99	Yes- Eligible for NRHP under Criteria A and possibly C	Wellfield and Pipeline
009855	**9855H	AE-CAD-8H	Rectangular rock alignment-possible grave	5-12-99	No	Wellfield
009856	**9856H	AE-CAD-11H	Historic debris scatter, rectangular arrangement of four wooden posts	4-13-99	No	Pipeline
009857	9857H	AE-CAD-12H	Two small mine prospects with wooden posts and tailings	4-27-99; updated 3-1-01	No	Pipeline
009858	**9858H	AE-CAD-13H	WWII Tank Corps desert training site- historic camp and debris scatter (part of CHL 985)	4-28 and 5-3, 1999	Yes- eligible for NRHP under Criteria A, C and D	Pipeline
010521	**10521H	FS 51a, b, c, d	Colorado River Aqueduct	4-13-00	Yes - Eligible for NRHP under Criteria A, B, and C	Pipeline
010525	*10525H	-	Historic road – State Route 62	9-15-00	Yes - Not eligible for NRHP	Pipeline
010644	10644H	DB-S-JD-7	Historic debris scatter, possible WWII training camp (part of CHL 985)	2-28-01	Yes – Not eligible for NRHP	Wellfield
010645	*10645H	DB-S-JD-8	Historic debris scatter, possible WWII training camp (part of CHL 985)	3-1-01	Yes – Not eligible for NRHP	Pipeline
010646	**10646H	DB-S-JD-9	“Sablon,” RR siding and debris scatter	3-6-01	No	Pipeline
010647	10647H	DB-S-JD-10	Historic can scatter	3-6-01	No	Pipeline
010653	10653H	DB-S-SR-6	Historic road segments	2-27-01	No	Wellfield
010654	10654H	DB-S-SR-7	Historic can scatter	2-27-01	No	Wellfield
010655	10655H	DB-S-SR-8	Historic can scatter	3-1-01	No	Pipeline

Primary Number (P-36-)	Permanent Trinomial (CA-SBR-)	Other Designation	Description	Date Recorded	Previously Evaluated for Significance?	Project Component
010656	10656H	DB-S-SR-9	Historic debris scatter (metal, glass, ceramics, buttons)	3-1-01	No	Pipeline
010657	10657H	DB-S-SR-10	Historic debris scatter (metal, glass, window screen)	3-7-10	No	Pipeline
011582	**11582H	Camp Cadiz	Desert Strike camp, ca. 1964 (rock alignments and clusters, debris dumps)	1-22-04; updated 11-2-04	Yes - Potentially eligible for NRHP	Wellfield
011583	**11583H	AAPL-Cadiz 2	Cadiz-Parker Road	1-22-04	No	Wellfield and Pipeline
011584	**11584H	AAPL-Cadiz 3	Cadiz-Cadiz Pass Road	1-22-04	No	Wellfield
011586	**11586H	AAPL-Cadiz 5	Dirt road	1-22-04	No	Wellfield
019895	13232	ASM-MDR-22-01	Lithic scatter- small workshop area; rhyolite core and debitage	1-3-09	No	Wellfield
019896	13233	ASM-MDR-22-02	Lithic scatter- small workshop area; rhyolite debitage	1-3-09	No	Wellfield
**020149	-	AAPL-Cadiz Iso 1	Historic isolate- half a mule shoe	1-22-04	Yes - Not significant	Wellfield
021094	13618H	JB-47	Phone line remnants and associated access road	5-6-09	No	Wellfield
**060315	-	BC-7	Prehistoric isolate- bifacial chopper	8-10-78	Yes - Not significant	Wellfield
**060319	-	Isolated Artifact #4	Prehistoric isolate- scraper	n.d.	Yes - Not significant	Wellfield
**060922	-	SBCM #358	Prehistoric isolate- scoop-style metate	1-12-63	Yes - Not significant	Wellfield
**064132	-	AE-CAD-ISO-2	Prehistoric isolate- pointed unifacial tool	5-11-99	Yes - Not significant	Wellfield
064414	-	DB-I-JD-4	Prehistoric isolate- single waste flake	2-28-01	Yes - Not significant	Wellfield

**Indicates cultural resource recorded within Project area
*Indicates cultural resource recorded adjacent to the Project area
SOURCE: SBAIC, 2010

Previously Recorded Cultural Resources Within or Adjacent to Wellfield Project Area

Site CA-SBR-3243* is a prehistoric lithic scatter recorded in 1978. The artifact assemblage is described as numerous cores of chert and chalcedony, some expended, with one associated piece of debitage. These materials are sparsely scattered over a large area of deflated dunes, and show heavy patination (Echkardt, 1978a). This site does not appear to have been previously evaluated for its significance (Applied Earthworks, Inc., 1999: Table 1).

Site CA-SBR-3281H ** is the western portion of the railroad siding camp of "Cadiz." This site, recorded in 1978, includes several wood-framed buildings, a well and water tower, an electrical distribution station, and a spur of railroad track used for storage of "maintenance of way" cars.

Debris was also present at the time of recordation, but the material type(s) are listed as "unknown." The camp of Cadiz was supposedly founded as early as 1883; however, site recorders noted that none of the buildings or structures appeared to pre-date the 1920s (Crowley, 1978a). This site does not appear to have been previously evaluated for its significance (Applied Earthworks, Inc., 1999: Table 1).

Site CA-SBR-6693H** is a railroad line (Mojave to Needles branch) originally constructed in 1883 by the Southern Pacific Railroad Company and leased to the Atlantic & Pacific Railroad Company, a subsidiary of the Santa Fe Pacific Railroad. The branch line later became known as the ATSF Railway. A second parallel track was added in 1923. The line is now operated by the Burlington Northern Santa Fe Railway (BNSF) (Erickson, 2008). This linear historic resource was first recorded in 1990 (Glover et al., 1990) and has been updated several times. In 1994, this resource was determined eligible for listing in the NRHP under Criterion A, for its association with the history of transportation in California. Although the tracks have been upgraded and maintained for continued use, the railroad's route has remained the same and the resource was found to have retained integrity of location, design, setting, material, and association (Applied Earthworks, Inc., 1999: Table 1; Erickson, 2008).

Site CA-SBR-6694H** is a segment of a historic road and an associated telephone pole line. It was recorded in 1990 as the "Old Road to Cadiz," the original automobile route through the area dating from at least as early as 1914 (Lerch, 1990). The telephone poles along the line provided service to the eastern Mojave Desert until 1989. No wires remained on the poles at the time of recordation 1n 1990. This resource was recommended not eligible for the NRHP (Lerch, 1990).

Site CA-SBR-9848** is a small prehistoric lithic scatter recorded in 1999 (Inoway et al., 1999a). The site contains 10 flakes of gray-and-white banded agate chert from a single toolmaking episode. This site was determined not to be a significant resource (Applied Earthworks, Inc., 1999: Table 2).

Site CA-SBR-9853H** is the ATSF Parker Cutoff railroad line and associated trestles and culverts. This resource extends from the wellfield Project area along the same alignment as the pipeline Project area. According to the site record, the ATSF Parker Cutoff to Cadiz was constructed in 1910, although trestles along the alignment bear later dates. The rails were replaced as late as 1975-1976 (Applied Earthworks 1999:55). The tracks were still in use when the line was recorded in 1999 (Easter et al., 1999). Applied Earthworks, Inc. (1999: 55) determined that CA-SBR-9853H was eligible for listing in the NRHP under Criteria A and possibly C for its historical association with transportation and railroads. Although the tracks have been upgraded and maintained for continued use, the railroad's route has remained the same and the resource was found to have retained integrity of location, setting, feeling, and association.

Site CA-SBR-9855H** is a rectangular rock alignment outlining an area approximately 185 centimeters by 65 centimeters. It is believed to represent a historic grave; however, when the resource was recorded in 1999, no confirmation of this supposition was available (Inoway and Paniagua, 1999a). No artifacts were found in association with the alignment. The rectangle lies parallel to the ATSF Railroad tracks, suggesting it may be associated with the railroad. This

resource does not appear to have been previously evaluated for its significance (Applied Earthworks, Inc., 1999: Table 1).

Site CA-SBR-11582H** has been identified as a military camp associated with the Joint Exercise Desert Strike training scenario conducted in 1964. Originally recorded in January 2004, the site was updated and the boundaries expanded in November 2004 (Underwood, 2004a). The later recorders conducted substantial archival research in to the Joint Exercise Desert Strike and were able to identify features and artifacts with precision. Features include 22 rock alignments (including roads identified as Tent Rows 1-5), rock clusters, mounds, and pits, as well as a single remaining 7-foot-tall communications pole. Eight can scatters and one glass scatter were recorded in various locations around the camp, with the glass scatter containing fragments that pre-date the Desert Strike training exercise. Machine guns cartridges (blanks), wire, automobile fragments, various hardware and personal grooming implements, and modern intrusive camp hearths were also noted. Underwood (2004b: 29) suggested that this resource be considered eligible for listing in the NRHP until formally evaluated.

Site CA-SBR-11583H** is the historic Old Cadiz-Parker Road. The recorded section of the formerly graded road extends between the two railroad siding camps of Cadiz and Rice (Underwood, 2004c). Upon recording in 2004, the road had deteriorated in parts to a narrow two-track. A road following approximately the same alignment is shown on the 1896 "Parris Miners Map of the Desert Region of Southern California;" however, this road could also be associated with construction of the ATSF Parker Cutoff, completed in 1910. This resource was determined to lack integrity, but was not formally evaluated for its eligibility for listing in the NRHP or CRHR (Underwood, 2004b: 29).

Site CA-SBR-11584H** is the historic Cadiz-Cadiz Pass Road. The road connects the railroad siding camp of Cadiz with Cadiz Summit, which lies to the northeast on Route 66, across the Marble Mountains. When recorded in 2004, it was noted that the rough 10-foot-wide road had been graded, but not recently (Underwood, 2004d). This resource was determined to lack integrity, but was not formally evaluated for its eligibility for listing in the NRHP or CRHR (Underwood, 2004b: 29).

Site CA-SBR-11586H** is an unnamed historic road that extends in a general southwest-northeast direction from Amboy Road, along the southern shore of Bristol Lake, across the Cadiz Valley, and south of the Marble Mountains to intersect with Route 66 in the vicinity of Danby Road. The 2004 recorders noted that the road had been graded, but not recently (Underwood, 2004e). This resource was determined to lack integrity, but was not formally evaluated for its eligibility for listing in the NRHP or CRHR (Underwood, 2004b: 29).

Isolate P-36-020149** is a historic isolate consisting of one-half of a mule shoe or small horse shoe. This artifact was identified in 2004 within a two-track portion of the Old Cadiz Road (Underwood and Hillard, 2004). Isolates are not considered significant resources and are not eligible for inclusion in the NRHP or CRHR.

Isolate P-36-060315** is a prehistoric isolated artifact consisting of a chopping tool. The heavily patinated bifacial tool is made of a red-and-white cryptocrystalline material, and was identified in

1978 on a deflated desert pavement surface (Eckhardt, 1978b). Isolates are not considered significant resources and are not eligible for inclusion in the NRHP or CRHR.

Isolate P-36-060319** is an isolated prehistoric artifact. The 4-cm scraper or cutting tool was identified as a unifacially modified chalcedony flake tool (Anon., n.d.). The recording date is unknown. Isolates are not considered significant resources and are not eligible for inclusion in the NRHP or CRHR.

Isolate P-36-060922** is an isolated artifact recorded in 1963. The artifact consists of a scoop-style metate crafted from an igneous rock. The recorder notes that it is in a style similar to metates from Arizona pueblos, with a well-defined channel and one open end (Shepard, 1963). Isolates are not considered significant resources and are not eligible for inclusion in the NRHP or CRHR.

Isolate P-36-064132** is a prehistoric isolate recorded in 1999. The pointed, bilaterally worked uniface was identified as a possible cutting tool, made from a fine-grained black material (possibly ignimbrite) (Inoway and Panaigua, 1999b). Isolates are not considered significant resources and are not eligible for inclusion in the NRHP or CRHR.

Previously Recorded Cultural Resources Within or Adjacent to Pipeline Project Area

Site CA-SBR-3233H (Milligan)** is the railroad siding camp of "Milligan," recorded in 1978 on the south side of the ARZC railroad tracks. Historic materials recorded at that time included twelve tamarisk and palo verde trees, planted and surrounded by cemented stone rings; the remains of a low rock wall; and broken fragments of concrete. The foundation of a railroad station and a section house were noted, as well as assorted glass and metal debris. The camp is believed to have been settled in approximately 1910. A concrete loading dock and a more recent stucco/concrete loading bin (ca.1960s) were noted on the north side of the tracks. This resource has not been previously evaluated for its eligibility for listing in the NRHP or CRHR (Crowley, 1978b).

Site CA-SBR-3235H (Saltmarsh)** is the railroad siding and mill camp of "Saltmarsh." The remains of at least 13 structures were identified during recordation in 1978, along with "great quantities" of metal, glass, ceramic, brick, wood, and other debris. Structures identified included a probable railroad station or freight house, storage buildings, loading docks, water tower foundations, possible residences, and underground storage rooms. The settlement dates from at least the 1930s. This resource has not been previously evaluated for its eligibility for listing in the NRHP or CRHR (Crowley, 1978c).

Site CA-SBR-3282H (Archer)** is the small railroad siding camp of "Archer" located along the historic ATSF Parker Cutoff route. A single building foundation was identified at the time of recordation in 1978, along with a well/water tank, scattered debris, and a small cemetery with seven wooden crosses and one stone grave marker (Crowley, 1978d). The inscriptions on two of the grave markers were transcribed on the site record form; both are in Spanish and mark the graves of young children who died prior to 1925. Applied Earthworks, Inc. (1999: Table 1) noted

that site CA-SBR-3282H was likely a significant resource; however, the resource has never been formally evaluated for its eligibility for listing in the NRHP or CRHR.

Site CA-SBR-3283H (Chubbuck)** is the "Chubbuck" Mill and settlement, and Desert Butte Mine District, originally recorded in 1978 and updated in 1999 and 2001. The recorded resources include the ruins and structures of the settlement of Chubbuck; the industrial buildings and structures of the mill southeast of Chubbuck; two railroad spurs; the main line of the ATSF Parker Cutoff; and an unimproved road leading to the Desert Butte Mine. Only two buildings in Chubbuck were standing at the time of district recordation in 1999; three towers at the mill were also extant, but all associated mill buildings were represented by concrete foundations and a few structural remains. Nine activity loci were recorded, as well as at least 37 discrete trash dump areas. The district dates from the 1930s-1940s, and theoretically includes the site of the Desert Butte Mine; however, this locus of the district was not recorded directly due to its location outside the recorders' project area (Hamilton, 1999). This resource was recommended eligible for listing in the NRHP under Criteria A and D for its local and regional contributions to railroad transportation and 20th-century mining (Applied Earthworks, Inc., 1999: 59).

Site CA-SBR-5606/H** was originally recorded in 1977 as a prehistoric lithic scatter with an overlying historic scatter of cans. Prehistoric artifacts included flaked-stone tools and debitage made from locally available chert, jasper, chalcedony, basalt, and quartz. Milling tools (manos, metates) were also recorded. Ration cans from historic military maneuvers were also found on the site, as well as one oil can. The site was revisited in 2001, and the recorders at that time only located a single chert flake. The site is crossed by the All American Pipeline, and is thought to have been largely destroyed in that area (Dietler and Toenjes, 2001a). It does not appear that this resource was previously evaluated for its significance.

Site CA-SBR-5819H** was recorded in 1985 as a historic debris scatter. Recorders noted glass, metal, and porcelain fragments near the ARZC rail line. Three shovel test pits, all sterile, were excavated. All visible artifacts were collected at that time; most of the site was mapped within the construction corridor for the All American Pipeline (Berry and Miller, 1985). It does not appear that this resource was previously evaluated for its significance.

Site CA-SBR-9849H** was recorded in 1999 as a small historic campsite/refuse scatter. Ceramic fragments, a variety of metal cans, and a few other assorted metal and glass items were found in close proximity to the ARZC rail line (Inoway et al., 1999b). Applied Earthworks, Inc. (1999: 54) indicated that CA-SBR-9849H did not have a subsurface component and was not a significant resource.

Site CA-SBR-9850H** is a historic campsite/trash scatter associated with the railroad. Glass fragments, metal cans and can lids, a bullet casing, kerosene lamp fragments, metal buttons, crockery fragments, burned faunal bone, and assorted other artifacts were recorded in 1999 (Inoway et al., 1999c). Applied Earthworks, Inc. (1999: 54) indicated that CA-SBR-9850H was likely related to the early history of the ATSF Parker Cutoff, but that its recordation exhausted its data potential; therefore CA-SBR-9850H was no longer to be considered a significant resource.

Site CA-SBR-9851H** is a small historic refuse scatter recorded in 1999. Noted artifacts include whiteware plate fragments, sun-colored amethyst and amber glass fragments, cans and can lids, wire, wire nails, and staples (Inoway et al., 1999d). Applied Earthworks, Inc. (1999: 54-55) indicated that CA-SBR-9851H was likely related to the early history of the ATSF Parker Cutoff, but that its recordation exhausted its data potential; therefore CA-SBR-9851H was no longer to be considered a significant resource.

Site CA-SBR-9852* is a large prehistoric lithic scatter recorded in 1999. Artifacts observed include 40 flakes and 20 tools. Material types present include cryptocrystalline silica, fine-grained quartzite, quartz, and obsidian (Inoway et al., 1999e). The site was recorded and tested, with all formed tools and obsidian collected, exhausting its data potential. Applied Earthworks, Inc. (1999: 55) indicated that as a result of these activities, CA-SBR-9852H was no longer considered a significant resource.

Site CA-SBR-9853H** is described above with the resources found within the wellfield Project area.

Site CA-SBR-9856H** is a large scatter of historic debris, recorded in 1999 immediately adjacent to the ARZC railroad tracks. Artifacts include household items (cans, ceramics, bottles) as well as iron machinery parts, tools, and hardware. A series of four narrow, short wooden posts may represent the remains of an animal pen or small corral (McDougall et al., 1999a). This site was subjected to archaeological testing and evaluation in 1999. Applied Earthworks, Inc. (1999: 56) excavated seven shovel test pits and determined that there was not a subsurface component to CA-SBR-9856H. The recordation of the site had exhausted its data potential; thus CA-SBR-9856H was no longer considered a significant resource.

Site CA-SBR-9858H** is a multicomponent historic archaeological site. One component represents the remains of an encampment or supply center associated with WWII-era military training exercises. According to the 1999 site record, this area was probably part of General George Patton's Desert Training Center (DTC). Linear rock features and alignments designating roadways and other use area were recorded, along with several discrete scatters of debris (food, beverage, and tobacco cans, concertina wire, glass fragments, and assorted hardware) (McDougall et al., 1999b). This component of the site was recommended eligible for listing in the NRHP under Criteria A, C, D, and possibly B (Applied Earthworks, Inc., 1999: 57-58).

The second component is sparse scatter of older debris and is likely a small railroad camp related to the ATSF Parker Cutoff railroad's construction and/or use (McDougall et al., 1999b). This component of the site was recommended eligible for listing in the NRHP under Criteria A and D for its association with the ATSF Parker Cutoff and contribution to transportation and the development of the transcontinental railroad (Applied Earthworks, Inc., 1999: 58).

Site CA-SBR-10521H (Colorado River Aqueduct)** is the historic Colorado River Aqueduct. This canal was constructed in the 1930s by the Metropolitan Water District of Southern California. As recorded in 2000, the concrete-lined canal measures 50 feet wide at the top and is fenced on both sides. The CRA was recommended eligible for the listing in the NRHP under Criteria A, B, and C (Neves and Goodman, 2000).

Site CA-SBR-10525-H* is a historic State Route (SR) 62. A segment of SR 62 from its intersection with SR 177 west to Sunburst Street was recorded and evaluated by SWCA in 2000. Although the highway was associated with the DTC and was a major automotive transportation route throughout the 20th century, SR 62 was recommended not eligible for listing in the NRHP by SWCA in 2000 (Purcell, 2000).

Site CA-SBR-10645-H* is a historic debris scatter, possibly related to WWII-era military training exercises. Materials observed in 2001 include cans, glass fragments, porcelain fragments, bullets, and wire (Dietler and Toenjes, 2001b). The site is located adjacent to the southwest side of Cadiz Road, approximately 30 meters from the ARZC railroad tracks. This site was recommended not eligible for listing in the NRHP (Pigniolo et al., 2001).

Site CA-SBR-10646H (Sablon)** is the historic railroad siding camp of "Sablon." As recorded in 2001, the site measured over 900,000 square feet; however the northern site boundary was not defined and the site was likely much more extensive at that time. The site included several concentrations of debris, as well as the railroad siding itself. Various cans, bottles and other glass fragments, railroad hardware, wire, glazed ceramic water pipe fragments, milled lumber, battery cores, and a single steel spoon were specifically noted. Artifact types suggested an occupation from 1910 into the 1960s (Dietler et al., 2001). Site CA-SBR-10646H was not evaluated for listing in the NRHP or CRHR at the time of its recordation (Pigniolo et al., 2001).

Site CA-SBR-11583H** is described above with the resources found within the wellfield Project area.

Native American Contact

A Sacred Lands File search with the Native American Heritage Commission (NAHC) was requested on November 8, 2010. Sacred Lands File search results prepared by the NAHC on November 12, 2010, indicated the presence of Native American cultural resources within ½-mile of the Project area in the Arica Mountains, and also noted that there were Native American resources in close proximity to the Project area in other locations.

Contact letters to all individuals and groups indicated by the NAHC as having affiliation with the Project area were prepared and mailed on November 17, 2010. The letters described the Project and included a map indicating the location of the Project area. Recipients were requested to reply with any information they are able to share about Native American resources that might be affected by the Project. Letters were sent to all individuals and tribes recommended by the NAHC. To date, two responses have been received. All correspondence is attached as Appendix B.

One response was received via email on December 15, 2010, from Bridget R. Nash-Chrabascz, Quechan Tribe Historic Preservation Officer. Ms. Nash-Chrabascz expressed the Quechan Cultural Committee's concern over the proposed Project's proximity to Old Woman Mountain. The Cultural Committee requested additional information and that further study be conducted. A phone message was left for Ms Nash-Chrabascz on January 20, 2011 by ESA archaeologist Monica Strauss. Ms. Nash-Chrabascz returned Ms. Strauss's phone call on February 2, 2011. Ms. Nash-Chrabascz

explained that the tribe is concerned that there may be prehistoric archaeological sites, pictographs, and petroglyphs in the vicinity of the Project. The tribe requested an archaeological survey be conducted and the opportunity to review the resulting report. Also, she reiterated that the tribe is concerned about visual impacts to the cultural traditional significance associated with the Old Woman Mountain and would like visual impacts to be taken into consideration. Ms. Strauss explained that the pipeline portion of the Project area has been surveyed and that no prehistoric sites or isolated artifacts were observed, and that the pipeline would be installed within the ARZC ROW. Ms. Nash-Chrabascz expressed that she was more concerned about the wellfield portion of the Project area and the scale of the Project on the landscape. Ms. Strauss indicated that the wellfield portion of the Project area would be subject to separate technical study at an unknown future date. Ms. Strauss also indicated that the Quechan Tribe, along with all others on the NAHC list, would be added to the EIR distribution list for the Project.

A second response was received via email on January 13, 2011 from Joseph Benitez, tribal elder of the Chemehuevi Tribe. Mr. Benitez expressed his concern about the impact to sacred sites, such as the Old [Woman] Mountain. A phone conversation between Mr. Benitez and ESA archaeologist Monica Strauss occurred on Jan 20, 2011. He indicated that the Old [Woman] Mountain range is a sacred site and that the general Project area was likely used prehistorically by the Chemehuevi to traverse to and from the Lake Havasu area. He also indicated that there could be a possibility of archaeological sites, especially near watercourses. Ms. Strauss explained that the pipeline survey did not result in the identification of any prehistoric sites and that the wellfield still needed to be surveyed. He asked that he be kept informed of the Project as it progresses. Ms. Strauss indicated that his comments would be noted in the EIR and that he would be added to the distribution list.

Field Survey

Field surveys were conducted between October 18 and 26, 2010. The survey crew was led by ESA archaeologists Madeleine Bray, M.A. and Candace Ehringer, M.A.

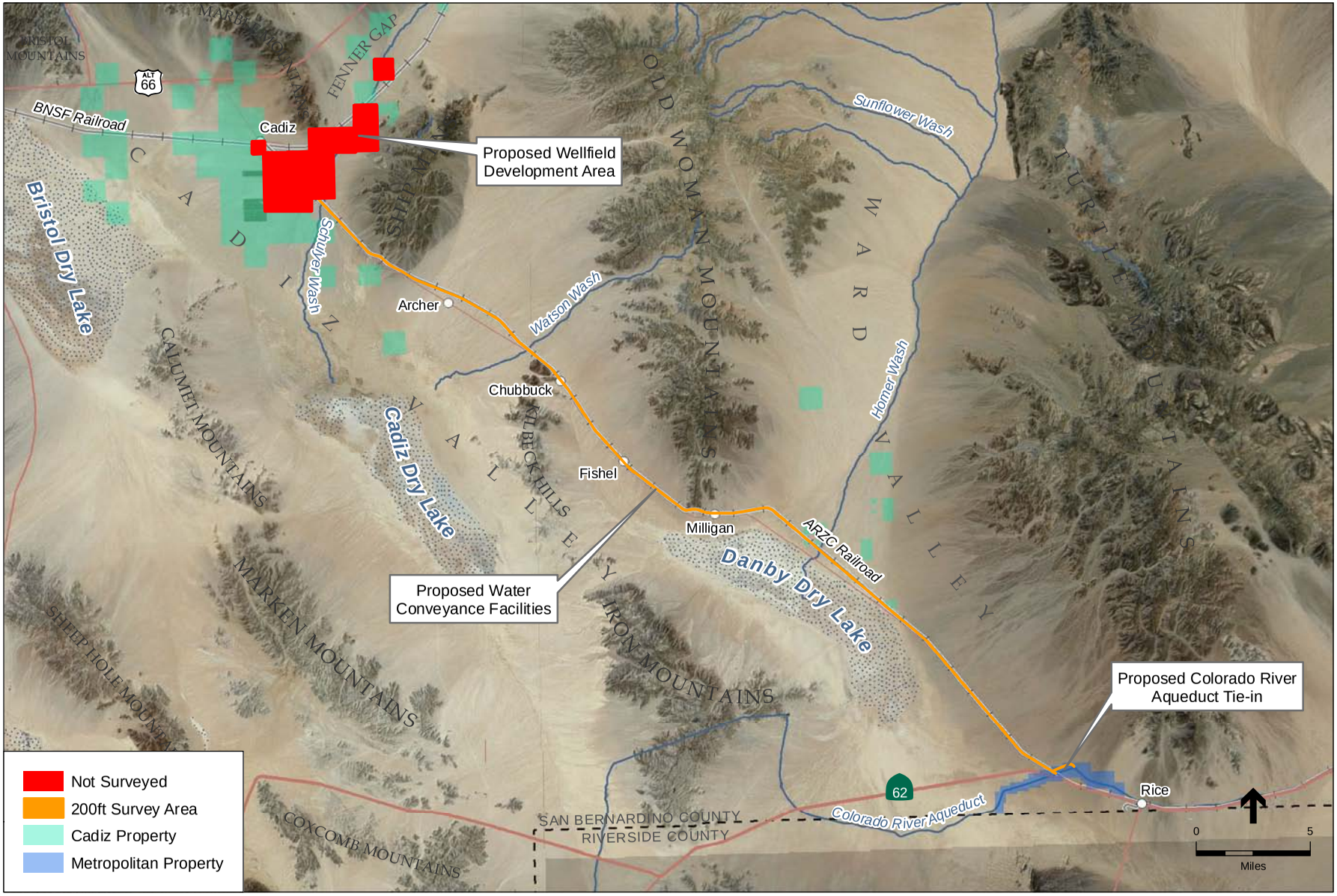
The survey area for the proposed pipeline portion of the Project area included 42.5 miles of the 200-foot-wide ARZC railroad ROW (100 feet on either side of the center line), from the proposed wellfield in the north to the CRA tie-in in the south; and an area from the ARZC railroad ROW east to the Freda Siphon, including the CRA tie-in Option 1(**Figure 3**). CRA tie-in Options 2a and 2b and the wellfield portion of the proposed Project area were not surveyed since the precise location of the wells, forebays, and access roads were not yet finalized. See Appendix C for detailed survey coverage as depicted on USGS topographic maps.

Areas that were not developed or otherwise disturbed were subject to intensive pedestrian survey. Survey was conducted in transects of no greater than 15 meters (50 feet). In general, two surveyors walked on either side of the railroad tracks. Very steep slopes and the railroad tracks and berm were not surveyed.

Any cultural resources encountered during the survey were documented and recorded on the appropriate Department of Parks and Recreation (523) (DPR) forms. An attempt was made to

relocate all previously recorded archaeological sites within or immediately adjacent to the Project area. Relocated sites were updated on DPR forms where appropriate. Each newly recorded resource was given a temporary field designation, then documented, photographed, and recorded. Isolated historic artifacts and modern (post-1965) features were not recorded and such objects and features are not considered cultural resources for the purpose of this analysis.

Ground cover within the proposed pipeline portion of the Project area consisted of disturbed creosote scrub. The Project area evidenced general surface disturbances of varying degree, particularly on the south and southwest side of the railroad, where the railroad access road, typically 20-25 feet wide, paralleled the railroad. Evidence of earth-moving activities near the railroad tracks, primarily on the north side, was frequently encountered. Aside from the obvious surface disturbances, depths of such disturbances, in general, could not be ascertained.



SOURCE: Bing Maps, 2010; BLM, 2009; ESRI, 2010; Cadiz Inc., 2010; and ESA, 2010

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 3

Survey Areas

Identified Cultural Resources

A total of 43 cultural resources were recorded or updated during the field surveys of the proposed pipeline portion of the Project area, including 15 previously recorded resources and 28 newly recorded resources (**Table 4)**. Two of the 15 resources that were previously recorded within the proposed pipeline portion of the Project area (CA-SBR-5606/H and -5819H) could not be relocated and are presumed to have been destroyed within the Project area; therefore a total of 41 resources are currently known to exist within the proposed pipeline portion of the Project area. Thirty-eight of the resources consist of historic-era archaeological sites, and three are historic architectural/engineering resources. The location of these resources in relation to the proposed Project area is depicted in Confidential Appendix D, **Figure 4**. All resources were documented on DPR 523 forms, which will be filed at the SBAIC (Confidential Appendix E). No prehistoric resources or artifacts were observed during the survey and no isolated artifacts were recorded.

TABLE 4
CULTRAL RESOURCES RECORDED OR UPDATED DURING SURVEY

Primary Number (P-36-)	Trinomial (CA-SBR-)	Field Designation	Description	Size (ft^2)	Est. Date Range	Comments
003233	3233H	-	"Milligan" RR settlement remnants and cemetery	606,800	Early- mid-20th c.	Relocated
003235	3235H	-	"Saltmarsh" RR settlement remnants	1,147,000	Early- mid-20th c.; most artifacts 1930s-1950s	Relocated
003282	3282	-	"Archer" RR settlement remnants and cemetery	2,090,000	Early- mid-20th c.	Relocated
003283	3283H	-	"Chubbuck" mill and settlement remnants	1,400,000	Early- mid-20th c.	Relocated
005606	5606/H	-	Lithic and historic scatter	-	Prehistoric/20th c.	Not relocated
005819	5819H	-	Historic debris scatter	-	First half of the 20th c.	Not relocated
009849	9849H	-	Historic debris scatter	1,080	First half of the 20th c.	Relocated
009850	9850H	-	Historic debris scatter	9,700	First half of the 20th c.	Relocated
009851	9851H	-	Historic debris scatter	3,500	First half of the 20th c.	Relocated
009853	9853H	-	ATSF RR – Parker Cutoff	N/A	1910-present	Relocated
009856	9856H	-	Historic debris scatter	199,200	Early 20th c.	Relocated
009858	9858H	-	WWII Tank Corps desert training site w/earlier RR component	549,500	Early 20th c., 1942-1944	Relocated
010521	10521H	-	Colorado River Aqueduct	N/A	1930s-present	Relocated
010646	10646H	-	"Sablon," RR siding and debris scatter	820,395	Early –mid-20th c; many artifacts 1950s-1960s	Relocated
011583	11583H	-	Cadiz-Parker Road	N/A	1910-present	Relocated
023578	14892H	ESA-C-1	Historic feature – earthen mound	25	Unknown	New site
023579	14893H	ESA-C-2	Small historic debris scatter	800	Early- mid-20th c.	New site
023580	14894H	ESA-C-3	Historic feature – fire ring	40	Unknown	New site

Primary Number (P-36-)	Trinomial (CA-SBR-)	Field Designation	Description	Size (ft^2)	Est. Date Range	Comments
023581	14895H	ESA-C-4	Extensive historic debris scatter	249,120	Early- mid-20th c.	New site
023582	14896H	ESA-C-5	Small historic debris scatter	11,250	Early- mid-20th c.	New site
023583	14897H	ESA-C-6	Historic feature – fire ring	4	Unknown	New site
023584	14898H	ESA-C-7	Historic feature – rock cairn	11.5	Unknown	New site
023585	14899H	ESA-C-8	Small historic debris scatter	400	1910-1920	New site
023586	14900H	ESA-C-9	Small historic debris scatter	16	Presently Undetermined	New site
023587	14901H	ESA-C-10	Small historic debris scatter	1800	Early- mid-20th c.	New site
023588	14902H	ESA-C-11	Rock alignment	49	Unknown	New site
023589	14903H	ESA-C-12	Small historic debris scatter	10	Early- mid-20th c.	New site
023590	14904H	ESA-C-13	Historic debris scatter	3600	Early- mid-20th c.	New site
023591	14905H	ESA-C-14	Small historic debris scatter	15	Early- mid-20th c.	New site
023592	14906H	ESA-C-15	Historic debris scatter	2236	Early- mid-20th c.	New site
023593	14907H	ESA-C-16	Small historic debris scatter	25	Presently Undetermined	New site
TBD	TBD	ESA-C-17	Small historic debris scatter	100	Early- mid-20th c.	New site
023594	14908H	ESA-C-18	Small historic debris scatter	225	Mid-20th c.	New site
023595	14909H	ESA-C-19	Small Historic debris scatter	36	Early- mid-20th c.	New site
023596	14910H	ESA-C-20	Small historic debris scatter	2100	Early- mid-20th c.	New site
023597	14911H	ESA-C-21	Small historic debris scatter	2500	Early- mid-20th c.	New site
023598	14912H	ESA-C-22	Historic debris scatter	6000	Early- mid-20th c.	New site
023599	14913H	ESA-C-23	Historic debris scatter	13,000	Early- mid-20th c.	New site
023600	14914H	ESA-C-24	Historic debris scatter	30,000	Early- mid-20th c.	New site
023601	14915H	ESA-C-25	Small historic debris scatter	100	ca.1910s-1950s	New site
023602	14916H	ESA-C-26	Small historic debris scatter	6000	Early- mid-20th c.	New site
023603	14917H	ESA-C-27	Small historic debris scatter	900	Early 20th c.	New site
023604	14918H	ESA-C-28	Small historic debris scatter	19,596	Early- mid-20th c.	New site

Previously Recorded Archaeological Resources

CA-SBR-3233H (Milligan)

CA-SBR-3233H is the railroad siding and settlement of "Milligan" first recorded in 1978 (**Figure 5**). Historic materials recorded at that time included twelve tamarisk and palo verde trees, planted and surrounded by cemented stone rings; the remains of a low rock wall; and broken fragments of concrete. The foundation of a railroad station and a section house were noted, as well as assorted glass and metal debris. A concrete loading dock (ca.1940s) and a more recent stucco/concrete loading bin (ca.1960s) were noted on the north side of the tracks.

Overview (to NE)

Feature 14 (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 5

Photos: CA-SBR-3233H (Milligan)

Site CA-SBR-3233H was relocated on October 24, 2010. The site includes an area of 606,800 square feet, or 13.9 acres. Nineteen features were recorded, including the "Miligan" sign, two historic debris concentrations, two loading docks, foundations and other structural features, eight tamarisk trees surround by rock rings, two "fireplaces," two fire rings, and a cemetery. Eleven features were recorded within the Project area and the remaining eight features are located outside of the Project area. The remains of the section house recorded in 1978 were not relocated; however, concrete chunks and other structural debris, as well as extensive scatter of historic artifacts, were also noted across the site. Artifact types suggest an early to mid-20th century occupation.

- Feature 1 (in Project area) is a concrete slab foundation covered in rubble. It measures about 20 feet N/S by 65 feet E/W and appears to correspond to the foundation of the Milligan railroad station noted on the 1978 sketch map. It is located between two dirt roads.
- Feature 2 (in Project area) is a foundation which appears to have been formed from small rocks cemented together and painted white. It measures about 15 feet N/S by 35 feet E/W. This foundation is located directly adjacent to the railroad tracks and is about 25 feet due north of Feature 1. It may also be part of the Milligan railroad station noted on the 1978 sketch map.
- Feature 3 (in Project area) is a square concrete-lined pit that measures 4 feet by 4 feet. The pit has been filled in with white painted rocks and debris.
- Feature 4 (in Project area) is a round rock foundation with decayed wooden posts and metal. The feature measures 6 feet in diameter by 2 feet in height.
- Feature 5 (in Project area) consists of four concrete pads that once supported the water tower.
- Feature 6 (in Project area) is a rock wall, formed from small rocks cemented together and painted white. It is about 25 feet in length.
- Feature 7 (borders Project area) appears to be a small drainage pit with a concrete collar. It measures approximately 15 feet E/W by 2 feet N/S and has been filled in with dirt and debris.
- Feature 8 (outside Project area) is a round pit with a large rectangular metal container at the bottom. The pit is about 6 feet in diameter and 3 feet deep. The metal container has hinged lids on both sides.
- Feature 9 (outside Project area) resembles a small rectangular fireplace measuring about 2.5 feet by 2 feet. It is formed of small to medium sized cobbles and has a raised wall (about 10 inches high) at the back. The center contains charred wood fragments.
- Feature 10 (outside Project area) appears to be the remains of another small rectangular fireplace that has collapsed.
- Features 11 and 12 (outside Project area) are two small circular firepits formed from cobbles. They each measure about 12 to 18 inches in diameter and have charred wood fragments in the center.

- Feature 13 (outside Project area) consists of eight tamarisk trees surrounded by a ring of small rocks cemented together and painted white.
- Feature 14 (in Project area) is the 1940s loading dock (easternmost dock) depicted on the 1978 sketch map (see Figure 5). It measures about 145 feet N/S and 35 feet E/W. The ramp is an earthen berm fronted along the tracks by a wall of cement blocks. A wood and metal loading apparatus was attached to the top of the cement block wall. The top of the ramp is paved with asphalt.
- Feature 15 (in Project area) is the 1960s concrete and stucco loading dock (westernmost dock) depicted on the 1978 sketch map. It measures about 120 feet north to south by 35 feet E/W, with two ramps extending from the northern end an additional 70 feet to the west.
- Feature 16 (outside Project area) is the Milligan Cemetery. It encompasses an area of about 800 square feet.
- Feature 17 (in Project area) is Concentration 1. The artifact concentration included over 50 fragments of amber, clear, sun-colored amethyst, and aqua glass. Some fragments appear to have been fire-affected. Embossed maker's marks include an amber bottle base with "W F & __", which was probably manufactured by William Franzen & Son (1900-1929). This mark is commonly found on beer bottles in the Midwest (Toulouse, 1971: 536-537; Whitten, 2011). White porcelain dishware fragments were also noted.
- Feature 18 (outside Project area) is Concentration 2. The artifact concentration included over 50 fragments of amber, clear, and applied color label (ACL) 7-UP bottle fragments. Embossed maker's marks observed include: an amber base with Maywood Glass Company's "MG (slanted left)" mark (1930-1959); a clear base with Thatcher Glass Manufacturing Company's "T (anchor-shaped) with MC" mark (1949-1985); a base with the Owens-Illinois diamond O-I mark (Plant 20 [Oakland, CA], Year 1948); and a clear base with "Duraglas (script)" (1940-ca.1963) (Lockhart, 2004a: 24-25; SHA, 2011a: Question #17; Whitten, 2011).
- Feature 19 (in Project area) is the "Miligan" sign located adjacent to the tracks.

Artifacts observed across the site included over 300 glass bottle fragments, over 50 cans, over 50 fragments of ceramics and porcelain, metal fragments, an aqua glass insulator, and a brown-glazed ceramic insulator. Can types observed included key-wind sardine, church-key, knife, and can-opener opened cans, sanitary cans, coffee cans, cone top cans, bi-metal pull-tab cans, and modern aluminum sardine cans. Glass bottle fragments included clear, amber, aqua, 7-UP green, green, cobalt, yellow amber, and sun-colored amethyst.

Bottle types included Tabasco, liquor, condiment, milk, medicine, and bleach. One milk glass "Mentholatum" jar (ca.1906-1955) and one cobalt blue "Noxema"-style glass jar were noted (Fike, 2006: 298). Both Clorox and Purex amber glass bottle fragments were recorded (one neck fragment dated to the 1930s) (The Clorox Company, 2011). One sun-colored amethyst medicine bottle with a tooled, bead-type finish was noted (ca.1890-1920) (SHA, 2011b: Tooled Finishes). One amber liquor bottle embossed with "FEDERAL LAW PROHIBITS SALE OR REUSE OF

THIS BOTTLE", which dates to 1935-ca.1964, was also noted (SHA, 2011a: Question #10). Numerous bottles with embossed with either the Maywood Glass Company's "MG" mark (1930-1959) or the Glass Containers, Inc. mark, "GC (vertically intertwined)", (1933/45-1983) were observed (Whitten, 2011). Several Owens-Illinois diamond O-I marks were present, including two amber bases dating to 1948 (Lockhart, 2004a: 25).

CA-SBR-3235H (Saltmarsh)

CA-SBR-3235H is the railroad siding camp of Saltmarsh (**Figure 6**). When the site was originally recorded in 1978, remains of at least 13 structures were identified, along with "great quantities" of metal, glass, ceramic, brick, wood, and other debris. Structures identified included a probable railroad station or freight house, a circular concrete reservoir, storage buildings, loading docks, water tower foundations, possible residences, and underground storage rooms. In addition, numerous sand fences were observed at that time.

This site was relocated on October 24, 2010 and measured about 1.2 million square feet (approx. 26 acres). The remains of six structural features, including a circular concrete reservoir, a well, a foundation, a wooden "loading dock" with nearby shaft, and two wood-lined shafts, were recorded during the survey. The remains of buildings and other structures mapped south of the road in 1978 were not relocated during the 2010 survey. The sand fences observed in 1978 were observed extending intermittently from CA-SBR-3235H north to ESA-C-28 and were located on both sides of the tracks. Tamarisk trees lined the southern side of the tracks.

- Feature 1(in Project area) is a circular concrete reservoir measuring about 25 feet in diameter and 2 feet high. The top is covered with asphalt. The concrete is inscribed "February 3, 1942." A concrete base abutting the tracks is located just northeast of the reservoir.
- Feature 2 (in Project area) is the Saltmarsh well, now filled and capped. It measured about 15 feet long by 10 feet wide and had two railroad ties bolted to the concrete. Embedded a recent patch of concrete is a plaque indicating that the well was capped in 2002.
- Feature 3 (in Project area) is a foundation located next to the tracks and is presumably the station or freight house recorded in 1978. The poured concrete foundation measured roughly 500 feet long by 10 feet wide and was covered in rubble and a historic debris scatter.
- Feature 4 (in Project area) is a wooden "loading dock" with a related wood-lined shaft (see Figure 6). The main portion of the loading dock is composed of 4-by-4-foot wooden posts and measured approximately 35 feet long by 15 feet wide. The posts extended about 5 to 6 feet above ground. A line of wooden posts (presumably part of the dock) was located adjacent (parallel) to the tracks and measured about 95 feet in length. A 3-foot by 3-foot wooden lined shaft was noted just northeast of the loading dock.
- Features 5 and 6 (outside Project area) are two wooden-lined shafts, possibly underground storage pits, located at the northwestern end of the site. Each shaft measured about 7 feet square.

Overview (to SE)

Feature 4 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 6

Photos: CA-SBR-3235H (Saltmarsh)

- The site also includes a very large historic debris scatter comprised primarily of glass bottles and metal cans. The majority of artifacts were concentrated on the southern side of the tracks. Over 1000 glass fragments, many of them diagnostic, were observed and included clear, pale green, 7-UP green, cobalt, sun-colored amethyst, yellow amber, amber, black amber, and aqua glass. One artifact concentration contained over 100 clear glass fragments with ACL, including 7-UP, Royal Crown Cola, Pepsi-Cola, and Barq's. One fragment of a 7-UP bottle with swim front label was recorded and dates from 1937 to 1953 (Lockhart, 2005: 24). Glass bottle types observed include soda, Coca-Cola, beer, bleach, and milk. Numerous yellow amber, thin-walled stubby beer bottles and amber crown finish bottle necks were also observed. One amber base embossed with "CLOROX in a diamond (1929-1930), one amber base with an Owens-Illinois mark (1939), one amber liquor bottle with an Obear-Nestor Glass Co. mark (1915-1980), and one clear base with the Hazel-Atlas maker's mark (1923-ca.1964) were noted (The Clorox Company, 2011; Lockhart, 2004a: 27; Toulouse, 1971: 373-374; and Whitten, 2011).

Recorded cans included sanitary cans, bimetal pull tabs, key wind sardine cans, hole-in-top cans, church key opened, pocket tobacco cans, coffee cans, meat cans, and modern aluminum cans. Whiteware ceramic fragments, one "snowball" brick, which dates from 1854 to 1935, and part of an old car, possibly a Model T, were observed. Artifact types suggest an early to mid-20th century occupation, with a large number of artifacts dating to the 1930s to 1950s.

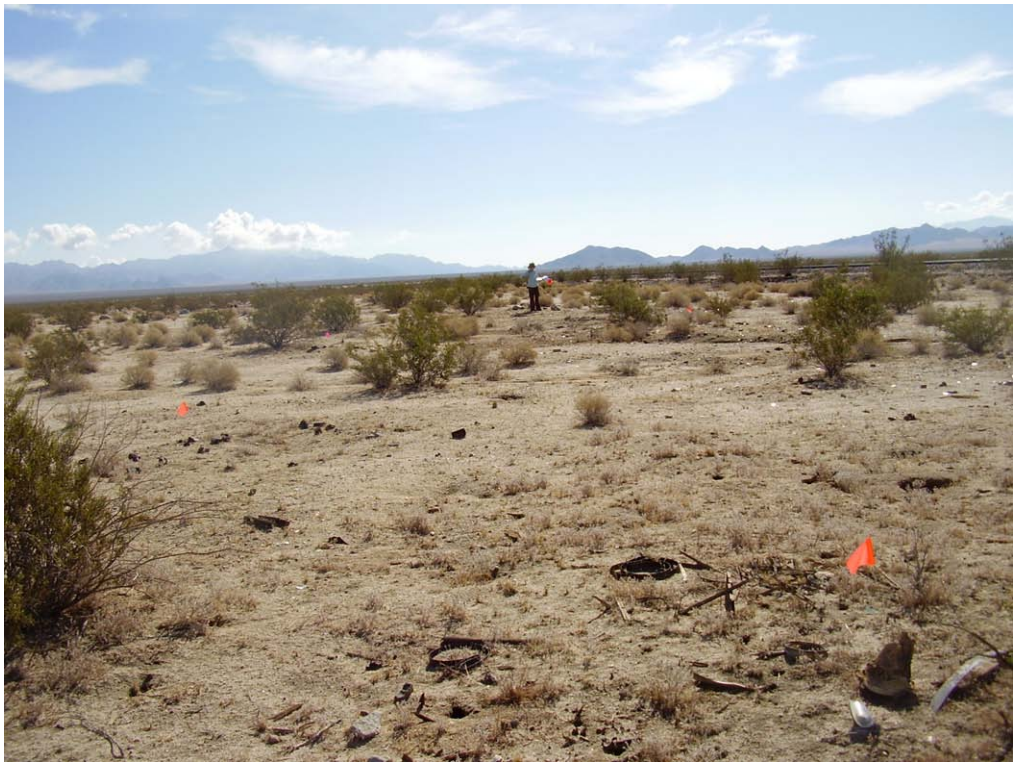
CA-SBR-3282H (Archer)

CA-SBR-3282H is the small railroad siding camp of "Archer" located along the ARZC tracks (historic ATSF Parker Cutoff) (**Figure 7**). A single building foundation was identified at the time of recordation in 1978, along with a well/water tank, scattered debris, and a small cemetery with seven wooden crosses and one stone grave marker. The inscriptions on two of the grave markers were transcribed on the site record form; both are in Spanish and mark the graves of young children who died prior to 1925.

This historic site was relocated on October 20, 2010 and measured about 2.1 million square feet, or approximately 48 acres. This large historic site contains 37 features and an extensive historic scatter. The site extends on both sides of the railroad tracks. Features include a well, cemetery, 25 artifact concentrations, three concrete or asphalt features, a group of wooden posts arranged in a rectangular shape, an earthen mound, and five depressions. Ten features are located within the Project area and are described in detail below. The remaining 27 features are not included here for the sake of brevity, but were recorded on DPR 523 forms. Feature 15, the cemetery (see Figure 7), is located only 10 feet outside the Project area. Artifact types indicate an early to mid-20th century occupation of Archer, with several dating prior to 1930.

- Feature 1 is Archer's well, now filled and capped. It is comprised of a 13-by-13-foot-square concrete platform with a smaller 18-by-18 inch raised square at each corner. There is a 62 inch by 37 inch by 12 inch raised platform in the center. Embedded in the center is a recent patch of concrete with a plaque indicating that the well had been capped in 2004. A pile of recent gravel surrounds the platform.

Feature 18 (foreground) and Feature 15 (background) (to N)



Feature 22 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 7

Photos: CA-SBR-3282H (Archer)

- Feature 2 is a 10-by-10-foot pile of fragmentary bricks and windowpane glass. The largest fragment measured 10 by 6 by 6 inches. Most bricks were impressed with the maker's mark "LAPBCO" (Los Angeles Pressed Brick Co) or "GMcB" (Gladding, McBean and Co).
- Feature 13 is comprised of two parallel linear concrete features, with large chunks of concrete scattered around them. About 12 feet to the west is a pile of similar concrete rubble. Large cobbles are embedded in concrete.
- Feature 14 is a raised earthen mound, measuring 20 feet E/W by 30 feet N/S. At the south end is a large chunk of cement, with two lengths of pipe protruding from the ground.
- Feature 17 is comprised of seven wooden posts and one post hole arranged in a rectangular shape, with crumbling asphalt in the middle
- Feature 18 is a pile of crumbling asphalt with large rock cobbles ringing the northern side (see Figure 7). Associated artifacts include amber glass, cans, over 12 metal barrel hoops, and over 20 wire rings.
- Feature 22 is a 2500 square foot historic scatter with two piles of asphalt and large rocks (see Figure 7). Artifacts included metal lids, clear glass fragments, bricks, hole-in-top cans, milk glass, brown-glazed earthen ware, whiteware, jadeite, metal hoops, wire, over 50 cans, hundreds of glass fragments, one milk glass bowl base labeled "Oven Fire-King Ware," a paint can, and wood fragments.
- Feature 23 is a 36-by-36 inch concrete square with two metal loops protruding from center. A piece of wire is attached to loop. Clear glass, wood fragments, clay pigeon fragments, and shoe sole were recorded adjacent to the feature.
- Feature 29 is a concentration of over 20 cans, including sardine tins, sanitary cans, and hole-in-top cans, as well as metal wire, one piece of jadeite, and asphalt.
- Feature 30 is a concentration of 15 cans, including sanitary cans and hole-in-top cans.

CA-SBR-3283H (Chubbuck)

CA-SBR-3283H is the "Chubbuck" Mill and Settlement, and Desert Butte Mine District, originally recorded in 1978 and updated in 1999 and 2001 (**Figure 8**). The recorded resources include the ruins and structures of the settlement of Chubbuck; the industrial buildings and structures of the mill southeast of Chubbuck; two railroad spurs; the main line of the ATSF Parker Cutoff; and an unimproved road leading to the Desert Butte Mine. Only two buildings in Chubbuck were standing at the time of district recordation in 1999; three towers at the mill were also extant, but all associated mill buildings were represented by concrete foundations and a few structural remains. Nine activity loci were recorded, as well as at least 37 discrete trash dump areas. The district dates from the 1930s to 1940s, and theoretically includes the site of the Desert Butte Mine; however, this locus of the district was not recorded directly due to its location outside the recorders' project area.

Cement Plant (to W)

Linear Feature 4 (to S)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 8

Photos: CA-SBR-3283H (Chubbuck)

This historic site was relocated on October 21, 2010 and found to be exactly as previously recorded. Most of the previously recorded features are located outside of the Project area; however, Linear Feature 4, the narrow-gauge railroad segment, is located within the Project area, approximately 10 feet west of the ARZC rail line (see Figure 8). There was a general sparse historic debris scatter observed within site boundaries.

CA-SBR-5606/H

This site, originally recorded as a prehistoric lithic scatter with an overlying historic scatter of cans, could not be relocated. The site was re-recorded in 2001 and was reported to have been largely destroyed or absent with the All American Pipeline project area. No artifacts were observed during the survey and it appears that the site no longer exists within the Project area.

CA-SBR-5819H

The site could not be relocated during the survey; however, according to the 1985 site record, the site was 100 percent surface collected as part of a previous archaeological study. Therefore, it appears that the site no longer exists within the Project area.

CA-SBR-9849H

CA-SBR-9849H was recorded in 1999 as a small historic campsite/refuse scatter. Ceramic fragments, a variety of metal cans, and a few other assorted metal and glass items were found in close proximity to the ARZC rail line. The site was dated to the first half of the 20th century.

This historic site was relocated on October 18, 2010 and was found to be generally as recorded (**Figure 9**). As originally reported, the site measured about 1,080 square feet, or 0.03 acre. One new historic concentration was recorded, consisting of five cans (including a possible military C-ration can), 10 pieces of aqua and sun-colored amethyst glass, and one piece of burnt bone.

CA-SBR-9850H

CA-SBR-9850H was first recorded in 1999 as a historic campsite/trash scatter associated with the railroad. Glass fragments, metal cans and can lids, a bullet casing, kerosene lamp fragments, metal buttons, crockery fragments, burned faunal bone, and assorted other artifacts were noted. The site was dated to the first half of the 20th century.

This historic site was relocated on October 18, 2010 and found to be exactly as previously recorded. The site measured 9,700 square feet, or 0.22 acre.

CA-SBR-9851H

CA-SBR-9851H is a small historic refuse scatter recorded in 1999. Noted artifacts include whiteware plate fragments, sun-colored amethyst and amber glass fragments, cans and can lids, wire, wire nails, and staples. The site was dated to the first half of the 20th century.

This historic site was relocated on October 18, 2010 and found to be exactly as previously recorded (Figure 9). The site measured 3,500 square feet, or 0.08 acre.

CA-SBR-9849H (to E)

CA-SBR-9851H (to NNW)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 9

Photos: CA-SBR-9849H and -9851H

CA-SBR-9853H (ATSF Parker Cutoff)

This resource extends from the wellfield area along the same alignment as the proposed water conveyance pipeline alignment. It is currently still in use and is now known as the ARZC railroad. According to the site record, the ATSF Parker Cutoff was constructed in 1910, although trestles along the alignment bear later dates indicating that modifications have occurred. This resource was previously recorded by Applied Earthworks, Inc. in 1999, and consists of railroad tracks set on a raised grade on rock ballast.

The railroad was observed during the 2010 ESA survey and found to be as previously described (**Figure 10**). Dates noted on the tracks themselves span from 1916 to the 1950s. The railroad is still in use.

CA-SBR-9856H

CA-SBR-9856H is a large scatter of historic debris, recorded in 1999 immediately adjacent to the ARZC railroad tracks. Artifacts include household items (cans, ceramics, and bottles) as well as iron machinery parts, tools, and hardware. A series of four narrow, short wooden posts may represent the remains of an animal pen or small corral.

This historic site was relocated on October 20, 2010. None of the previously recorded features are located within the Project area, although Feature 1, which consists of four wood posts arranged in a square, is located just outside of the Project area. The Project area was generally found to contain a sparse scatter of historic debris, including cans (round tobacco tins, sanitary cans) and glass. One new historic artifact concentration was recorded on the northeast side of the railroad (**Figure 11**). The concentration consisted of 15 cans, primarily knife-opened hole-in-top cans and sanitary cans. Based on a diagnostic bottle fragment, this concentration likely dates to the early 20th century.

CA-SBR-9858HCA-SBR-9858H is a multicomponent historic archaeological site. One component represents the remains of an encampment or supply center associated with WWII-era military training exercises. According to the 1999 site record, this area was probably part of General George Patton's DTC. Linear rock features and alignments designating roadways and other use area were recorded, along with several discrete scatters of debris (food, beverage, and tobacco cans, concertina wire, glass fragments, and assorted hardware). The second component is sparse scatter of older debris and is likely a small railroad camp related to the ATSF Parker Cutoff railroad's construction and/or use.

This historic site was relocated on October 18, 2010. Features 10, 11, 13, and 16 were relocated within the Project area and generally found to be as previously recorded. Artifact types noted at the site indicate that the area was in use from the early to mid 20th century. The remaining previously recorded features are located outside of the Project area.

- Feature 10 is a historic debris scatter about 8 feet in diameter. Over 30 cans and 10 clear and amber glass fragments were originally noted. No additional artifacts were observed during the current survey.

Railroad Tracks (to NNE)

Profile (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 10

Photos: CA-SBR-9853H (ATSF Parker Cutoff)

CA-SBR-9856H, New Concentration (to W)

CA-SBR-9858H, New Feature (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 11

Photos: CA-SBR-9856H and -9858H

- Feature 11 is a historic debris scatter measuring 18 feet in diameter. Over 50 cans, including sanitary cans, key-wind sardine and coffee cans, small juice cans, and evaporated milk cans, and over 150 amber, clear, and sun-colored amethyst glass fragments were originally recorded. Saw-cut bone and yellow plastic fragments were also observed during the current survey.
- Feature 13 is an earthen loading/unloading platform measuring 26 feet by 13 feet. The sides slope at a 45-degree angle and are bolstered by small to large cobbles.
- Feature 16 is a historic debris scatter measuring 16 feet in diameter. Over 30 cans, including sanitary, key-wind opened, and evaporated milk cans, and over 10 yellow/green and clear glass fragments were originally noted. No additional artifacts were observed during the current survey.

One new feature was recorded during the current survey (Figure 11). The new feature was a large earthen platform, measuring approximately 75 feet N/S by 125 feet E/W, located on the northeast side of the railroad. The feature abuts the railroad and is level with it. The sides of the platform slope at about 45 degrees and are not lined or supported. The surface of the platforms shows clear evidence of earth-moving activities, and wooden stakes and railroad ties are present within the disturbed earth. The date of the feature is unknown.

CA-SBR-10521H (Colorado River Aqueduct)

CA-SBR-10521H is the historic Colorado River Aqueduct (CRA). This canal was constructed in the 1930s by the Metropolitan Water District of Southern California and is still in use. As recorded in 2000, the concrete-lined canal measures 50 feet wide at the top and is fenced on both sides.

On October 26, 2010, the aqueduct was relocated at the southern terminus of the Project area and found to be as previously recorded.

CA-SBR-10646H (Sablon)

CA-SBR-10646H is the historic railroad siding camp of "Sablon." As recorded in 2001, the site measured over 900,000 square feet; however the northern site boundary was not defined and the site was likely much more extensive at that time. The site included several concentrations of debris, as well as the railroad siding itself. Various cans, bottles and other glass fragments, railroad hardware, wire, glazed ceramic water pipe fragments, milled lumber, battery cores, and a single steel spoon were specifically noted. Artifact types suggested an occupation from 1910 into the 1960s (Dietler et al., 2001).

This historic site was relocated on October 25, 2010 (**Figure 12**). This is a very large historic debris scatter with seven features, including five artifact concentrations and two structural features. At this time, the total site encompasses 820,395 square feet (18.8 acres), with the majority of the site being located on the northern side of the railroad tracks. It appears that the majority of the site previously located south of the tracks has been destroyed by construction of an underground pipeline.

Overview (to E)

Feature 6 (to NNE)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 12

Photos: CA-SBR-10646H (Sablon)

Six of the seven recorded features are located within the Project area. Artifacts observed across the site included over 20 pocket tobacco cans, over 20 sanitary cans, over 150 bi-metal pull-tab cans (mostly soda), over 10 square and rectangular key-wind opened cans, as well as a small concentration of tires, paint cans, spray paint cans, and 10 gallon drums. Bottle types included condiment, cosmetic, beer, liquor, and soda. Artifact types date to the early to mid-20th century, with many from the 1950s to 1960s.

- Feature 1 (in Project area) is an artifact concentration covering about 625 square feet. The concentration contained over 100 bimetal pull tab soda cans, over 10 7-UP bottles, amber beer/soda bottles and screw cap jars, and some modern cans.
- Feature 2 (in Project area) is a discrete artifact concentration covering about 400 square feet. The concentration contained over 25 yellow amber stubby beer bottles, over 50 bimetal pull tab cans, and about 5 amber liquor bottles.
- Feature 3 (outside Project area) is a small, sparse debris scatter located on the south side of the tracks consisting of sun-colored amethyst glass, non-diagnostic can fragments, and batteries.
- Feature 4 (in Project area) is a small artifact concentration covering an area of about 100 square feet. Over 10 clear and amber bottles, both whole and fragmented, were noted.
- Feature 5 (in Project area) is a small artifact concentration with over 25 fragments of sun-colored amethyst and several cobalt blue glass fragments.
- Feature 6 (in Project area) is a piece of cut track inserted vertically into the ground and surrounded by a pile of rocks (Figure 12). The track extends about 5 feet above the ground.
- Feature 7 (in Project area) is a concrete-lined shaft, measuring 3 feet in diameter, located on the south side of the tracks.

CA-SBR-11583 (Cadiz Road)

CA-SBR-11583 is the historic Old Cadiz-Parker Road. The recorded section of the formerly graded road extends between the two railroad siding camps of Cadiz and Rice. Upon recording in 2004, the road had deteriorated in parts to a narrow two-track. A road following approximately the same alignment is shown on the 1896 “Parris Miners Map of the Desert Region of Southern California;” however, this road could also be associated with construction of the ATSF Parker Cutoff, completed in 1910.

A section of the road is located within the Project area. During the current survey, the road was found to be as previously described and is currently in use.

Newly Recorded Resources

CA-SBR-14892H (ESA-C-1)

This isolated historic feature was recorded on October 18, 2010. The resource is a small round feature composed of adobe-like, irregularly shaped material surrounding a gravel-filled center (**Figure 13)**. The feature is approximately 5 feet in diameter. There were few associated artifacts other than a general sparse scatter of sanitary cans. The date of the feature is unknown.

CA-SBR-14893H (ESA-C-2)

This historic site was recorded on October 18, 2010. The resource contains a small concentration of over 30 cans within an 800 square foot area (Figure 13). Can types include key-wind sardine, church-key opened and knife opened beverage cans, and pocket tobacco cans. Artifacts likely date from the early to mid-20th century.

CA-SBR-14894H (ESA-C-3)

This historic feature was recorded on October 18, 2010 and is composed of a 5-foot-diameter fire ring formed by approximately 15 pumice cobbles (**Figure 14**). The cobbles range in size from 6 inches to 15 inches in diameter, with the exception of one that is much larger than the others, at 24 inches in diameter. Some of the pumice has vitrified. Just south of the fire ring are the remains of two burnt timbers and a metal rod. The date of the feature is unknown.

CA-SBR-14895H (ESA-C-4)

This historic site was recorded on October 19, 2010. This is a large historic artifact scatter (Figure 14) with 10 features, including three can concentrations, two glass concentrations, four concentrations of burnt bone, and three rock cairns.

- Feature 1 consists of a can concentration located primarily in a drainage perpendicular to the railroad tracks. The scatter continues north into less disturbed desert pavement.
- Feature 2 consists of a concentration of over 50 cans located in a drainage.
- Feature 3 consists of a concentration of over 50 cans located in a drainage.
- Feature 4 is three small rock cairns.
- Feature 5 consists of a glass concentration. Over 40 sun-colored amethyst and aqua colored glass fragments were observed.
- Feature 6 is a glass concentration consisting of hundreds of sun-colored amethyst, amber, and green glass fragments. One amber glass bottle base embossed with “A. B. CO” on the heel was noted. This mark dates from 1905-1914 (Lockhart et al., 2007). A shattered dark green bottle and a shattered amber glass flask were also observed.
- Features 7 through 10 consist of burnt bone concentrations. Hundreds of faunal bones (probably cow based on size) were noted.

ESA-C-1 (to E)

ESA-C-2 (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 13

Photos: Newly Recorded Cultural Resources

ESA-C-3 (to E)

ESA-C-4 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 14

Photos: Newly Recorded Cultural Resources

Site CA-SBR-14895H (ESA-C-4) is located between the ARZC rail line and Cadiz Road, and is 249,120 square feet, or 5.7 acres, in size. Over 100 cans were recorded., including least 50 hole-in-cap cans (measuring 4-6/16 inches high by 3 inches in diameter), over 20 larger hole-in-cap cans (6-12/16 inches high by 6-2/16 inches in diameter), over 10 large hole-in-top cans (4-12/16 inches high by 4-3/16 inches in diameter), one sardine tin, over 10 unidentifiable sanitary cans, five aluminum pull-tab beverage cans, and more than 15 partially buried and unidentifiable cans. Most of the hole-in-cap cans were knife or puncture opened. These types of cans date from the early 1800s to about 1930. The hole-in-cap cans measuring 4-6/16 inches high by 3 inches in diameter may date from 1903 to 1914 (Simonis, 2001). Also recorded were one Chesebrough New-York Vaseline® clear jar (1908-1955), one large metal lid, one painted metal cookpot, one metal pail, a plastic gallon jug, several whiteware fragments, twisted metal rods and straps, and five barrel hoops (Fike, 2006: 56). The site likely dates from the early to mid-20th century.

CA-SBR-14896H (ESA-C-5)

This historic site was recorded on October 19, 2010 on the southwest side of the ARZC rail line. This small, localized can dump consists of three concentrations of cans within an 11,250 square foot area (**Figure 15**). Concentration 1 contains three hole-in-top cans and four large sanitary cans. Concentration 2 is approximately 10 feet north of Concentration 1 and consists of two hole-in-top cans and three unidentified sanitary cans. Concentration 3 is comprised of two hole-in-top cans and one sanitary can. Approximately 20 feet north of Concentration 3 is a burnt railroad tie and one sanitary can. The site likely dates from the early to mid-20th century.

CA-SBR-14897H (ESA-C-6)

This historic feature was recorded on October 19, 2010. The feature consists of a small isolated fire ring, approximately 2 feet in diameter, composed of small (6-inch diameter) cobbles with no associated artifacts. The date of the feature is unknown.

CA-SBR-14898H (ESA-C-7)

This historic feature was recorded on October 19, 2010 and is comprised of a rock cairn with a wood post embedded in it. The cairn is 5.75 feet in diameter, composed of medium- to large-sized cobbles. Sediment has accumulated in the middle of the cairn such that the middle of the cairn has been elevated to about 1 foot above the ground surface. The date of the feature is unknown.

CA-SBR-14899H (ESA-C-8)

This historic site was recorded on October 19, 2010 on southwest side of the ARZC rail line, 75 feet west of the railroad. ESA-C-8 is 400 square feet in size and consists of a concentration over 100 aqua and sun-colored amethyst glass fragments and a scatter of metal cans within a 400 square foot area (Figure 15). Many of the glass fragments were melted. Additionally, there were three earthenware fragments (possibly part of a large cook pot), a square meat tin, a crushed large metal bucket, one sanitary can, and one large hole-in-top can measuring 6-$^{15}/_{16}$ inches high by 6-$^{10}/_{16}$ inches diameter. Two aqua bottle bases were embossed with the A-B connected mark, which dates to 1905-1917 (Lockhart, 2004b: 17). Based on this mark and the large number sun-colored amethyst fragments, this site likely dates from 1910 to 1920.

ESA-C-5 (to NNW)

ESA-C-8 (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 15

Photos: Newly Recorded Cultural Resources

CA-SBR-14900H (ESA-C-9)

This historic site was recorded on October 19, 2010 and is comprised of a small concentration of artifacts including dozens of wire nails, metal straps, one melted cobalt glass jar with a screw-on metal lid, one barrel hoop, and one broken clear glass jar (**Figure 16**). The site covers an area of about 16 square feet. No diagnostic artifacts were noted, other than the cobalt blue glass jar, which has a temporal range of ca. 1920 to the 1960s.

CA-SBR-14901H (ESA-C-10)

This historic site was recorded on October 19, 2010 and measures 1800 square feet, or 0.04 acre. ESA-C-10 is made up of two concentrations of historic artifact scatters (Figure 16). Concentration 1 consists of one aqua bottle neck, two screw top clear bottles, three amber bottle necks, and over 50 cans within a 50 square foot area. The cans included sanitary cans, church-key-opened beverage cans, a cigar tin, hole-in-top cans, and coffee cans. Concentration 2 consists of one gas can, amber glass, a clear bottleneck and over 50 cans (mainly church-key-opened beverage cans) within a 10 square foot area. The site likely dates to the early to mid-20th century.

CA-SBR-14902H (ESA-C-11)

This isolated feature was recorded on October 19, 2010. ESA-C-11 is a rock alignment, measuring 7.5 feet N/S by 6.5 feet E/W. The alignment is composed of about fifty 8-inch diameter white or light colored cobbles arranged in a pattern (**Figure 17**). The date of the feature is unknown.

CA-SBR-14903H (ESA-C-12)

This historic site was recorded on October 19, 2010 about 40 feet northeast of the ARZC rail line. This site is a small (10 square foot) historic scatter consisting of four church-key-opened cans, a small metal drum, and some metal wire (Figure 17). The site probably dates to the early to mid-20th century.

CA-SBR-14904H (ESA-C-13)

This historic site was recorded on October 19, 2010. ESA-C-13 is a historic scatter with three concentrations of historic artifacts within a 3600 square foot area (**Figure 18**). Concentration 1 consists of 20 sanitary cans and church-key-opened beverage cans within 10 square feet. Concentration 2 consists of over 20 sanitary cans and church-key-opened beverage cans, as well as three clear glass bottles with threaded tops. The three bases were embossed with a "C" in a square, indicating they were manufactured between 1921 and 1928 by the Crystal Glass Co. of Los Angeles (Toulouse, 1971: 108). Concentration 3 consists of over 100 clear, green, and aqua glass fragments and some metal wire fragments. Additionally, there were four sanitary cans in a wash about 20 feet west of Concentration 3. The site dates to the early to mid-20th century.

CA-SBR-14905H (ESA-C-14)

This historic site was recorded on October 19, 2010 approximately 75 feet northeast of the ARZC rail line. The site is a small historic scatter and measures 15 square feet (Figure 18). It consists of one hole-in-cap can, one hole-in-top can, two sanitary cans, and one small round key-opened can. The site dates to the early to mid-20th century.

ESA-C-9 (to N)

ESA-C-10 (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 16

Photos: Newly Recorded Cultural Resources

ESA-C-11 (to N)

ESA-C-12 (to S)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 17

Photos: Newly Recorded Cultural Resources

ESA-C-13 (to SW)

ESA-C-14 (to NNE)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 18

Photos: Newly Recorded Cultural Resources

CA-SBR-14906H (ESA-C-15)

This historic site was recorded on October 20, 2010 approximately 50 feet southwest of the ARZC railroad tracks. ESA-C-15 consists of two concentrations of historic artifacts within an approx. 2200 square foot area (**Figure 19**). Concentration 1 contains approximately 40 crushed hole-in-cap cans within a 100 square foot area. Concentration 2 contains approximately 20 hole-in-cap cans, and two larger crushed coffee can-sized sanitary cans. Other miscellaneous artifacts, including a wire strap, wood scraps, and five cans, are located 10 feet north of Concentration 1. The site dates to the early to mid-20th century.

CA-SBR-14907H (ESA-C-16)

This historic site was recorded on October 21, 2010 and is locates about 15 feet south of the ARZC access road. The site is a small historic scatter consisting of three pieces of lumber, two hole-in-top cans, and three crushed unidentifiable cans within a 25 square foot area (Figure 19). The site is located near the historic siding of Archer. The date of the site is presently undetermined.

ESA-C-17

Recorded on October 21, 2010, ESA-C-17 is located approximately 75 feet southwest of the ARZC rail line, southwest of the railroad access road and northeast of Cadiz Road. The resource is a small, discrete refuse scatter concentrated within a 100 square foot area (**Figure 20**). Artifacts observed include amber and clear glass fragments, whiteware fragments, metal caps, four key-opened sardine cans, five sanitary cans, seven unidentifiable cans (some knife opened), two lids from key-opened meat tins, one hole-in-top can, a round tobacco can, a round key-open lid, and a crushed metal pail. Although not conclusive, the site probably dates to the early to mid-20th century.

CA-SBR-14908H (ESA-C-18)

This is a small historic scatter recorded on October 21, 2010 just south of the railroad access road, and consists of about 10 wood, metallic, and glass artifacts within a 225 square foot area (Figure 20). Artifacts include five pieces of timber, one church-key-opened beverage can, two crushed sanitary cans, one amber glass bottle with "15 B (in a circle) 66" embossed on the base, one metal paint can lid, a piece of concrete, and one aluminum-top beer can. The embossed mark on the amber bottle indicates it was manufactured by the Brockway Glass Company's Oakland, California plant in 1966 (Whitten, 2011). The site probably dates to the mid 20th century.

CA-SBR-14909H (ESA-C-19)

This site was recorded on October 22, 2010 and is located about 85 feet southwest of the ARZC rail line. The site is a small, discrete historic scatter consisting of over 40 cans, glass fragments, and ceramic fragments within a 36 square foot area (**Figure 21**). The artifacts included four small hole-in-top cans (measuring 2-$^{7}/_{16}$ inches high by 2-$^{8}/_{16}$ inches diameter), one hole-in-top can (measuring 3-$^{15}/_{16}$ inches high by 2-$^{15}/_{16}$ inches in diameter), seven sanitary cans, two rectangular meat tins with key-wind open, one key, one aluminum Pepsi pull-tab can, three white ceramic fragments, one clear bottle base with a Hazel-Atlas maker's mark (1923-ca. 1964), one shattered amber glass jug, sun-colored amethyst glass, and one cobalt blue glass fragment (Whitten, 2011). The site is located near the historic Fishel railroad siding. The site probably dates to the early to mid-20th century.

ESA-C-15 (to N)

ESA-C-16 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 19

Photos: Newly Recorded Cultural Resources

ESA-C-17 (to E)

ESA-C-18 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 20

Photos: Newly Recorded Cultural Resources

ESA-C-19 (to E)

ESA-C-20 (to E)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 21

Photos: Newly Recorded Cultural Resources

CA-SBR-14910H (ESA-C-20)

Recorded on October 22, 2010, this site is located just south of the railroad access road. The resource is a historic scatter with two discrete concentrations, and totaling 2100 square feet in area (Figure 21). Concentration 1 is a can dump comprised of over 30 cans within 100 square feet. The cans are mostly church-key-opened beverage cans, but also included two key-opened sardine cans and one coffee can, as well as four clear glass bottle necks. Concentration 2 is located 20 feet east of Concentration 1 and consists of a discrete scatter of over 100 timber fragments. Additionally, a burnt railroad tie was observed south of Concentration 1. The site is located near the historic Fishel railroad siding. The site probably dates to the early to mid-20th century.

CA-SBR-14911H (ESA-C-21)

This sparse historic can scatter was recorded on October 22, 2010 and is comprised of approximately 20 cans within a 2500 square foot area, located north of the ARZC rail line (**Figure 22**). The cans consisted of two sardine tins, four beverage cans, eleven sanitary cans (most of which were buried in a small drainage that was adjacent to the railroad), and a green glass bottle neck. Two of the beverage cans contained partially preserved labels that read "White Rock Orange…Luscious…True". White Rock was established in 1871 and is still in operation today. The fairy depicted on beverage cans is called "Psyche" and became the company logo after 1893 (Whiterockbeverages.com, 2010). The site is located near the historic Fishel railroad siding and probably dates to the early to mid-20th century.

CA-SBR-14912H (ESA-C-22)

This site was recorded on October 22, 2010 just south of the railroad access road. The site measures 6000 square feet, or 0.14 acre, and consist of a historic artifact scatter with four discrete debris concentrations (Figure 22). The site probably dates to the early to mid-20th century.

- Concentration 1 was comprised of 15 to 20 cans, some of which were partially buried. Types identified include over 6 hole-in-top cans, knife-opened sanitary cans, and one all-aluminum beverage can.
- Concentration 2 consisted of over 20 cans, most of which were crushed, partially disintegrated, and buried. Artifacts included sanitary cans, hole-in-top cans, coffee cans, and one whiteware fragment, as well as a cow bone fragment.
- Concentration 3 contained 10 to15 cans on a small dirt mound, most of which were too crushed to determine type, and sun-colored amethyst glass fragments. Identifiable cans included sanitary cans (can opener opened), and a few hole-in-top cans.
- Concentration 4 was comprised of approximately 10 cans, most of which were crushed and partially buried. Types identified include hole-in-top cans, sanitary cans, and pocket tobacco cans. An enameled tin cup with blue and white swirled pattern was also recorded.

Other artifacts observed across the site include cow bone fragments, sanitary cans, wire fragments, car parts, pocket tobacco cans, and a flattened metal bucket with a handle. The site is located near the historic Fishel railroad siding.

ESA-C-21 (to SW)

ESA-C-22 (to N)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 22

Photos: Newly Recorded Cultural Resources

CA-SBR-14913H (ESA-C-23)

This site was recorded on October 22, 2010 and is comprised of a historic scatter with over 50 cans within a 13,000 square foot area (0.30 acre), located north of the ARZC rail line (**Figure 23**). The cans included four hole-in-cap cans, hole-in-top cans, sanitary cans, pocket tobacco cans, two safety razor holders in a blue plastic and metal case labeled "Gillette", six key-opened meat tins, two large metal barrels, three sardine cans, as well as some clear glass fragments and a metal fork. Additionally, there was concentration of artifacts on the north end of the site, but outside of the Project area, that contained 20 cans, most of which were hole-in-top cans that were knife-opened across the bottom. There was also one square meat tin, a sardine can, a larger sanitary can (that was partially buried), a clear glass jar rim, and a burnt cow bone. The site is located near the historic Fishel railroad siding and probably dates to the early to mid-20th century.

CA-SBR-14914H (ESA-C-24)

This resource, recorded on October 22, 2010, is a historic scatter with five concentrations of artifacts, north of the ARZC rail line and near the historic Fishel railroad siding (Figure 23). The site measures 30,000 square feet, or 0.75 acre, and dates to the early to mid-20th century.

- Concentration 1 was comprised of seven cans (beverage and sanitary cans) in creosote bush as well as a large broken Coke bottle with a Maywood Glass Company maker's mark on the base consisting of "MG (slanted left)" (1930-1959) (Whitten, 2011).
- Concentration 2 contained 14 church-key-opened beverage cans in a creosote bush. One had a preserved label reading "White Rock Root Beer" with a drawing of a fairy. White Rock was established in 1871 and is still in operation today. The fairy depicted on beverage cans is called "Psyche" and became the company logo after 1893 (Whiterockbeverages.com, 2010).
- Concentration 3 consisted of approximately 50 church-key-opened beverage cans near two creosote bushes and two shoe soles with nails.
- Concentration 4 was comprised of approximately 60 cans, most of which were church-key-opened beverage cans, as well as five broken clear glass bottles with "California Wine Association" embossed on the base, two amber glass bottles, one glass jar, and two aluminum-top cans. The California Wine Association was established in 1894 and was dominant in the marketplace until Prohibition (1920) (Pinney, 1989: 356)
- Concentration 5 contained over 40 cans, mostly church-key-opened beverage cans, but also including sanitary cans, one meat tin, three aluminum-top pull-tab cans, and six clear glass bottles.

Other artifacts observed across the site include a 7-UP bottle with swim front label, a hole-in-cap can, a clear glass fragment, and 30 to 40 beverage cans. The 7-UP bottle with swim front label dates from 1937 to 1953 (Lockhart, 2005: 24).

ESA-C-23 (to E)

ESA-C-24 (to S)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 23

Photos: Newly Recorded Cultural Resources

CA-SBR-14915H (ESA-C-25)

This site is a small, discrete scatter of historic artifacts within a 100 square foot area recorded on October 22, 2010 (**Figure 24**). Artifacts observed included green and amber glass fragments, wood fragments, four complete amber bottles, five bottle necks (one green and four amber), one amber glass bottle base with "IPG" in a triangle (Illinois Pacific Glass Co., 1926-1930), one amber glass bottle base embossed with an "S" in a star (Southern Glass Co., 1926-1931), and one green glass bottle base embossed with the Clicquot Club Eskimo logo (1913-ca.1954) (Lockhart et al., 2005: 77; Lockhart et al., 2007: 52; Lockhart et al., 2009: 56; Milford Daily News, 2007). The site dates from ca. 1910s to 1950s.

CA-SBR-14916H (ESA-C-26)

This historic scatter, recorded on October 22, 2010 100 feet south of the railroad access road, contained 20 cans, most crushed or partially buried, within a 6000 square foot area (Figure 24). The site is bounded by the ARZC access road to the south and an older unused dirt access road to the north. There were five hole-in-top square meat tins (key-opened), three large hole-in-top cans ($4\text{-}^{9}/_{16}$ inches high by 4 inches in diameter), a gas can, four hole-in-cap cans, one sanitary can, and one hole-in-top can. Other artifacts included burnt bone, whiteware fragments with ivy-patterned decal, wire, 12 sun-colored amethyst glass fragments, and a jar rim. The site probably dates to the early to mid-20th century.

CA-SBR-14917H (ESA-C-27)

Recorded on October 22, 2010 just south of the railroad access road, this site consist of a can dump with approximately 25 cans, mostly hole-in-cap (**Figure 25**). There were two large hole-in-cap cans with machine soldered side seam, and 18 smaller hole-in-cap cans, as well as other cans that were too crushed to identify and some metal fragments. All artifacts were within a 900 square foot area. The site probably dates to the early 20th century.

CA-SBR-14918H ESA-C-28

This site was recorded on October 24, 2010 and is a small historic debris scatter measuring 19,596 square feet (Figure 25). The scatter included over 50 glass bottle fragments (clear, aqua, amber, and sun-colored amethyst). There were also over 25 fragments of ceramics and porcelain, as well as a few fragments of jadeite and one teacup. Observed cans include one rectangular meat can, three sanitary cans, three hole-in-top cans, several pull tab cans, church-key-opened beverage cans, and key-wind-opened sardine cans. Other artifacts consisted of one shoe sole, one plastic 4-hole button, and a milk-glass Ponds jar. Glass bottle types included beer/soda, bleach, and Cola-Cola. "La Vida Distinctive Beverages" and "Shasta" applied color labels and an amber jug fragment with "CLOROX" embossed on the shoulder were noted. Maker's marks observed on glass bottles include Owens-Illinois diamond O-I mark (1929-ca.1959), Latchford-Marble Glass Company "LM" in a circle mark (ca. 1939-1957), Lincoln Glass Bottle Company "L" in a keystone mark (1942-1952), and Fairmount Glass Works/Company "F" in a hexagon mark (1933-ca. 1968) (Toulouse, 1971; Whitten, 2011). The remains of sand fences were noted on either side of the tracks. The site probably dates to the early to mid-20th century.

ESA-C-25 (to S)

ESA-C-26 (to NW)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 24

Photos: Newly Recorded Cultural Resources

ESA-C-27 (to E)

ESA-C-28 (to SSE)

SOURCE: ESA, 2010.

Cadiz Valley Water Conservation, Recovery, and Storage Project . 210324

Figure 25

Photos: Newly Recorded Cultural Resources

Evaluation of Cultural Resources

A total of 43 cultural resources were recorded or updated as a result of this study. The following section provides the regulatory framework and preliminary significance evaluations for these resources.

Regulatory Framework

Numerous laws and regulations require federal, State, and local agencies to consider the effects a Project may have on cultural resources. These laws and regulations stipulate a process for compliance, define the responsibilities of the various agencies proposing the action, and prescribe the relationship among other involved agencies (e.g., State Historic Preservation Office and the Advisory Council on Historic Preservation). The National Historic Preservation Act (NHPA) of 1966, as amended; CEQA; and the CRHR, Public Resources Code (PRC) 5024, are the primary federal and State laws governing and affecting preservation of cultural resources of national, State, regional, and local significance.

Federal

Section 106 of the NHPA

Archaeological resources are protected through the NHPA of 1966, as amended (16 USC 470f), and its implementing regulation, Protection of Historic Properties (Code of Federal Regulations [CFR] 36 Part 800), the Archaeological and Historic Preservation Act of 1974, and the Archaeological Resources Protection Act of 1979. Prior to implementing an "undertaking" (e.g., issuing a federal permit), Section 106 of the NHPA requires federal agencies to consider the effects of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation and the State Historic Preservation Officer a reasonable opportunity to comment on any undertaking that would adversely affect properties eligible for listing in the NRHP. As indicated in Section 101(d)(6)(A) of the NHPA, properties of traditional religious and cultural importance to a tribe are eligible for inclusion in the NRHP. Under the NHPA, a resource is considered significant if it meets the NRHP listing criteria at 36 CFR 60.4.

National Register of Historic Places

The NRHP was established by the NHPA of 1966, as "an authoritative guide to be used by federal, State, and local governments, private groups and citizens to identify the Nation's historic resources and to indicate what properties should be considered for protection from destruction or impairment" (36 CFR Section 60.2). The NRHP recognizes both historical-period and prehistoric archaeological properties that are significant at the national, state, and local levels. In the context of the Project, which does not involve any historical-period structures, the following NRHP criteria are given as the basis for evaluating archaeological resources.

To be eligible for listing in the NRHP, a resource must be significant in American history, architecture, archaeology, engineering, or culture. Districts, sites, buildings, structures, and objects of potential significance must meet one or more of the following four established criteria (US Department of the Interior, 1995):

- Are associated with events that have made a significant contribution to the broad patterns of our history;
- Are associated with the lives of persons significant in our past;
- Embody the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- Have yielded, or may be likely to yield, information important in prehistory or history.

Unless the property possesses exceptional significance, it must be at least fifty years old to be eligible for NRHP listing (US Department of the Interior, 1995).

In addition to meeting the criteria of significance, a property must have integrity. Integrity is defined as "the ability of a property to convey its significance" (US Department of the Interior 1995). The NRHP recognizes seven qualities that, in various combinations, define integrity. To retain historic integrity a property must possess several, and usually most, of these seven aspects. Thus, the retention of the specific aspects of integrity is paramount for a property to convey its significance. The seven factors that define integrity are location, design, setting, materials, workmanship, feeling, and association.

State

The State implements the NHPA through its statewide comprehensive cultural resources surveys and preservation programs. The California Office of Historic Preservation (OHP), as an office of the California Department of Parks and Recreation, implements the policies of the NHPA on a statewide level. The OHP also maintains the California Historic Resources Inventory. The State Historic Preservation Officer (SHPO) is an appointed official who implements historic preservation programs within the State's jurisdictions.

California Register of Historical Resources

The CRHR is "an authoritative listing and guide to be used by State and local agencies, private groups, and citizens in identifying the existing historical resources of the State and to indicate which resources deserve to be protected, to the extent prudent and feasible, from substantial adverse change" (PRC § 5024.1[a]). The criteria for eligibility for the CRHR are based upon NRHP criteria (PRC § 5024.1[b]). Certain resources are determined by the statute to be automatically included in the CRHR, including California properties formally determined eligible for, or listed in, the NRHP.

To be eligible for the CRHR, a prehistoric or historical-period property must be significant at the local, State, and/or federal level under one or more of the following criteria:

- Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;
- Is associated with the lives of persons important in our past;

- Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values; or
- Has yielded, or may be likely to yield, information important in prehistory or history.

A resource eligible for the CRHR must meet one of the criteria of significance described above, and retain enough of its historic character or appearance (integrity) to be recognizable as a historical resource and to convey the reason for its significance. It is possible that a historic resource may not retain sufficient integrity to meet the criteria for listing in the NRHP, but it may still be eligible for listing in the CRHR.

Additionally, the CRHR consists of resources that are listed automatically and those that must be nominated through an application and public hearing process. The CRHR automatically includes the following:

- California properties listed on the NRHP and those formally Determined Eligible for the NRHP;
- California Registered Historical Landmarks from No. 770 onward; and,
- Those California Points of Historical Interest that have been evaluated by the OHP and have been recommended to the State Historical Commission for inclusion in the CRHR.

Other resources that may be nominated to the CRHR include:

- Historical resources with a significance rating of Category 3 through 5 (Those properties identified as eligible for listing in the NRHP, the CRHR, and/or a local jurisdiction register);
- Individual historical resources;
- Historical resources contributing to historic districts; and,
- Historical resources designated or listed as local landmarks, or designated under any local ordinance, such as an historic preservation overlay zone.

California Environmental Quality Act

CEQA is the principal statute governing environmental review of projects occurring in the State and is codified at PRC Section 21000 et seq. CEQA requires lead agencies to determine if a proposed project would have a significant effect on the environment, including significant effects on historical or archaeological resources.

Under CEQA (Section 21084.1), a project that may cause a substantial adverse change in the significance of an historical resource is a project that may have a significant effect on the environment. The *CEQA Guidelines* (Section 15064.5) recognize that an historical resource includes: (1) a resource listed in, or determined to be eligible by the State Historical Resources Commission, for listing in the CRHR; (2) a resource included in a local register of historical resources, as defined in PRC Section 5020.1(k) or identified as significant in a historical resource survey meeting the requirements of PRC Section 5024.1(g); and (3) any object, building,

structure, site, area, place, record, or manuscript which a lead agency determines to be historically significant or significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military, or cultural annals of California by the lead agency, provided the lead agency's determination is supported by substantial evidence in light of the whole record. The fact that a resource does not meet the three criteria outlined above does not preclude the lead agency from determining that the resource may be an historical resource as defined in PRC Sections 5020.1(j) or 5024.1.

If a lead agency determines that an archaeological site is a historical resource, the provisions of Section 21084.1 of CEQA and Section 15064.5 of the *CEQA Guidelines* apply. If a project may cause a substantial adverse change (defined as physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of an historical resource would be materially impaired) in the significance of an historical resource, the lead agency must identify potentially feasible measures to mitigate these effects (*CEQA Guidelines* Sections 15064.5(b)(1), 15064.5(b)(4)).

If an archaeological site does not meet the criteria for a historical resource contained in the *CEQA Guidelines*, then the site may be treated in accordance with the provisions of Section 21083, which is a unique archaeological resource. As defined in Section 21083.2 of CEQA a "unique" archaeological resource is an archaeological artifact, object, or site, about which it can be clearly demonstrated that without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

- Contains information needed to answer important scientific research questions and there is a demonstrable public interest in that information;
- Has a special and particular quality such as being the oldest of its type or the best available example of its type; or,
- Is directly associated with a scientifically recognized important prehistoric or historic event or person.

If an archaeological site meets the criteria for a unique archaeological resource as defined in Section 21083.2, then the site is to be treated in accordance with the provisions of Section 21083.2, which state that if the lead agency determines that a project would have a significant effect on unique archaeological resources, the lead agency may require reasonable efforts be made to permit any or all of these resources to be preserved in place (Section 21083.1(a)). If preservation in place is not feasible, mitigation measures shall be required.

The *CEQA Guidelines* note that if an archaeological resource is neither a unique archaeological nor a historical resource, the effects of the project on those resources shall not be considered a significant effect on the environment (*CEQA Guidelines* Section 15064.5(c)(4)).

Local

San Bernardino County General Plan

The Conservation Element of the recently adopted San Bernardino County General Plan (2007a) governs the natural and cultural resources of the County. The San Bernardino County General Plan has the following relevant goals and policies related to the protection of cultural resources.

GOAL CO 3. The County will preserve and promote its historic and prehistoric cultural heritage.

POLICIES

CO 3.1 Identify and protect important archaeological and historic cultural resources in areas of the County that have been determined to have known cultural resource sensitivity.

1. Require a cultural resources field survey and evaluation prepared by a qualified professional for Projects located within the mapped Cultural Resource Overlay area.

CO 3.2 Identify and protect important archaeological and historic cultural resources in all lands that involves disturbance of previously undisturbed ground.

1. Require the Archaeological Information Center at the San Bernardino County Museum to conduct a preliminary cultural resource review prior to the County's application acceptance for all land use applications in planning regions lacking Cultural Resource Overlays and in lands located outside of planning regions.

2. Should the County's preliminary review indicate the presence of known cultural resources or moderate to high sensitivity for the potential presence of cultural resources, a field survey and evaluation prepared by a qualified professional will be required with Project submittal.

CO 3.4 The County will comply with Government Code Section 65352.2 (SB 18) by consulting with tribes as identified by the California Native American Heritage Commission on all General Plan and specific plan actions.

1. Site record forms and reports of surveys, test excavations, and data recovery programs will be filed with the Archaeological Information Center at the San Bernardino County Museum, and will be reviewed and approved in consultation with that office.

   a. Preliminary reports verifying that all necessary archaeological or historical fieldwork has been completed will be required prior to Project grading and/or building permits.

   b. Final reports will be submitted and approved prior to Project occupancy permits.

3. When avoidance or preservation of an archaeological site or historic structure is proposed as a form of mitigation, a program detailing how such long-term avoidance or preservation is assured will be developed and approved prior to conditional approval.

CO 3.5 Ensure that important cultural resources are avoided or minimized to protect Native American beliefs and traditions.

5.b. The concerns of the Native American community will be fully considered in the planning process.

c. If human remains are encountered during grading and other construction excavation, work in the immediate vicinity will cease and the County Coroner will be contacted pursuant to the state Health and Safety Code.

a. In the event that Native American cultural resources are discovered during Project development and/or construction, all work in the immediate vicinity of the find will cease and a qualified archaeologist meeting US Secretary of Interior standards will be hired to assess the find. Work on the overall Project may continue during this assessment period.

b. If Native American cultural resources are discovered, the County will contact the local tribe. If requested by the tribe, the County will, in good faith, consult on the discovery and its disposition with the tribe.

Significance Evaluation of Cultural Resources

A total of 43 cultural resources were recorded or updated during the survey of the pipeline portion of the Project area, including three historic architectural/engineering resources and 39 historic-era archaeological resources, and one multi-component archaeological resource. Two archaeological resources, one historic-era site (CA-SBR-5819H) and the multi-component site (CA-SBR-5606/H) were not relocated within the Project area and are not addressed further in this report. Of the 41 resources located within the pipeline portion of the Project, ten are recommended eligible for listing in the NRHP and/or CRHR (**Table 5**) and should be considered significant resources under CEQA. The remaining 31 resources are recommended not eligible for listing in the CRHR and are therefore not considered significant resources under CEQA.

TABLE 5
SIGNIFICANT CULTURAL RESOURCES

Primary Number (P-36-)	Trinomial (CA-SBR-)	Field Designation	Description	Eligibility	Comments
003233	3233H	-	"Milligan" RR settlement remnants and cemetery	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
003235	3235H	-	"Saltmarsh" RR settlement remnants	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
003282	3282H	-	"Archer" RR settlement remnants and cemetery	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
003283	3283H	-	"Chubbuck" mill and settlement remnants	Previously recommended eligible for NRHP under Criteria A and D (therefore eligible for CRHR under Criteria 1 and 4)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
009853	9853H	-	ATSF RR – Parker Cutoff	Previously recommended eligible for NRHP under Criteria A and C (therefore eligible for CRHR under Criteria 1 and 3)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district
009858	9858H	-	1) WWII Tank Corps desert training site and 2) earlier railroad-related components	1) Previously recommended eligible for NRHP under Criteria A, C and D (therefore eligible for CRHR under Criteria 1, 2, and 4) 2) Previously recommended eligible for NRHP under Criteria A and D (therefore eligible for CRHR under Criteria 1 and 4)	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff and/or DTC district
010521	10521H	-	Colorado River Aqueduct	Previously recommended eligible for NRHP under Criteria A, B, and C (therefore eligible for CRHR under Criteria 1, 2, and 3)	-
010646	10646H	-	"Sablon" RR settlement remnants	Recommended eligible for CRHR under Criteria 1 and 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff and/or DTC district
011583	11583H	-	Cadiz-Parker Road	Recommended eligible for CRHR under Criterion 1	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district

Primary Number (P-36-)	Trinomial (CA-SBR-)	Field Designation	Description	Eligibility	Comments
023581	14895H	ESA-C-4	Extensive historic debris scatter	Recommended eligible for CRHR under Criterion 4	As an individual resource or as a contributor to a potential ATSF RR-Parker Cutoff district

Pipeline Portion of the Project Area

Historic Architectural/Engineering Resources

Three of the 41 resources encountered during the survey of the pipeline portion of the Project area are categorized as historic-era architectural/engineering resources (CA-SBR-9853H, CA-SBR-10521H, and CA-SBR-11583H). All three of these resources are recommended eligible for listing in the CRHR and should be considered significant resources under CEQA.

CA-SBR-9853H (ATSF Railroad, Parker Cutoff): This resource extends from the wellfield portion of the Project area along the same alignment as the proposed water conveyance pipeline. The ATSF Parker Cutoff was constructed in 1910, although trestles along the alignment bear later dates indicating that modifications have occurred. This resource was previously recorded by Applied Earthworks, Inc. in 1999, and consists of railroad tracks set on a raised grade on rock ballast. The resource was previously recommended eligible for listing in the NRHP under Criteria A and possibly C (Applied Earthworks, Inc., 1999: 55).

The railroad was observed during the 2010 ESA survey and found to be as previously described. Dates noted on the tracks themselves span from 1916 to the 1950s and the railroad is still in use. The resource appears to have changed little from the time of its original recording and appears to maintain integrity and its eligibility for listing in the NRHP; therefore it is considered eligible for listing in the CRHR under Criteria 1 and possibly 3. Resource CA-SBR-9853H should be considered a significant resource under CEQA.

CA-SBR-10521H (Colorado River Aqueduct): The CRA was constructed in the 1930s by the Metropolitan Water District of Southern California and is still in use. As recorded in 2000, the concrete-lined canal measures 50 feet wide at the top and is fenced on both sides. The CRA was previously recommended eligible for listing in the NRHP under Criteria A, B, and C (Neves and Goodman, 2000: 3) and is therefore eligible for listing in the CRHR. Resource CA-SBR-10521H should be considered a significant resource under CEQA.

CA-SBR-11583H (Cadiz-Parker Road): The recorded section of this dirt road extends between the historic railroad settlement sites of Cadiz and Rice, and generally follows the route of the ARZC (Historic ATSF Parker Cutoff). The road may be associated with construction of the ATSF Parker Cutoff, completed in 1910. The roadway has not been formally evaluated for its eligibility to the NRHP or the CRHR, but appears eligible for its association with the ATSF Parker Cutoff (CRHR Criterion 1). There is no evidence available at the present time to suggest

that the resource is eligible for its association with important persons (CRHR Criterion 2) or that the resource represents a distinctive type, style, or manufacture technology (CRHR Criterion 3). Given the nature of this resource, it does not have the potential to yield information important in history (CRHR Criterion 4). Since resource CA-SBR-11583H is recommended eligible for the CRHR under Criterion 1, it should be considered a significant resource under CEQA.

Archaeological Resources

Thirty-one of the 38 recorded historic-era archaeological resources are not recommended eligible for listing in the CRHR and do not otherwise meet CEQA's definitions for historical resources and unique archaeological resources (*CEQA Guidelines* 15064.5) (CA-SBR-9849H, -9850H, -9851H, -9856H, ESA-C-1, -C-2, -C-3, -C-5, -C-6, -C-7, -C-8, -C-9, -C-10, -C-11, -C-12, -C-13, -C-14, -C-15, -C-16, -C-17, -C-18, -C-19, -C-20, -C-21, -C-22, -C-23, -C-24, -C-25, -C-26, -C-27, and -C-28 [see Table 4 for corresponding trinomials for sites with temporary field designations]). These resources consist primarily of either surface scatters of historic trash, primarily containing non-diagnostic metal can and glass elements with no features, or are isolated non-diagnostic features. The underrepresentation of diagnostic materials from which to identify artifacts and date the resources limits their potential to yield information important in history (CRHR Criterion 4). While all resources can be broadly dated to the first half of the 20th century and are likely associated with human activity related to railroad construction and/or maintenance, none can be tied to specific historically-significant events or persons (CRHR Criteria 1 and 2). Likewise, the resources do not contain features or artifacts that represent a distinctive type, style, or manufacture technology (CRHR Criterion 3). These 31 resources are therefore not recommended eligible and have been exhausted of their limited data potential simply through the process of their recording on DPR 523 forms. No further work is recommended for these resources.

The remaining seven historic-era archaeological resources are recommended eligible for listing in the CRHR (CA-SBR-3223H, -3235H, -3282H, -3283H, 9858H, -10646H, and -14895H [ESA-C-4]). Five of these are associated with the historic settlements or railroad sidings of Milligan, Saltmarsh, Archer, Chubbuck, and Sablon (CA-SBR-3233H, -3235H, -3282H, and -3283H, -10646H, respectively). The remaining two resources recommended eligible are CA-SBR-9858H, a WW-II military encampment or supply depot with an earlier railroad component, and CA-SBR-14895H [ESA-C-4], a large historic artifact scatter. These resources are discussed in detail below.

Historic Settlements

CA-SBR-3233H (Milligan): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Milligan, which appears on maps as early as 1917-1918. The site is over 600,000 square feet (14 acres) in size and contains numerous structural remains, historic trees, a cemetery, and rather dense concentrations of historic artifacts, many with diagnostic qualities. This resource has not been previously evaluated for its eligibility for listing in the NRHP or CRHR (Crowley, 1978b).

CA-SBR-3235H (Saltmarsh): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Saltmarsh, which appears on maps as early as 1917-1918. The site is over 1.1 million square feet (26 acres) in size and contains numerous structural remains, a well, a loading platform, and concentrations of historic artifacts, many with diagnostic

qualities. This resource has not been previously evaluated for its eligibility for listing in the NRHP or CRHR (Crowley, 1978c).

CA-SBR-3282H (Archer): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement of Archer, which appears on maps as early as 1917-1918. The site is over 2 million square feet (46 acres) in size and contains a well, structural remains, a cemetery, and concentrations of historic artifacts, many with diagnostic qualities. Archer served as a watering station for steam locomotives along the line and was probably first occupied when the water well was drilled in 1910 (de Kehoe, 2007: 98). When the railroad switched to diesel locomotives in the 1950s, the site was abandoned (de Kehoe, 2007: 96). The small community was comprised primarily of Mexican laborers and their families (de Kehoe, 2007: 96-97). Applied Earthworks, Inc. (1999: Table 1) noted that site CA-SBR-3282H was likely a significant resource; however, the resource was not formally evaluated for its eligibility for listing in the NRHP or CRHR.

CA-SBR-3283H (Chubbuck): This historic-era archaeological site represents the remnants of the early to mid-20th century mining settlement/railroad siding of Chubbuck. Chubbuck was established in the early to mid 1920s as a mining settlement/railroad siding, but is not depicted in available historic maps. The site is over 1.1 miles long and contains numerous structural remains, including the remains of a mill, and extensive concentrations of historic artifacts. Charles Inglis Chubbuck, manufacturer of products used in cement and masonry, purchased a 1600-acre mining claim from Marcus Pluth and Tom Schofield in 1922. The claim contained a white limestone outcrop, perfect for cement manufacture, and was located about one-half mile west of the ATSF Parker Cutoff, facilitating shipment to market. Mr. Chubbuck built the primary crusher at the limestone quarry and kilns adjacent to the railroad tracks. Over 40 buildings were located at Chubbuck, including a company store, school (1932), post office (1938), and residential structures. Occupants were primarily Mexican laborers and their families (Applied Earthworks, Inc.,1999: 43). The mill ceased operation in 1951. Site CA-SBR-3283H was previously recommended eligible for listing in the NRHP by Applied Earthworks, Inc. (1999: 58) under Criteria A and D, for its association with the history of the railroad and early mining in the area. The site is therefore eligible for listing in the CRHR under Criteria 1 and 4.

CA-SBR-10646H (Sablon): This historic-era archaeological site represents the remnants of the early to mid-20th century settlement/railroad siding of Sablon, which appears on maps as early as 1917-1918. The site currently measures 820,395 square feet (18.8 acres) and contains several features, including dense artifact concentrations and structural features. Site CA-SBR-10646H was not evaluated for NRHP or CRHR eligibility at the time of its recordation (Pigniolo et al., 2001).

The five historic settlement sites (CA-SBR-3233H, -3235H, -3282H, -3283H, and -10646H) appear to be eligible for listing in the CRHR under Criteria 1 and 4. While the sites do appear to have been partially pothunted (as evidenced by shallow depressions), they appear to maintain a fair amount of integrity based on surface evidence observed during the course of the survey. Therefore, these five sites contain sufficient archaeological data to yield information significant to the history of the area (CRHR Criterion 4). The settlements of Milligan, Saltmarsh, Archer,

Chubbuck and Sablon are five of a number of settlements that began as small railroad siding or mining camps along the ATSF Parker Cutoff railroad. These settlements sprung up early in the 20th century primarily to support the railroad and local mining, and continued to be used for movement of goods and materials through the area during WWII and the mid 20th century. For this reason, the sites are also recommended eligible for events (CRHR Criterion 1) for their association with themes relating to transportation, mining, and possibly military activity. There is no evidence available at the present time to suggest the sites are eligible for their association with important persons (CRHR Criterion 2) or that the sites or their constituents represent a distinctive type, style, or manufacture technology (CRHR Criterion 3). Furthermore, the sites appear to be inextricably tied to the railroad and consideration of them as contributing elements to an as yet undefined ATSF Parker Cutoff railroad district, related to the themes mentioned, may deserve consideration.

WW-II Military Site

CA-SBR-9858H: This site appears to represent the remnants of an encampment or supply depot associated with WWII-era military training exercises and contains linear rock features and alignments designating roadways and other use areas along with several discrete scatters of refuse. The site also contains an earlier component related to the use of the site during the ATSF Parker Cutoff railroad's construction and/or use. The WWII-era military component of the site was recommended eligible for listing in the NRHP by Applied Earthworks, Inc. (1999: 57-58) in 1999 under Criteria A, C and D. The earlier railroad component was recommended as eligible for listing in the NRHP under Criteria A and D for its association with the history of the railroad. Since the site has been recommended as eligible for the NRHP, it is also considered eligible for the CRHR and should be considered a significant resource under CEQA.

Historic Debris Scatter

CA-SBR-14895H (ESA-C-4): This is a large (approx. 249,000 square foot) historic artifact scatter with three can concentrations, two glass concentrations, four concentrations of burnt bone, three rock cairns, and a general historic scatter of hundreds of cans and glass fragments, many of which contain diagnostic characteristics. The site likely dates to the early and possibly mid 20th century and may be associated with the early use of the railroad. The site does not contain structural remains, nor does it appear to coincide with any mapped historic settlement sites.

The size of the site and density of artifacts present suggests that this site contains sufficient archaeological data to yield information important to the local and regional history (CRHR Criterion 4). Based on surface evidence, it does not however appear to be associated with important events (CRHR Criterion 1) or persons (CRHR Criterion 2), nor does the site or any of the identified surface constituents appear to represent a distinctive type, style, or manufacture technology (CRHR Criterion 3).

Wellfield Portion of the Project Area

Less than 10 percent of the wellfield portion of the Project area has been previously surveyed. Sixteen cultural resources were identified during the records search as being located within or immediately adjacent to the wellfield portion of the Project area (CA-SBR-3243, -3281H, -

6693H, -6694H, -9848, -9853H, -9855H, -11582H, -11583H, -11584H, -11586H, P-36-020149, P-36-060315, P-36-060319, P-36-060922, and P-36-064132). Of these 16 resources, one (CA-SBR-6693H), the historic Atchison, Topeka, & Santa Fe Railroad, is known to have been evaluated and determined eligible for listing in the NRHP by Applied Earthworks, Inc. (1999) and another (CA-SBR-9855H), possibly containing a grave, is believed to be eligible, although sufficient study to determine this was never conducted. No archaeological survey of the wellfield portion of the Project area was conducted as part of this study effort since the precise location of wells pads and access roads were not finalized.. Therefore, the condition of the previously identified eligible resource (CA-SBR-6693H) and the potentially eligible resource (CA-SBR-9855H) have not been confirmed, nor has it been determined the number and types of any other cultural resources that might be present in the wellfield portion of the Project area.

Conclusions and Recommendations

A total of 43 resources were recorded or updated during the survey, two of which are no longer located within the Project area. Of the 41 resources located with the pipeline portion of the Project area, 10 are recommended eligible for listing in the CRHR and should be considered significant resources under CEQA. The remaining 31 resources are recommended not eligible for listing in the CRHR and are therefore not considered significant resources under CEQA.

Three of the eligible resources (CA-SBR-9853H, CA-SBR-11583H, and CA-SBR-10521H) are historic/architectural/engineering resources and are not anticipated to be subject to Project-related impacts that would result in a substantial adverse change in the significance of these resources.

Resource CA-SBR-9853H, the ATSF Railroad, Parker Cutoff, is considered eligible for listing in the CRHR under Criteria 1 and possibly 3. However, the proposed pipeline would be constructed at least 50 feet from the railroad. In some areas the pipeline may need to cross under the railroad; however, this would be accomplished via jack and bore or directional drilling construction methods, which would not impact the resource's eligibility for listing in the CRHR. Therefore, no significant impacts to CA-SBR-9853H as a result of the Project are anticipated.

Resource CA-SBR-11583H, Cadiz-Parker Road, may be associated with the construction of the ATSF Parker Cutoff and the early settlement of the region, and thus is recommended eligible for listing in the CRHR. However, the road would be used only for transportation of materials during Project construction, which would not impact the resource's eligibility for listing in the CRHR. Therefore, no significant impacts to CA-SBR-11583H as a result of the Project are anticipated.

Resource CA-SBR-10521H, the CRA, was recommended eligible for the NRHP and CRHR. The Project would connect the proposed water conveyance pipeline to the CRA's sidewall; however, Project construction would only impact a very small section of the CRA. Considering the length of the resource in relation to the size of the area to be impacted by the Project, an overall change to the resource's character or construction style is not anticipated. The Project is not anticipated to affect the resource's eligibility for listing in the NRHP or CRHR. Therefore, no significant impacts to CA-SBR-10521H as a result of the Project are anticipated.

The remaining seven of the significant historical resources considered eligible for the CRHR are archaeological sites located within the pipeline portion of the Project area (CA-SBR-3233H, CA-SBR-3235H, CA-SBR-3282H, CA-SBR-3283H, CA-SBR-9858H, CA-SBR-10646H, and CA-SBR-14895H [ESA-C-4]**)**. These seven sites may be impacted by the Project. Potential impact mechanisms to significant historical resources can include both surface disturbance by vegetation removal and by the movement of large construction vehicles and equipment, and subsurface disturbance through excavation or grading.

Avoidance is the preferred means of mitigating impacts to cultural resources. While mitigation through data recovery excavations would be a means to capture and preserve important data the resources contain, excavation is an inherently destructive process and would lead to the ultimate destruction of the resources. Thus, an attempt should be made to avoid impacts to these resources before data recovery is considered as a viable means of mitigating impacts. The construction zone should be narrowed or otherwise altered to avoid all significant historical resources where feasible. Significant resources should be marked with exclusion markers to ensure avoidance. A long-term management plan should be prepared for those resources or portions of resources that may be avoided.

However, of the seven significant archaeological resources, all but one (site ESA-C-4) are extensive sites that extend on both sides of the railroad tracks, and thus it may prove difficult to avoid impacts to the resources. If the Project will impact any of the resources that have been recommended eligible, a treatment plan that identifies procedures to reduce impacts to these resources should be developed by a qualified archaeologist and implemented prior to the issuance of Project permits. The treatment plan should include a research design and a scope of work for data recovery of the portion of the significant resources to be impacted by the Project. Treatment for most resources would consist of (but would not be not limited to) sample excavation, surface artifact collection, site documentation, and historical research, with the aim to target the recovery of important scientific data contained in the portion of the significant resource to be impacted by the Project. The treatment plan should include provisions for analysis of data in a regional context, reporting of results within a timely manner, and curation of artifacts and data at an approved facility.

As discussed above, no archaeological survey of the wellfield portion of the Project area was conducted as part of this study effort and therefore the number and types of resources located in this portion of the Project area are presently unknown. Prior to the issuance of Project permits, any areas that were not surveyed as part of this study, including the proposed wellfield and any new areas added to the Project area after the completion of this study, should be surveyed by a qualified archaeologist for the purposes of identifying eligible resources. The survey should identify and evaluate the significance of any potentially eligible resources that may be directly or indirectly impacted by the proposed Project, and should be documented in a Phase 1 Cultural Resources Survey report. Any eligible resources identified in newly surveyed areas should be avoided, where feasible, and appropriate treatment procedures implemented where avoidance is not possible.

Finally, there exists the possibility of uncovering previously unknown buried archaeological resources or human remains during Project construction. The high number of recorded prehistoric and historic-era archaeological sites within and adjacent to the Project indicate a potential for archaeological resources discoveries during Project implementation. In addition, the existence of historic burial sites within the Project area indicates that there is a potential for the discovery of human remains during Project implementation. A possible historic gravesite, documented as resource CA-SBR-9855H, was recorded in the wellfield portion of the Project area, and two historic-era cemeteries have been identified near the pipeline portion of the Project area. The cemetery at the historic railroad settlement of Archer (CA-SBR-3282H), which dates to the early 20th century, is located less than 10 feet outside of the Project area. The cemetery at the historic railroad settlement of Milligan (CA-SBR-3233H) is located less than 100 feet outside of the Project area. Neither of these cemeteries are located within the Project area and neither would be impacted. However, both cemeteries are located very close to the Project area. There remains a possibility that unmarked graves may exist near these cemeteries but outside of their marked boundaries. An exclusion zone of 50 feet outside of the cemeteries at Archer and Milligan should be established in order to minimize any inadvertent discovery of human remains.

Because of the Project area's sensitivity for buried archaeological resources and human remains, an archaeological monitor should monitor all ground-disturbing activities, including brush clearance and grubbing, within 100 feet of all significant historical resources. The monitor would work under the supervision of a qualified archaeologist. The duration and timing of monitoring should be determined by the qualified archaeologist in consultation with the lead agency and be based on the grading plans. In the event that cultural resources are unearthed during ground-disturbing activities, the archaeological monitor should be empowered to halt or redirect ground-disturbing activities away from the vicinity of the find so that the find can be evaluated and appropriate treatment determined. If human remains are uncovered during Project construction, all work in the vicinity of the find will be halted and the County Coroner will be contacted to evaluate the remains, and follow the procedures and protocols set forth in Section 15064.5 (e)(1) of the CEQA Guidelines. If the County Coroner determines that the remains are Native American, the NAHC will be contacted, in accordance with Health and Safety Code Section 7050.5, subdivision (c), and Public Resources Code 5097.98 (as amended by AB 2641). Per Public Resources Code 5097.98, the landowner shall ensure that the immediate vicinity, according to generally accepted cultural or archaeological standards or practices, where the Native American human remains are located, is not damaged or disturbed by further development activity until the landowner has discussed and conferred, as prescribed in this section (PRC 5097.98) with the most likely descendents taking into consideration their recommendations, and developing a treatment plan, taking into account the possibility of multiple human remains.

References

Anonymous, Site Record for P-36-060319, on file at SBAIC, San Bernardino County Museum, Redlands, n.d.

Anonymous, Combined Environmental and Historic Report, Arizona and California Railroad Company – Abandonment – in San Bernardino and Riverside Counties, CA (Between Rice and Ripley), Docket No. AB-1022 (Sub-No. 1X), on file at the San Bernardino Archaeological Information Center, 2008.

Applied Earthworks, Inc., Cadiz Groundwater Storage and Dry-Year Supply Program Environmental Planning Technical Report: Cultural Resources, 1999.

Bean, Lowell John, and Sylvia Brakke Vane, *The Native American Ethnography and Ethnohistory of Joshua Tree National Park: An Overview*, produced for the National Park Service, 2002.

Berry, J. and M. Miller, Site Record for CA-SBR-5819H, on file at SBAIC, San Bernardino County Museum, Redlands, 1985.

Bischoff, Matthew C., *The Desert Training Center/ California-Arizona Maneuver Area, 1942-1944: Historical and Archaeological Contexts*, Tucson, Arizona, Statistical Research, Incorporated, Technical Series 75, 2000.

CH2MHill, *Cadiz Groundwater Conservation and Storage Project*. July 2010.

Clorox Company, The, Bottle Guide, electronic document http://www.thecloroxcompany.com/company/history/bottleguide/index.html, accessed February 3, 2011.

Crowley, S., Site Record for CA-SBR-3281H, on file at SBAIC, San Bernardino County Museum, Redlands, 1978a.

Crowley, S., Site Record for CA-SBR-3233H, on file at SBAIC, San Bernardino County Museum, Redlands, 1978b.

Crowley, S., Site Record for CA-SBR-3235H, on file at SBAIC, San Bernardino County Museum, Redlands, 1978c.

Crowley, S., Site Record for CA-SBR-3282H, on file at SBAIC, San Bernardino County Museum, Redlands, 1978d.

de Kehoe, Joe, *The Silence and the Sun*. Trails End Publishing Company, Bakersfield, CA, 2007.

Dietler John and Julianne Toenjes, Site Record for CA-SBR-5606/H, on file at SBAIC, San Bernardino County Museum, Redlands, 2001a.

Dietler John and Julianne Toenjes, Site Record for CA-SBR-10645H, on file at SBAIC, San Bernardino County Museum, Redlands, 2001b.

Dietler, John, Julianne Toenjes, and Stephanie Rose, Site Record for CA-SBR-10646H, on file at SBAIC, San Bernardino County Museum, Redlands, 2001.

Easter, P., C. Inoway, J. George, J. Panaigua, Site Record for CA-SBR-9853H, on file at SBAIC, San Bernardino County Museum, Redlands, 1999.

Eckhart, W., Site Record for CA-SBR-3243, on file at SBAIC, San Bernardino County Museum, Redlands, 1978a.

Eckhart, W., Site Record for P-36-060315, on file at SBAIC, San Bernardino County Museum, Redlands, 1978b.

Erickson, Kirsten, Site Record for CA-SBR-6693H, on file at SBAIC, San Bernardino County Museum, Redlands, 2008.

Fike, Richard E., *The Bottle Book: A Comprehensive Guide to Historic, Embossed Medicine Bottles*, Blackburn Press, Caldwell, New Jersey, 2006.

Glover, L., et al., Site Record for CA-SBR-6693H, on file at SBAIC, San Bernardino County Museum, Redlands, 1990.

Greene, Linda W., *Historic Resource Study: A History of Land Use In Joshua Tree National Monument.* Performed for Branch of Cultural Resources Alaska/Pacific Northwest/Western Team, US Department of the Interior National Park Service, 1983.

Gudde, Erwin Gustav, *California Place Names*, University of California Press, Berkeley, CA, 1969.

Hamilton, M. Colleen, Site Record for CA-SBR-3283H, on file at SBAIC, San Bernardino County Museum, Redlands, 1999.

Inoway C., and J. Panaigua, Site Record for CA-SBR-9855H, on file at SBAIC, San Bernardino County Museum, Redlands, 1999a.

Inoway C., and J. Panaigua, Site Record for P-36-064132, on file at SBAIC, San Bernardino County Museum, Redlands, 1999b.

Inoway, C., P. Easter, J. Panaigua, Site Record for CA-SBR-9848, on file at SBAIC, San Bernardino County Museum, Redlands, 1999a.

Inoway, C., P. Easter, J. Panaigua, Site Record for CA-SBR-9849, on file at SBAIC, San Bernardino County Museum, Redlands, 1999b.

Inoway, C., P. Easter, J. Panaigua, Site Record for CA-SBR-9850, on file at SBAIC, San Bernardino County Museum, Redlands, 1999c.

Inoway, C., P. Easter, J. Panaigua, Site Record for CA-SBR-9851, on file at SBAIC, San Bernardino County Museum, Redlands, 1999d.

Inoway, C., P. Easter, J. George, Site Record for CA-SBR-9852, on file at SBAIC, San Bernardino County Museum, Redlands, 1999e.

Kelly, I. T., and C.S. Fowler, "Southern Paiute", in *Handbook of North American Indians, Volume 11: Great Basin*, edited by Warren L. D'Azevedo, pp. 368-397, Smithsonian Institution, Washington, 1986.

King, C., and D. G. Casebier, *Background to Historic and Prehistoric Resources of the East Mojave Desert Region*, Report prepared by Archaeological Research Unit, University of California, Riverside, Submitted to the US Department of the Interior, BLM, Riverside, California, 1976.

Kremmerer, J., *Map of San Bernardino County, California Showing Roads, Railroads, Springs, and Mining Districts of the Desert Portion*, 1925.

Kroeber, A. L., *Handbook of the Indians of California*, Reprint Edition of 1976, Dover Publications, New York, 1925.

Lerch, M., Site Record for CA-SBR-6694H, on file at SBAIC, San Bernardino County Museum, Redlands, 1990.

Lockhart, Bill, The Dating Game: Owens-Illinois Glass Co., *Bottle and Extras*, pp. 24-27, 2004a.

Lockhart, Bill, The Dating Game: The A-B Connected Mark, *Bottles and Extras*, pp. 16-17, 2004b.

Lockhart, Bill, The Other Side of the Story: A Look at the *Back* of Seven-Up Bottles, *The Soda Fizz*, Vol. 3, No. 1, pp. 20-24, January-February 2005.

Lockhart, Bill, P. Schulz, C. Serr, and B. Lindsey, The Dating Game: Southern Glass Co., *Bottles and Extras*, pp. 50-61, 2009.

Lockhart, Bill, M. Miller, B. Lindsey, C. Serr, and D. Whitten, The Dating Game: Illinois Pacific Glass Company, *Bottles and Extras*, pp. 73-80, 2005.

Lockhart, Bill, P. Schulz, C. Serr, B. Lindsey, and D. Whitten, The Dating Game: The American Bottle Co., A Study in Contracts and Contradictions, *Bottles and Extras*, pp. 47-58, 2007.

McDougall, D. D. Bircheff, and J. George, Site Record for CA-SBR-9856H, on file at SBAIC, San Bernardino County Museum, Redlands, 1999a.

McDougall, D. D. Bircheff, P. Easter, and J. Paniagua, Site Record for CA-SBR-9856H, on file at SBAIC, San Bernardino County Museum, Redlands, 1999b.

Milford Daily News, Mr. Know-It-All: Clivquot Club Finally Fizzled Out in Millis, electronic document http://www.milforddailynews.com/entertainment/arts/x14163901 accessed November 24, 2010, 2007.

Myrick, David, F., *Railroads of Nevada and Eastern California: Volume Two-The Southern Roads*, Howell-North Books, Berkeley, California, 1963.

Neves, J., and J. Goodman, Site Record for CA-SBR-10521, on file at SBAIC, San Bernardino County Museum, Redlands, 2000.

Pigniolo, Andrew R., John Dietler, and Stephanie Murray, Cultural Resources Survey Report for the All American Pipeline Replacement Project, Daggett to Blythe, San Bernardino and Riverside Counties, California, prepared for KEA Environmental, Inc., prepared by Tierra Environmental Services, 2001.

Pinney, Thomas, *A History of Wine in America from the Beginnings to Prohibition: Volume 1*, University of California Press, Berkeley, 1989.

Purcell, D.E., Site Record for CA-SBR-10525H, on file at SBAIC, San Bernardino County Museum, Redlands, 2000.

Rustycans.com, Can of the Month: Eastside Beer, electronic document http://www.rustycans.com/COM/month0305.html accessed on December 15, 2010, 2005.

SHA (Society for Historical Archaeology), Machine-Made Bottle Dating, electronic document http://www.sha.org/bottle/machinemadedating.htm#Question%2010, accessed February 3, 2011a.

SHA (Society for Historical Archaeology), Bottle Finished & Closures, electronic document http://www.sha.org/bottle/finishes.htm, accessed February 3, 2011b.

Shepard, G., Site Record for P-36-060922, on file at SBAIC, San Bernardino County Museum, Redlands, 1963.

Simonis, Don, Condensed/Evaporated Milk Cans – Chronology for Dating Historical Sites, in *IMACS User's Guide*, 2001.

Sutton, Mark Q., Mark E. Basgall, Jill K. Gardner, and Mark W. Allen, "Advances in understanding Mojave Desert Prehistory", in *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, pp 229-245, 2007.

Thompson, David G., *Relief Map of Part of Mohave Desert Region Showing Desert Watering Places*, USGS Survey, 1917-1918.

Toulouse, Julian Harrison, *Bottle Makers and Their Marks*, Thomas Nelson Inc., New York, 1971.

Underwood, Jackson, Site Record for CA-SBR-11582H, on file at SBAIC, San Bernardino County Museum, Redlands, 2004a.

Underwood, Jackson, *Cultural Resources Survey of the Cadiz Lateral/Interconnect, a Potential Future Facility of the Line 1903 Project, San Bernardino County, CA*, prepared for ENSR International, prepared by EDAW, Inc., 2004b.

Underwood, Jackson, Site Record for CA-SBR-11583H, on file at SBAIC, San Bernardino County Museum, Redlands, 2004c.

Underwood, Jackson, Site Record for CA-SBR-11584H, on file at SBAIC, San Bernardino County Museum, Redlands, 2004d.

Underwood, Jackson, Site Record for CA-SBR-11586H, on file at SBAIC, San Bernardino County Museum, Redlands, 2004e.

Underwood, Jackson and Gay Hillard, Site Record for P-36-020149, on file at SBAIC, San Bernardino County Museum, Redlands, 2004d.

US Army, *Milligan 15' Topographic Map*, War Department Corps of Engineers, US Army, 1943.

US Army, *Rice 15' Topographic Map*, War Department Corps of Engineers, US Army, 1944.

US Department of the Interior, National Park Service. *National Register Bulletin: How to Apply the National Register Criteria for Evaluation.* National Park Service, Washington, D.C., 1995.

USGS, *Cadiz 15' Topographic Map*, US Department of the Interior Geological Survey, 1956.

USGS, *Cadiz Lake 15' Topographic Map*, US Department of the Interior Geological Survey, 1956.

USGS, *Iron Mountains 15' Topographic Map*, US Department of the Interior Geological Survey, 1956.

USGS, *Milligan 15' Topographic Map*, US Department of the Interior Geological Survey, 1956.

USGS, *Rice 15' Topographic Map*, US Department of the Interior Geological Survey, 1954.

Vredenburgh, Larry M., *An Overview of Mining in the California Desert*, electronic document http://vredenburgh.org/mining_history/pages/mining_overview2005.htm, accessed December 15, 2010; 2005.

Vredenburgh, Larry M., *The Mojave Desert Mining Community of Chubbuck*, electronic document http://vredenburgh.org/mining_history/pages/chubbuck.html accessed December 15, 2010, 1981 [revised 1996].

Vredenburgh, Larry M, Shumway, Gary L, and Russell D. Hartill, *Desert Fever: An Overview of Mining in the California Desert* , Canoga Park, Living West Press, 1981.

Warren, C. N., "The Desert Region", In *California Archaeology*, Coyote Press, Salinas, California, 1984.

Warren, Elizabeth Von Till, Robert H. Crabtree, Claude N. Warren, Martha Knack, and Richard McCarty, *A Cultural Resources Overview of the Colorado Desert Planning Units,* BLM Cultural Resources Publication, Bureau of Land Management, California, 1981.

Whiterockbeverages.com, Early History of White Rock, electronic document http://www.whiterockbeverages.com/ accessed on November 24, 2010.

Whitten, David, Glass Factory Marks on Bottles, electronic document http://www.myinsulators.com/glass-factories/bottlemarks.html accessed on January 11, 2011.

Appendix A
Personnel Qualifications

MADELEINE BRAY

Archaeologist

Madeleine Bray is an archaeologist and cultural resources project manager with 10 years of survey, excavation and mapping experience related to historically significant sites. She has managed numerous projects in California in compliance with CEQA and with Section 106 of the National Historic Preservation Act, including Phase I surveys, site significance testing and evaluation, mitigation recommendations, and archaeological construction monitoring. She has worked extensively throughout southern California, with particular experience in the context of the Mojave and California deserts, historic mining sites, and historic artifacts. She is currently involved in several fieldwork efforts in Los Angeles County. Internationally, she has participated in the excavation of a Roman temple in Omrit, Israel, and in the pedestrian and geophysical survey of Sikyon, an important urban site in Greece.

Education

M.A., Archaeology, University of California, Los Angeles

B.A., Classical Archaeology, Macalester College, Saint Paul, Minnesota

Years Experience: 10

Professional Affiliations

Society for American Archaeology

Register of Professional Archaeologists

Qualifications

Meets Secretary of the Interior's Standards

Riverside County certified

CA State BLM Permitted

Certified in CA BLM Protocol

Continuing Education

ACHP Section 106 Basics seminar

Riverside County certification course, 2007 and 2009

Relevant Experience

City of Los Angeles Recreation and Parks Hansen Dam Skate Park Project, Los Angeles County, CA. *Archaeologist.* ESA prepared a joint EA and ISMND for the Los Angeles Department of Recreation and Parks (DRP) in coordination with the U.S. Army Corps of Engineers (Corps) for a proposed skate park facility within the Hansen Dam Recreation Area. Madeleine conducted archival research, facilitated Native American outreach, performed an archaeological survey of the project site, coordinated with the Corps, and co-authored the technical report and EA/ISMND cultural resources section.

CPUC Presidential Substation Project, Ventura County, CA. *Cultural Resources Project Manager.* ESA prepared an EIR under contract to the CPUC to evaluate the potential impacts from Southern California Edison's proposed Presidential Substation project. This project included the construction of a substation and associated subtransmission lines. The project was controversial and faced significant community opposition due to aesthetic and other issues. Madeleine reviewed cultural resources technical documents and assisted in drafting the cultural resources EIR section. Madeleine also coordinated with SCE regarding mitigation for a significant archaeological site within the project area.

Bureau of Land Management On-Call Cultural Resources Services. Riverside County, CA. *Archaeologist.* ESA has been retained by the Bureau of Land Management under an on-call contract to provide cultural resource services including compliance monitoring for projects under BLM jurisdiction. Madeleine has participated in a number of projects for the BLM (Palm Springs South Coast Field Office) providing a wide range of cultural resources services for solar projects and other projects taking place on BLM lands in compliance with Section 106 and specified BLM protocols, including compliance monitoring and peer review, Phase 1 archaeological resources surveys, resource evaluations, the preparation of reports, and Native American consultation.

Relevant Experience (Continued)

Sweetwater Reservoir Water Main Replacement. San Diego County, CA. ***Cultural Resources Project Manager.*** ESA was retained by Sweetwater Authority to prepare an IS/MND for the replacement of a 36-inch pipeline leading from Sweetwater Dam. Sweetwater Dam is a National Register-eligible structure that was originally constructed in the late 19th century and was subject to upgrades in 1917. Madeleine conducted a Phase 1 Cultural Resources Assessment including archival research, pedestrian, survey, historical research, Native American outreach, and the preparation of a technical report documenting archaeological and historic-architectural resources that might be impacted by the project. The study concluded that features that would be altered by the project that were contributing elements to the historic dam would need to be replaced in kind.

Bureau of Land Management Abandoned Mine Land Archaeological Inventories, San Diego County, Kern County, San Bernardino County, and Riverside County, CA. ***Cultural Resources Project Manager.*** ESA has been retained to provide cultural resources services to the BLM in connection with the Abandoned Mine Lands program. The BLM proposes to conduct remediation of physical safety hazards associated with Abandoned Mine Lands. Remediation would consist of backfilling or closing off mine shafts, adits, and prospects. ESA prepared archaeological inventory reports documenting the abandoned mines, in compliance with Section 106 of the NHPA. Madeleine performed archival and historic research, coordinated with the BLM, led a team of surveyors in the documentation of over 100 mining features, and authored reports summarizing the documentation and providing significance and treatment recommendations.

City of Calabasas Archaeological Resource Mapping, Calabasas, CA ***Cultural Resources Project Manager.*** ESA was awarded an on-call contract by the City of Calabasas to provide environmental compliance services. The City requested that ESA conduct a city-wide archaeological records search and prepare confidential archaeological resources maps and materials to assist the city in planning and permitting endeavors. Maps and documents were linked electronically for quick reference to parcel information. Madeleine conducted a records search to identify and inventory previously recorded sites and provided quality control for the completed maps.

Red Mountain Ridge Wind Project, Kern County, CA ***Cultural Resources Project Manager.*** Madeleine conducted an archaeological constraints study of the project site, including research concerning previous archaeological work in proximity to the project site, nearby archaeological sites, and Native American sacred lands. ESA conducted a 30-45 day fatal flaw analysis for biological, cultural, and paleontological resources on the proposed 7.5 square-mile Red Mountain Ridge Project, which included approximately 8 miles of transmission line.

Relevant Experience (Continued)

Bureau of Land Management Santa Rosa National Monument Archaeological Survey, Riverside County, CA. *Archaeologist.* Madeleine assisted in conducting pedestrian archaeological studies of the 394-acre project area and in the documentation of seven new archaeological sites. ESA has been retained by the Bureau of Land Management under an on-call contract to provide cultural resource services including compliance monitoring for projects under BLM jurisdiction.

Bureau of Land Management Field Verification Studies, Blythe, Riverside County, CA. *Archaeologist.* ESA is providing support services to the BLM for the processing of applications for solar development on BLM lands. Madeleine led several projects that provided field verification, on behalf of the Bureau of Land Management, of Class III archaeological surveys.

Sacramento County Airport Systems Archaeological Monitoring, Sacramento, CA. *Archaeological Monitor*. ESA is providing on-call natural resources support and consulting services for the Sacramento County Airport System. Madeleine served as an archaeological monitor for the Sacramento County Airport Systems prior to routine disking at the Sacramento International Airport. Tasks included monitoring of disking activities and survey of the project area concurrent with or immediately following disking, documentation of the project including a daily monitoring log and photographs, analysis of cultural materials found during the course of construction, and the preparation of a final monitoring report.

Irvine Ranch Water District Baker Treatment Plant, Orange County, CA. Technical Analyst. *Cultural Resources Project Manager.* ESA was retained by the Irvine Ranch Water District (IRWD) to prepare an EIR for IRWD's Baker Treatment Plant near Lake Forest, Orange County. Madeleine conducted archaeological studies of the project site, including archival research and field survey, and prepared cultural resources technical reports and the cultural resources section of the EIR.

EMWD Gravity Sewer Project, Murrieta, Riverside County, CA. *Cultural Resources Project Manager*. Madeleine conducted archaeological studies of the project site, including archival research and field survey, and prepared a cultural resources technical report and cultural resources section of the ISMND. ESA prepared a Mitigated Negative Declaration for the installation of a sewer system in Murrieta, Riverside County.

Fast and Furious 5 Project, Rice and Vidal, Riverside and San Bernardino Counties, CA. *Archaeologist.* ESA has been retained by the Bureau of Land Management under an on-call contract to provide cultural resource services including compliance monitoring for projects under BLM jurisdiction. Madeleine assisted in the preparation of cultural resources technical studies for the Fast and Furious 5 project. ESA prepared a Phase 1 archaeological resources study, biological survey, and Environmental Assessment for a project area on

Relevant Experience (Continued)

BLM lands for which the BLM may grant a Special Use Film permit. Madeleine conducted archival research and assisted in the preparation of a Phase 1 Archaeological Resources Survey Report.

LAUSD Central Los Angeles High School #9, *Los Angeles, CA. Report contributor.* This project involved the construction of LAUSD Central High School #9, a new performing arts high school, in downtown Los Angeles. Over a 2-year period, data recovery of archaeological materials in connection with the 19th century Los Angeles City Cemetery in downtown Los Angeles was conducted. Madeleine assisted in drafting portions of the final report for the archaeological excavation.

Metropolitan Airpark Project, San Diego, CA. *Cultural Resources Project Manager.* ESA is preparing a master development plan, EIR, and EA for Metropolitan Air Park at Brown Field Airport in the City of San Diego. The project involves a 50-year land lease from the City of San Diego for a 400-acre portion of the airport property to be developed into airport and non-airport related land uses. The project requires the approval of the City of San Diego and the Federal Aviation Administration, and is being processed as Master Planned Development Permit Project. Madeleine managed the preparation of cultural resources technical studies for the Metropolitan Airpark project, including archival research and field surveys, and is managing the preparation of a Phase 1 Archaeological Resources Survey Report that addresses the significance of known sites and provides an impacts analysis and mitigation measures.

Antelope Valley Water Bank Recharge and Recovery Facility Improvement Project, Antelope Valley, CA. *Archaeologist*. ESA was retained by GEI Consultants, Inc. to conduct a Phase 1 Archaeological resources Assessment in connection with a groundwater banking project designed to provide up to 500,000 acre-feet of total surface water storage capacity underground in a partially depleted aquifer. The project is being carried out by the Antelope Valley East Kern Water Agency with the assistance of a Challenge Grant from the Bureau of Reclamation. Madeleine assisted in the preparation of archaeological technical studies for the Antelope Valley Water Bank project. Tasks included archival research, archaeological field survey, the preparation of Department of Parks and Recreation forms, and the preparation of a Section 106-compliant Phase I archaeological study.

The Cove Cultural Landscape Restoration, San Jacinto, Riverside County, CA. *Archaeological Monitor.* Madeleine periodically served as an archaeological construction monitor for The Cove Cultural Landscape Restoration Project. Tasks included ensuring compliance with project mitigation measures and relevant regulations, documentation of the project including a daily monitoring log and photographs, and analysis of cultural materials found during the course of construction.

Relevant Experience (Continued)

Department of Water Resources, East Branch Enlargement EIR. Antelope Valley, CA. ***Cultural Resources Project Manager.*** Madeleine coordinated the preparation of cultural resources technical studies for the EBE project, which will involve the enlargement of 100 miles of the California Aqueduct from the Tehachapi split through the Antelope Valley and Mojave River Basin to Silverwood Reservoir. Madeleine analyzed and summarized records search results, which resulted in identification of 130 cultural resources near the project area. She drafted a survey strategy for DWR approval, coordinated with DWR, and completed archaeological field survey of the 98-mile project area. She preparing the draft survey report and completed site records for the more than 100 cultural resources identified during survey. The Project is being carried out in compliance with CEQA and Section 106 of the NHPA. Impacts and mitigation measures will be addressed in the Cultural Resources section of the Project EIR. ESA has conducted technical studies to complete the EIR and has begun negotiating permit requirements and restoration planning with resource agencies including the USACE, RWQCB, and USFWS.

CPUC San Joaquin Cross Valley Loop Project, Tulare County, CA. ***Technical Analyst.*** Madeleine reviewed cultural resources technical documents and assisted in drafting the cultural resources EIR section for the CPUC San Joaquin Cross Valley Loop Project. ESA was selected by the CPUC to prepare an EIR for SCE's proposed San Joaquin Cross Valley Loop Project in Tulare County. The proposed project would involve construction of approximately 20 miles of 220 kV transmission line in mostly new right-of-way through agricultural and rural residential areas. SCE's proposed route was very unpopular with many local residents, so ESA implemented a rigorous public outreach program to engage the stakeholders in meaningful dialogue. Key technical issues which ESA addressed in the CEQA process included biological and cultural resources, aesthetics, land use and agriculture, and air quality and greenhouse gases.

Nacimiento Water Project Environmental Services, San Luis Obispo, CA. ***Technical Analyst/Archaeological Monitor*****.** Madeleine reviewed existing technical documents produced by sub-contracted specialists, particularly those pertaining to the evaluation and assessment of cultural resources and potential project impact on such resources. She also performed 8 weeks of cultural resources construction monitoring during the construction of the NWP, and assisted with as-needed archaeological pre-construction surveys and data recovery excavations. The project modifications include pipeline realignments, new turnouts, pump stations and reservoirs, and new water customers. The project consists of 45 miles of pipe, 3 storage tank sites, 3 pump stations, and an intake tower at Nacimiento Dam. ESA developed permit strategies, support district negotiations with regulatory agencies, prepared necessary biological and cultural assessments, assisted with mitigation planning, and developed a master mitigation and permit database.

Relevant Experience (Continued)

Department of Water Resources East Branch Extension Project. San Bernardino County, CA. *Archaeologist.* Madeleine assisted in the technical editorial review of the Cultural Resources section for the East Branch Extension (EBXII) EIR. She reviewed archaeological technical reports; helped revise the cultural EIR section; researched and assisted in the preparation of a historic evaluation of Grand Central Rocket Company facilities, and completed extended Phase I cultural resources surveys. She also assisted in the preparation of a cultural resources evaluation report. ESA prepared an EIR assessing potential impacts of the East Branch Extension Phase II Project, which will install 6 miles of pipeline across the Santa Ana River near Redlands. The new pipeline will increase water delivery capacity to the San Gorgonio Pass Water Agency serving the cities of Banning and Beaumont. The project includes construction of the Citrus Reservoir, a 26-acre lined storage reservoir that will require excavation and hauling off site of 1.8 million cubic yards of material over a three year construction period. ESA has managed biological surveys of the project corridor and is assisting in agency consultation required for natural resource permitting with the USFWS, CDFG, RWQCB, and the USACE.

Canyon Hills Cultural Resources Assessment. Lake Elsinore, CA. *Archaeologist.* ESA was retained by Pardee Homes to prepare a cultural resources assessment for Phases 7 & 8 of the Canyon Hills Specific plan. ESA conducted a Phase 1 and Phase II Archaeological Resources Investigation, identifying resources that might be impacted by the project. Monica directed the Phase II Testing Program to determine California Register and National Register eligibility of a recorded prehistoric archaeological site. Madeleine conducted archival research and managed the Phase I archaeological field survey and report. She assisted in conducting the Phase II archaeological evaluation.

West Kern Water District Groundwater Recharge Project EIR. Kern County, CA. *Cultural Resources Project Manager.* Madeleine managed the preparation of cultural resources technical studies for the West Kern Water District project. ESA is preparing a Phase 1 archaeological resources study of a 500-acre Project area proposed for groundwater recharge basins and a 9-mile pipeline in Kern County. The Project is being carried out in compliance with CEQA and Section 106 of the NHPA. The survey resulted in the identification of over 20 archaeological sites. Madeleine conducted archival research and field surveys and managed the preparation of a Phase 1 Archaeological Resources Survey Report and Cultural Resources EIR Section that addressed the significance of known sites and provided an impacts analysis and mitigation measures.

Joshua Basin Water District Recharge Basin and Pipeline Project. Joshua Tree, San Bernardino County, CA. *Cultural Resources Project Manager.* ESA was retained by the Joshua Basin Water District to prepare and EIR for the JBWD Recharge Basin and Pipeline Project, located in Joshua Tree. The project would involve the construction of a recharge basin and six-mile pipeline. Madeleine conducted an archaeological field survey at the project site, wrote the

Relevant Experience (Continued)

technical report summarizing the survey findings, and prepared the cultural resources section for the EIR. Madeleine prepared and submitted Department of Parks and Recreation forms for the 10 cultural resources found during the survey. In addition, Madeleine conducted a record search for previous archaeological work in proximity to the project site, including nearby Native American sacred lands and paleontological sensitivity. Finally, she prepared an updated Section 106-compliant Phase I archaeological study that was submitted to the EPA as part of an application for EPA funding.

City of Ventura Water and Sewer Main Replacement Project, Ventura County, CA. ***Cultural Resources Project Manager and Archaeological Monitor*****.** ESA provided on-call cultural resources monitoring services to the City of Ventura. The Water and Sewer Main Replacement Project involved the replacement of deteriorated water and sewer mains along city streets. Madeleine served as project manager and archaeological monitor for the project. Tasks included ensuring compliance with project mitigation measures and relevant regulations, documentation of the project including a daily monitoring log and photographs, and analysis of cultural materials found during the course of construction.

Morro Bay Cayucos Wastewater Treatment Plant Upgrade. Morro Bay, CA. ***Cultural Resources Project Manager.*** ESA was retained by the Morro Bay-Cayucos Sanitary District to produce and EIR for the Morro Bay-Cayucos Wastewater Treatment Plant (WWTP) Upgrade Project. Madeleine conducted archaeological studies of the project site, including research concerning previous archaeological work in proximity to the project site, nearby Native American sacred lands, and paleontological sensitivity. She prepared the cultural resources section of the EIR. The project would upgrade the WWTP to tertiary treatment and enable it to discharge an average of 1.5 mgd of tertiary-treated effluent to the ocean. ESA is working with the City of Morro Bay and Cayucos Sanitary District to meet the 8-Year Full Secondary Compliance Schedule for the WWTP.

City of Coachella General Plan EIR. Coachella, CA. ***Technical Analyst.*** ESA prepared an EIR for the City of Coachella General Plan, which will update allowable land uses and policies to guide the city thorough 30 years of growth. Madeleine prepared the cultural resources portion of the Existing Conditions Report for the City of Coachella General Plan EIR. She conducted research concerning the history of Coachella and the 195 known archaeological and historical sites within the 16 square miles that constitute the City of Coachella. The City of Coachella is a small but developing city, which includes extensive residential and commercial development, as well as agricultural and vacant land.

Special Needs Ball Field IS/MND and EA/FONSI. Los Angeles, CA. ***Cultural Resources Project Manager.*** ESA prepared a joint EA/FONSI and IS/MND and for the U.S. Army Corps of Engineers (Corps) and Los Angeles Department of Recreation and Parks (DRP), in partnership with the Los Angeles

Relevant Experience (Continued)

Dodgers Dream Foundation, for a proposed wheelchair accessible softball field within the Sepulveda Basin Recreation Area, Anthony C. Beilenson Park, Los Angeles, California. The proposed action would include a 50-foot softball field with backstop, dugouts, and field fencing. The field will take advantage of the existing universally accessible restroom and parking lot with ADA access. Madeleine conducted research concerning previous archaeological work in proximity to the project site, nearby archaeological sites and Native American sacred lands, and paleontological sensitivity. She also helped facilitate consultation with the State Historic Preservation Officer on behalf of the Army Corps of Engineers, as required by Section 106 of the National Historic Preservation Act. Finally, she prepared the cultural resources section of the ISMND.

Las Virgenes MWD Backbone Improvement Project, Calabasas, CA. ***Cultural Resources Project Manager*.** ESA prepared a Mitigated Negative Declaration for the Las Virgenes Municipal Water District's Backbone Improvement Project. Madeleine conducted archaeological studies of the project site, including research concerning previous archaeological work in proximity to the project site, nearby archaeological sites, and Native American sacred lands.

Caruso-Burton Way Mixed-Use MND, Los Angeles, CA. ***Cultural Resources Project Manager***. ESA prepared a Mitigated Negative Declaration for a mixed use project in west Los Angeles for a confidential client. Madeleine conducted archaeological studies of the project site and prepared a cultural resources technical report. In addition, she conducted research concerning previous archaeological work in proximity to the project site, nearby Native American sacred lands, and paleontological sensitivity. She prepared the cultural resources section of the environmental document.

LAUSD South Region High School No. 9. Los Angeles, CA. ***Technical Analyst.*** ESA prepared an environmental impact report for the Central Los Angeles High School No. 9 project. LAUSD proposed to construct a new high school in the Belmont Planning Area to help relieve crowding at Belmont High School. Madeleine conducted archaeological studies of the project site and prepared the cultural resources section of the Initial Study.

Gunner Ranch West Program EIR. Madera, CA. ***Technical Analyst***. ESA is preparing a Program EIR for the Gunner Ranch West project, a mixed-use development consisting of a regional shopping mall and power center, as well as residential, office and public facilities. Madeleine conducted archaeological studies of the project site, including research concerning previous archaeological work in proximity to the project site, nearby archaeological sites, and Native American sacred lands and prepared the cultural resources section of the EIR. Environmental documentation was previously prepared for the Gunner Ranch West Area Plan, which was certified by the Madera County Board of Supervisors in 1994. The only facility constructed on the site is the Children's Hospital of Central California. Subsequent to this approval, the proposed land

Relevant Experience (Continued)

uses in the Area Plan have been further refined with the preparation of a Infrastructure Master Plan and Development Agreement.

Sorensen County Park Phase III Constraints Analysis Cultural Monitoring. Los Angeles County, CA. *Archaeological monitor*. The County of Los Angeles Department of Recreation and Parks plans to further expand the Stephen Sorensen County Park in the unincorporated Lake Los Angeles area of northern Los Angeles County. ESA performed a constraints analysis to evaluate future development of the 100-acre site. ESA also prepared an EIR/EA for the project. Finally, ESA provided archaeological and biological monitoring of project construction. Madeleine provided technical review of numerous cultural resources technical documents, and provided archaeological monitoring of project construction.

Costello Pool and Bathhouse Replacement Project. Los Angeles, CA. ***Technical Analyst*** ESA prepared an Environmental Impact Report (EIR) for the City of Los Angeles Department of Recreation and Parks Lou Costello Recreational Center. The City of proposed to replace the existing pool and bathhouse at the Costello Recreation Center, located on East Olympic Boulevard in East Los Angeles. The pool and bathhouse facilities are considered historically significant, and ESA has work closely with the City to develop alternatives that would preserve such resources. Madeleine conducted review of technical documents and prepared the cultural resources section of the Initial Study.

TESLA Motors Model S Manufacturing Facility. Vacaville, CA. *Technical Analyst* . ESA was retained by TESLA Motors to provide permitting assistance, site evaluation support and environmental studies/ documentation to identify and entitle a development site for a zero emissions automobile manufacturing facility in the Vacaville and San Jose areas. The project included permitting assistance and the preparation of environmental technical studies. Madeleine performed cultural resources research and assisted in extended Phase 1 archaeological testing. The purpose of the extended Phase 1 archaeological testing was to delineate the boundaries of a previously known archaeological site in order to determine appropriate mitigation measures for the site.

The Preserve at San Juan EIR. Santa Ana, CA. *Technical Analyst* Madeleine assisted in CEQA analysis and documentation for The Preserve at San Juan EIR. The proposed project consisted of approximately 600-acres of undeveloped land that would be developed into 150 to 200 single-family residential lots. The project site is located along Ortega Highway in unincorporated Orange County, with a portion located in Riverside County. Due to the project's location adjacent to the Cleveland National Forest, analysis of cultural resources is an important aspect of this development project.

Department of Water Resources, Crafton Hills Reservoir Enlargement SEIR, Yucaipa, CA. *Technical Analyst.* Madeleine performed the technical

Relevant Experience (Continued)

editorial review of the archaeological survey report for the Crafton Hills Reservoir Enlargement SEIR. ESA prepared a Supplemental EIR for the Crafton Hill Reservoir Enlargement Project. The existing Crafton Hills Reservoir lies in the easterly edge of the Crafton Hills Open Space Area, within the City of Yucaipa, in southern San Bernardino County, California. The project would enlarge the reservoir to increase the capacity from 85 acre-feet (af) to 225 af. The reservoir enlargement would not change the conveyance capacity of the East Branch of the California Aqueduct. Rather, the project would provide greater operational flexibility, allowing DWR to fill the reservoir during off-peak energy demand periods and thus reduce energy demand during peak hours. The project also includes a connector pipeline between the East Branch Extension pipeline and the Yucaipa Pipeline.

Riverside Water Quality Control Plant Expansion Plan EIR, City of Riverside, CA. ***Technical Analyst.*** Madeleine conducted archaeological studies of the project site and prepared the cultural resources section of the EIR. The City of Riverside's Regional Water Quality Control Plant (RWQCP) has prepared a facilities plan that would increase the capacity of the plant by approximately 10 mgd. The upgrade would include three main components: the Plant 1 Primary Expansion, the Plant 1 Membrane Bioreactor (MBR) Facilities, and the Acid Phase Digester. Key issues in the CEQA analysis include consistency with the recently updated City General Plan, construction impacts, local land uses including the municipal airport, growth inducement, and discharge water quality.

Murrieta Historic Resources Evaluation. Unincorporated Riverside County, CA. ***Technical Analyst.*** Madeleine performed archival historical research in order to establish the historical significance of a property in Murrieta, California. ESA prepared a historic resources evaluation for a structure on property owned by the Riverside County Facilities Management Department, in order to determine whether, 1) the property would meet the federal, state, or local significance criteria and therefore would be considered a historic resource for CEQA purposes, and 2), the proposed demolition of the property would have a significant adverse impact on the historic significance of the property.

CPUC Devers-Mirage Project. Palm Springs, CA. ***Technical Analyst***
Madeleine reviewed cultural resources technical documents and assisted in drafting the cultural resources EIR section for the CPUC Devers-Mirage Project. ESA prepared an EIR under contract to the CPUC to evaluate the potential impacts from Southern California Edison's proposed Devers-Mirage 115 kV System Split project. This project includes approximately 12-miles of new and upgraded 115 kV transmission line segments, a new loop-in for a 220 kV transmission line to the Mirage Substation, and upgrades at several other substations in the area. A short segment of the transmission line would cross Bureau of Land Management land, requiring coordination with a NEPA analysis.

Relevant Experience (Continued)

Westside Cherry Valley Golf Club Mitigation and Monitoring Compliance. Tuolumne, CA. ***Technical Analyst*** Madeleine reviewed technical documents and assisted in drafting a Historic Properties Treatment Plan and a Memorandum of Agreement between the Tuolumne Band of Me-Wuk Indians, the Army Corps of Engineers, and the State Historic Preservation Officer. ESA is providing mitigation and monitoring compliance for the proposed construction of the Westside Cherry Valley Golf Club (championship level golf course) and assisting with mitigating impacts to cultural resources located in the project area.

El Granada Phase III Transmission Pipeline Replacement Project, San Mateo County, CA. ***Archaeological Monitor*****.** Madeleine served as an archaeological monitor for the El Granada project. Tasks included ensuring compliance with project mitigation measures and relevant regulations, documentation of the project including a daily monitoring log and photographs, and analysis of cultural materials found during the course of construction.

Europa Village EIR, Regulatory Permitting and Planning Support. Unincorporated Riverside County, CA. ***Archaeologist.*** Madeleine conducted an archaeological field survey at the project site and assisted with the preparation of the technical report. In addition, Madeleine conducted a record search for previous archaeological work in proximity to the project site, including nearby Native American sacred lands and paleontological sensitivity. Lastly, she assisted with the preparation of the cultural resources section for the EIR. ESA prepared an EIR and provide planning support for the 40-acre Europa Village Project, including 3 wineries, a 65-unit spa hotel and vineyards, located in unincorporated Riverside County, east of the City of Temecula. Regulatory compliance permitting including USACE Section 404, RWQCB NPDES 401 certification permitting and CDFDG 1602 SAA.

Fresh & Easy Riverside Facility. Riverside County, CA. ***Technical Analyst.*** Madeleine reviewed technical documents, performed updated archival research, and wrote the cultural resources section for the Fresh & Easy Riverside Facility EIR. ESA is providing technical support for Phase I and is also preparing the EIR for Phase II of the Riverside facility. Environmental issues include traffic, air quality/ greenhouse gas emissions, water quality/hydrology, hazards/hazardous materials, noise, and utilities and service systems.

West Covina Corporate Center/BKK Landfill EIR, West Covina, CA. ***Technical Analyst.*** Madeleine assisted with the research and preparation of the cultural resources section of the EIR. The City of West Covina and BKK has asked ESA to prepare a Supplemental EIR that would consider the effects of changing a portion of the anticipated land uses at a BKK development site (and former landfill) from a home improvement superstore to a corporate office complex.

Relevant Experience (Continued)

BKK Landfill Gas Station, West Covina, CA. *Technical Analyst.* The City of West ESA prepared a Mitigated Negative Declaration for the BKK Gas Station Project. The project involved the development of a gas station and food mart at the edge of the former BKK landfill. Madeleine conducted archival research, facilitated Native American outreach, performed an archaeological survey of the project site, and wrote the technical report and MND cultural resources section.

Additional Experience

Cotsen Institute of Archaeology, University of California, Los Angeles. *Publications Assistant*. Madeleine assisted in editing manuscripts for publication, maintained databases and inventory of published material, and processed orders and assisted customers.

Kenchreai Cemetery Project, Kenchreai, Greece. *Crew Member*. Madeleine assisted the survey a Roman-era cemetery near Corinth, Greece. The site consisted of 55+ tombs which she helped survey, map, photograph, and create scale drawings. Additionally, she inventoried and documented ceramic artifacts.

Macalester College Excavations, Omrit, Israel. *Crew Member and Registrar*. Madeleine participated in two sessions of the excavation of a Roman temple in Northern Israel. She helped excavate three separate trenches, and collaborated with excavation leaders to map, organize, document, inventory, and create a database of artifacts and architectural fragments.

Pioneer Memorial Cemetery Geophysical Survey, Sylmar, California. ***Crew Member***. Madeleine surveyed a 19th and 20th century A.D. historical site using magnetic & electromagnetic methods, resistivity, and Ground Penetrating Radar. She analyzed the results of the surveys and prepared a report on her findings.

Science Museum of Minnesota, Saint Paul, Minnesota. *Archaeology Intern*. As part of an independent project, Madeleine assisted the Science Museum of Minnesota in researching and cataloguing a small collection of Greek and Roman ceramic lamps that had never been identified by place or period of origin. Ultimately, Madeleine created a catalog of the lamps and prepared the data for entry into the museum's database for record and eventual publication.

Sikyon Survey Project, Sikyon, Greece. *Crew Member*. Madeleine participated in a collaborative, multi-national geophysical survey of a large Greek and Roman period urban site as part of a multidisciplinary study. She conducted a both geophysical and pedestrian archeological surveys of the site using a Geoscan FM36 Fluxgate gradiometer. Madeleine was also responsible for sorting, documenting, and cataloguing ceramic artifacts which she analyzed to help create a ceramic typology for the site.

Relevant Experience (Continued)

Statistical Research, Inc., Playa Vista, CA. *Field and Laboratory Technician*. Madeleine assisted an ongoing field curation project at the proposed construction site of an office complex in Playa Vista. Madeleine documented trenches through scale drawings and photographs of the project site. She also assisted in cataloguing of sorted materials and artifacts for future curation.

University of California, Los Angeles. *Research Assistant.* Assisted Professor Richard Lesure in digitizing archaeological drawings for publication. Used Abode Illustrator to trace and refine hand drawn site illustrations.

University of California, Los Angeles. *Teaching Assistant.* Madeleine worked as a teaching assistant for three Classics courses. She taught two 50-student sections per course, graded papers, and administered exams.

Public Outreach and Education

2006. Guest lecturer at Daniel Webster Middle School regarding career opportunities in archaeology, Los Angeles, CA.

2005. Guest lecturer at Foshay Learning Center regarding the field of archaeology, Los Angeles, California.

2005-2006. Co-president, Graduate Student Association of Archaeology at the Cotsen Institute of Archaeology, University of California, Los Angeles. Organized weekly lectures on archaeological topics for Cotsen Institute affiliates and the general public.

CANDACE R. EHRINGER, RPA

Senior Associate I

Candace Ehringer is an archaeologist with over 12 years of experience in cultural resources management in California. Her strengths include managing field surveys, archaeological monitoring, lab analysis, and coordination with Native American representatives. Candace has experience with archaeological sites in both California's desert and coastal environments, and has worked in Los Angeles, Orange, Riverside, San Bernardino, San Diego, Kern, Inyo, Alameda, Sacramento, Stanislaus, and Ventura counties. She authors and provides senior level review of documentation in support of CEQA, NEPA, and Section 106 compliance. In addition to her knowledge of prehistoric site contexts, Candace has developed extensive expertise with identification and classification of all types of historic materials, including ceramics, glass bottles, garment-related items, and coffin hardware.

Education

M.A. Anthropology,
California State University

B.A. Anthropology,
East Carolina University

Years Experience – 12

Professional Affiliations

Register of Professional Archaeologists

Society for California Archaeology

Society for Historical Archaeology

Qualifications

Meets Secretary of Interior Standards

CA State BLM Permitted

Certified in CA and NV BLM Protocol

Relevant Experience

Bureau of Land Management (BLM) Santa Rosa & San Jacinto Mountains National Monument. Riverside County, CA. *Field Director*. The BLM Palm Springs-South Coast Field Office contracted with ESA to conduct a Class III survey of 394 acres in the northeastern extent of the Santa Rosa and San Jacinto Mountains National Monument. The survey resulted in the identification of seven new prehistoric and historic archaeological resources. Candace served as the field director and authored the technical report.

BLM Dos Palmas Preserve Tamarisk Eradication. Riverside County, CA. *Field Director*. The BLM Palm Springs-South Coast Field Office is removing tamarisk (*Tamarix* spp.) on public lands within the Dos Palmas Preserve Area of Critical Environmental Concern that continue to infest affected public lands and deteriorate the watershed. Since this project is being funded by a federal American Recovery and Reinvestment Act grant, the National Environmental Protection Act process requires that a project take into consideration its effect on cultural resources that may be present within the area of impact. ESA conducted a survey of two parcels, resulting in the recordation of several prehistoric and historic resources. ESA provided monitoring services for the tamarisk removal process. Candace assisted with management of the archaeological survey and monitoring.

BLM Genesis Solar Project Support Services. Riverside County, CA. *Principal Investigator.* Candace is managing the cultural resources oversight fieldwork for the BLM for the Genesis Solar Project. This concentrated solar electric generating facility located in Riverside County, California and would consist of two independent solar electric generating facilities with a nominal net electrical output of 125 megawatts (MW) each, for a total net electrical output of 250 MW. The project site is located approximately 25 miles west of the city of Blythe, California, on lands managed by the BLM.

Relevant Experience (Continued)

BLM Solar Millennium Palen Project Support Services. Riverside County, CA. *Principal Investigator.* Candace served as principal investigator and report co-author for the cultural resources field verification efforts for the BLM Palen Project. This project would be a concentrated solar thermal electric generating facility with two adjacent, independent, and identical solar plants of 250 megawatt (MW) nominal capacity each for a total capacity of 500 MW. It would also utilize solar parabolic trough technology to generate electricity. The project site is located approximately 10 miles east of Desert Center, along Interstate 10 approximately halfway between the cities of Indio and Blythe, in Riverside County, California.

BLM Solar Millennium Blythe Project Support Services. Riverside County, CA. *Principal Investigator.* Candace served as principal investigator and report co-author for the cultural resources field verification efforts for the BLM for the Blythe Project. This project would be a concentrated solar thermal electric generating facility with two adjacent, independent, and identical solar plants of 250 megawatt (MW) nominal capacity each for a total capacity of 500 MW nominal. It would utilize solar parabolic trough technology to generate electricity. The project site is located approximately two miles north of Interstate-10 and eight miles west of the City of Blythe in an unincorporated area of Riverside County, California.

Helix Water District (HWD)-El Monte Valley, San Diego County, CA. *Cultural Resources Project Manager*. ESA is providing professional Environmental Consulting services in support of the HWD's El Monte Mining, Reclamation, and Groundwater Recharge Project. The project includes mining of approximately 10 million tons of aggregate from the El Monte Valley in San Diego County. The project will augment HWD's water supply by up to 4,000 acre-feet per year and support new riparian habitats along the San Diego river. Candace's duties involve managing the project including survey, Native American coordination, historical research, and the preparation of a CEQA and Section 106 compliant technical report. The project approach will be in conformance with the County of San Diego, Guidelines for Determining Significance.

Sacramento County Airport System On-Call Natural Resources Advisory & Consulting Services. Sacramento County, CA. *Field Archaeologist.* ESA is providing on-call natural resources support and consulting services for the Sacramento County Airport System. Candace served as an archaeological monitor/surveyor during field disking.

San Juan Water District (SJWD) Solar Array. Sacramento County, CA. *Field Archaeologist.* ESA provided environmental compliance services and prepared the IS/MND for a 3.5-acre solar (photovoltaic) array that will be used to power the SJWD water treatment plant, shop, and two pump stations. Candace conducted an archaeological resources survey of the 3.5-acre project area.

Relevant Experience (Continued)

West Stanislaus Fish Screen Feasibility Study. Stanislaus County, CA. *Field Archaeologist.* The West Stanislaus Irrigation District (WSID) wants to perform a feasibility study to determine if the current diversion form the San Joaquin River can be screened. The project will be funded in part by the U.S. Bureau of Reclamation - Central Valley Project Improvement Act, CDBA (Calfed) and California Department of Fish and Game. Candace conducted an archaeological resources survey and provided recommendations regarding resource avoidance.

Metropolitan Air Park. San Diego County, CA. *Archaeological Surveyor*. ESA is preparing a master development plan, EIR, and EA for Metropolitan Air Park at Brown Field Airport in the City of San Diego. The project involves a 50-year land lease from the City of San Diego for a 400-acre portion of the airport property to be developed into airport and non-airport related land uses. The project requires the approval of the City of San Diego and the Federal Aviation Administration, and is being processed as Master Planned Development Permit Project. Candace conducted survey of the project area in conformance with City of San Diego Historical Resources Guidelines to identify evidence of archaeological materials in support of the cultural resources technical report in compliance with CEQA and Section 106.

California Department of Water Resources (DWR) East Branch Extension Phase II. San Bernardino County, CA. *Report Author*. ESA is preparing an EIR assessing potential impacts of the East Branch Extension Phase II Project, which will install 6 miles of pipeline across the Santa Ana River near Redlands. The new pipeline will increase water delivery capacity to the San Gorgonio Pass Water Agency serving the cities of Banning and Beaumont. The project includes construction of the Citrus Reservoir, a 26-acre lined storage reservoir that will require excavation and hauling off site of 1.8 million cubic yards of material over a three year construction period. Candace authored a cultural resources technical report in support of CEQA and Section 106 compliance, providing DWR with eligibility recommendations for identified cultural resources.

SFPUC Seismic Upgrade of Bay Division Pipeline No. 3 & 4. Alameda County, CA. *Technical Analyst.* The proposed project will replace the existing BDPL No. 3 with a new parallel pipeline across the main trace and two secondary traces of the Hayward Fault, Interstate 680, and Mission Boulevard in Fremont. The BDPL No. 4 is adjacent to the BDPL No. 3 and will undergo minor seismic upgrades. The goal of the proposed project is to improve the seismic and hydraulic reliability of SFPUC's water supply transmission system serving the San Francisco Peninsula area. The improvements would result in an unavoidable adverse impact to National Register-eligible site CA-ALA-576. Candace authored an Archaeological Research Design and Treatment Plan/Historic Property Treatment Plan designed to mitigate anticipated project-related effects to site CA-ALA-576.

Relevant Experience (Continued)

Antelope Valley Water Bank Initial Recharge and Recovery Facility Improvement Project Archaeological Survey. Kern County, CA. *Field Director*. Candace led the archaeological survey and authored the subsequent technical report in fulfillment of CEQA and Section 106 requirements. The Antelope Valley Water Bank is a groundwater banking project designed to provide up to 500,000 acre-feet of total surface water storage capacity underground in a partially depleted aquifer. The Antelope Valley Water Bank Project contributes to accomplishing the goals of making more water available through recharge and recovery to meet existing and future water requirements during periods when water supplies fall short. The project is being carried out by the Antelope Valley East Kern Water Agency with the assistance of a Challenge Grant from the Bureau of Reclamation.

Port of Los Angeles Marine Oil Terminal Engineering Maintenance Standards (MOTEMS) Project Historic Resources Evaluation. Los Angeles County, CA. *Technical Analyst.* As part of ESA's on-call environmental services contract with the Port of Los Angeles, Candace provided historic research in support of the evaluation of approximately 16 timber wharves. The wharves date to circa 1925 and would be subject to alterations, including new piling, decking, and fendering systems, in order to accommodate greater shipping loads, as well as seismic and life/safety improvements. Two sets of timber wharves at Berths 150-151 and 163-164 were identified as eligible for listing in the National Register and California Register as contributors to two marine oil terminal districts.

BLM Abandoned Mine Lands Cultural Resources Evaluation: Spangler, Rademacher Hills, and Randsburg South Locales, San Bernardino and Kern counties. *Field Archaeologist.* The BLM proposes to conduct remediation of physical safety hazards associated with Abandoned Mine Lands (AML). Remediation would consist of backfilling or closing off mine shafts, adits, and prospects. These remediation measures would ensure public safety on BLM lands by preventing public exposure to the dangers associated with abandoned mine features. Candace served as an archaeological surveyor for this project.

Irvine Ranch Water District (IRWD) Tustin Wells Project MND/EA. Orange County, CA. *Technical Analyst.* Candace conducted a Phase I cultural resources study for the Tustin Wells Project. She led the cultural resources survey and authored a technical report in support of a MND/EA. The lead federal agency was the Bureau of Reclamation.

West Kern Water District Groundwater Recharge Project EIR. Kern County, CA. *Technical Analyst.* Candace co-authored the technical report for the Phase 1 archaeological resources survey of a 500-acre Project area proposed for groundwater recharge basins and a 9-mile pipeline in Kern County. The project is being carried out in compliance with CEQA and Section 106 of the NHPA. The survey resulted in the identification of over 20 archaeological sites.

Relevant Experience (Continued)

Canyon Hill Cultural Resource Assessment. Lake Elsinore, Riverside County, CA. *Field Director.* Candace assisted in the creation of a research design for archaeological testing at site CA-RIV-1021 and served as field director during testing. As a report-co-author, she assisted with determining the significance of the site under CEQA and Section 106 of the NHPA.

Olivas Adobe Monitoring. Ventura County, CA. *Technical Analyst.* The City of Ventura contracted with ESA to provide archaeological monitoring during improvements to the historic Olivas Adobe. Olivas Adobe, constructed in 1847, is currently a City museum. Candace monitored improvements to the small adobe located in the courtyard.

DWR, East Branch Enlargement (EBE) EIR. Antelope Valley, Kern County, CA. *Technical Analyst.* Candace served as a research assistant for a Phase 1 archaeological resources survey report for the EBE project. The project consists of the enlargement of 100 miles of the California Aqueduct from the Tehachapi split through the Antelope Valley and Mojave River Basin to Silverwood Reservoir. Cultural resources studies are being carried out in compliance with CEQA and Section 106 of the NHPA. A total of 99 cultural resources were identified as a result of the survey.

San Juan Capistrano Recycled Water Pipeline Mainline. San Juan Capistrano, Orange County, CA. *Technical Analyst.* Candace compiled information regarding two archaeological sites located within the project area. The information was used to assist project planners design a pipeline route that would avoid impacts to the sites.

Extension of Historic Streetcar Service Environmental Impact Statement (EIS). Alameda County, CA. *Technical Analyst.* ESA is working with the National Park Service (Denver Service Center) in cooperation with San Francisco Municipal Transportation Agency, and Federal Transit Administration to complete an EIS to analyze the proposed extension of the historic streetcar line from Fisherman's Wharf through the San Francisco Maritime National Historical Park and Fort Mason Center in Golden Gate National Recreation Area. Candace assisted in writing the cultural resources EIS section.

Prior to ESA

Los Angeles Unified School District (LAUSD), Central Los Angeles High School #9. Los Angeles County, CA. *Field Archaeologist, Lab Director, Contributing Report Author.* The project involved identifying and excavating 171 burial features. The cemetery dated to the mid to late 19th century and reflected the growing Protestant population of Los Angeles. The majority of features was located in the private section of the cemetery, and was from upper-middle-class families. Analysis of this cemetery provides a rare opportunity to compare other excavated 19th-century cemeteries, which typically represent people of lower socioeconomic and/or marginalized status, to the presumed

Relevant Experience (Continued)

ideal of Victorian mortuary practices. Candace directed grading to facilitate detection of soil changes indicative of burials, trained incoming staff, excavated burial features, and maintained a field specimen log. She also served as one of the principal field photographers.

As lab director, Candace's responsibilities included assessing artifact conditions and conservation needs, developing and implementing artifact cleaning procedures, identifying historic coffin hardware and personal artifacts, creating a 19thcentury coffin hardware typology, library research, developing and maintaining an artifact catalog using Excel and Access, and cataloging over 3000 artifacts. Other duties included overseeing the cleaning of skeletal remains, as well as photo-documenting bone pathologies and traumas for the project osteologist. Candace contributed to report chapters regarding coffin hardware, personal artifacts, trends in 19th-century mortuary practices, field and lab methods, and mortuary feature analysis.

Las Encinas Hospital, Pasadena, Los Angeles County, CA. ***Technical Analyst.*** Candace conducted an archaeological field survey and archival research of Las Encinas Hospital grounds. The hospital, once known as the Southern California Center for Nervous Diseases, has been in operation as a mental health facility since 1904. Prior to this, the area was part of the Sunny Slope Ranch owned by Leonard Rose. During the survey, several historic artifact scatters and building foundations associated with the ranch and hospital's early years were recorded. Candace authored a technical report, providing recommendations for further work and mitigation measures, in compliance with CEQA.

City of Los Angeles, Echo Park Lake Rehabilitation. Los Angeles County, CA. ***Technical Analyst..*** Candace conducted a field survey of a 33-acre recreational park located in Echo Park and archival research at UCLA Aerial Photography Archive and Los Angeles Public Library. She authored the historical context report section documenting the development of Echo Park. Echo Park was one of Los Angeles's earliest public parks, established in 1892. The design was implemented by Joseph Tomlinson, Los Angeles's first Superintendent of Parks, and modeled after the picturesque English style.

City of West Hollywood, 8801 Sunset Boulevard Specific Plan EIR. Los Angeles County, CA. ***Project Archaeologist.*** The applicant proposes to construct approximately 52,031 square feet of commercial and retail space, plus parking. The site houses the former Tower Records Sunset building. Candace conducted a field survey and co-authored a technical report in support of the EIR. The Tower Records Sunset site was found to be historically significant for its contribution to the development of West Hollywood's rock music scene.

City of West Hollywood, Sunset Time Specific Plan EIR. Los Angeles County, CA. ***Project Manager.*** The applicant proposes to construct up to 149 hotel rooms, 40 residential condominium units, 5 low-income affordable

Relevant Experience (Continued)

housing units, and up to 35,456 square-feet of commercial and entertainment space. Historically, the area was a mix of residential housing and commercial uses. During the 1920s and 1930s, the area currently occupied by the House of Blues was the site of one of the many nightclubs that flourished along the Sunset Strip during that time period. Candace conducted a field survey and prepared a cultural resources technical report and EIR section with findings and recommendations for further work, pursuant to CEQA.

City of West Hollywood, Movietown Plaza Specific Plan EIR. Los Angeles County, CA. *Project Manager.* The applicant proposes to construct approximately 371 residential units and approximately 32,300 square feet of retail/commercial uses on a site currently occupied by a strip mall. The site was first developed when film studios moved into the area. In the 1920s and 1930s, the site was occupied by Educational Films Studio, a producer of one-reel comedies. Shirley Temple began her film career at this location. The site was later occupied by Eagle-Lion Studios, which produced B-movies. Candace conducted a field survey and prepared a cultural resources technical report and EIR section with findings and recommendations for further work, pursuant to CEQA.

DMJM-Harris, Exposition Light Rail. Los Angeles County, CA. *Technical Analyst.*. Participated in archaeological field survey of several proposed routes for the new Exposition Light Rail. Prepared DPR 523 forms for all historic resources observed, including the railroad right-of-way and railroad-related components such as switches and cantilevered signals. Conducted extensive research into the history Los Angeles's railroad systems and their role in the development of Santa Monica, West Los Angeles and Culver City. Historic railroads covered include the Los Angeles & Independence, the Southern Pacific, the Los Angeles Pacific, the Pacific Electric, and the Santa Monica Air Line. Assisted in the preparation of an Archaeological Resources Technical Report and EIR section with findings and recommendations for further work, pursuant to CEQA and Section 106 requirements.

City of Los Angeles, Bureau of Engineering, Temple Street Widening Project. Los Angeles County, CA. *Archaeological Monitor.* Candace served as an archaeological monitor during road construction and utilities relocation for the Temple Street Widening Project. The Zanja, part of Los Angeles's first irrigation system, was discovered during grading. Candace documented the Zanja segment and helped develop measures to insure its protection during on-going construction.

LAUSD, South Regional Elementary School (SRES) #1. Los Angeles County, CA. *Technical Analyst.* Candace conducted the lab analysis and co-authored the report on an artifact assemblage recovered during archaeological monitoring of South SRES #1 in south-central Los Angeles. The area was first settled circa 1909 and was the home of several domestic, religious, and retail establishments. The artifact assemblage consisted of early 20th-century

Relevant Experience (Continued)

domestic and vocational refuse. The technical report provided findings and recommendations for further work, pursuant to CEQA.

Excel Paving, Alameda Street. Los Angeles County, CA. ***Technical Analyst.*** Candace provided archaeological monitoring of street construction at Alameda Street in downtown Los Angeles. The project resulted in the identification and recovery of over 300 historic-era artifacts. In addition, segments of both narrow-gauge and standard gauge rail lines, sections of brick foundations, and brick irrigation features were documented. A large section of late 19th to early 20th century brick pavement and part of the Zanja were also uncovered and documented during construction.

BLM Spangler Hills Open Area. Kern County, CA. ***Field Archaeologist.*** The Spangler Hills Off-Highway Vehicle Area (OHV) offers over 57,000 acres of open public land for recreational use. The area is managed by the Bureau of Land management. Archaeological survey was required to determine the effects of OHV activities on known and unknown cultural resources. Candace surveyed selected portions of Spangler Hills, locating, recording, and mapping various types of archaeological sites.

City of Seal Beach, Hellman Ranch Monitoring and Data Recovery. Orange County, CA. ***Crew Chief, Lab Analyst.*** Candace supervised a team of archaeologists charged with monitoring construction activities, archaeological testing, and excavation of over 30 Native American burials and associated features at Hellman Ranch in Seal Beach, CA. The Hellman Ranch area (Landing Hill) was occupied by the Gabrielino for over 6,000 years. Excavation revealed an extensive mortuary complex, including large amounts of cremated human remains and broken, or “killed,” ground stone.

Candace was responsible for implementing and overseeing work delegated by field directors. She contributed to lab analysis by sorting artifacts and beginning initial classification of lithic debitage, and assisting with artifact and osteological photo-documentation, and providing key support to visiting osteological and faunal specialists.

County of Los Angeles Coroner’s Crypt. Los Angeles County, CA. ***Research Assistant.*** In support of an MND, Candace conducted extensive historic research of the area now occupied by the Los Angeles County Corner and authored the cultural resources section of the MND. The County was proposing additions to the current Medical Examiner’s facility. This area was the location of Los Angeles’s first county hospital, and has been in continuous use as medical facilities since the 1870s.

City of Los Angeles, Asphalt Plant No. 1 Project. Los Angeles County, CA. ***Crew Chief, Report Co-author.*** The Bureau of Engineering proposed modifications to an existing truck route and construction of new route at Asphalt Plant No. 1. Candace conducted a Phase I archaeological study. The study

Relevant Experience (Continued)

identified potential archeological issues and provided recommendations for further work, pursuant to CEQA.

County of Los Angeles, Department of Public Works, Morris Dam. Los Angeles County, CA. ***Field Archaeologist.*** Conducted field survey and prepared cultural resources section of a Mitigated Negative Declaration (MND) for a proposed access route to Morris Dam, located in the San Gabriel Mountains.

City of Temecula, Western Bypass Bridge. Riverside County, CA. ***Crew Chief.*** Candace led a Phase I survey of the one-acre project area. One previously recorded archaeological site was re-located and documented.

Conejo Park and Recreation District, Lang Ranch. Thousand Oaks, Ventura County, CA. ***Field Archaeologist.*** Candace participated in archaeological testing of a 46-acre project area. Project work involved the archaeological testing at two artifact isolate locations to determine presence of sub-surface deposits.

Twining Labs, El Toro. Tustin, Orange County, CA. ***Archaeological Monitor.*** Candace served as an archaeological monitor during the grading of new roadways. She was responsible for maintaining detailed daily reports and coordinating work schedules with on-site construction foreman.

Twining Labs, Home Depot Center. Lake Elsinore, Riverside County, CA. ***Archaeological Monitor, Report Author.*** Candace conducted on-site monitoring of controlled grading during the expansion of an existing roadway located next to a cemetery. She prepared daily monitoring logs and co-authored a negative final report for the client.

Seep Spring, China Lake Naval Air Weapons Station. Kern County, CA. ***Crew Chief.*** Candace led a team of field archaeologists in locating, describing, and mapping archaeological sites at Seep Spring. She was responsible for creating the field schedule, assigning tasks to crew, and collating site records, field notes, photographs and sketch maps.

Bierman Caves, China Lake Naval Air Weapons Station. Kern County, CA. ***Field Archaeologist.*** Candace was a member of a survey team entrusted with re-locating and recording previously discovered rock art sites at Bierman Caves, as well as recording any new, undiscovered rock art sites.

Santa Ysabel Ranch Testing and Data Recovery at CA-SLO-2084. San Luis Obispo County, CA. ***Field Archaeologist.*** Candace assisted with archaeological testing, which included excavation units and monitoring of mechanical trench excavation.

State of California, Owens Valley PM10 Planning Area Demonstration of

Relevant Experience (Continued)

Attainment State. Inyo County, CA. ***Field Archaeologist.*** Candace was a member of an archaeological survey team that covered large portions of the Owens Valley Dry Lake Bed. She assisted with the documentation and mapping of several large lithic scatters and historical sites.

A.F. Gilmore Company, The Grove at Farmers Market Monitoring Project. Los Angeles County, CA. ***Archaeological Monitor.*** Candace **s**erved as an archaeological monitor responsible for collecting historic artifact isolates, maintaining paperwork, and coordinating work schedule with on-site construction crews.

BLM Ancient Searles Lake, Christmas Canyon ACEC. San Bernardino County, CA. ***Field Archaeologist.*** Member of survey team charged with locating, describing, and mapping archaeological sites. Several test units were conducted as part of the Phase I survey. Participated in lab analysis.

BLM Dove Springs Open Area. Kern County, CA. ***Field Archaeologist***. Candace was part of a survey team covering portions of a BLM open area to determine the effects of off-road vehicles on archaeological sites. She assisted with the documentation and mapping of several archaeological sites.

PROFESSIONAL PAPERS AND PRESENTATIONS

Ehringer, C. 2008 Mortuary Consumerism in 19th-Century Los Angeles: Coffins, Caskets and Trimmings from City Cemetery. Oral paper presentation at the Society for American Archaeology 73rd Annual Meeting, Vancouver, BC.

Ehringer, C., L. Kry, S. Dietler, and M. Strauss. 2008. After the Bones Are Gone: The Role Of Personal Effects in Identifying Unmarked Historic Burials. Poster presentation at the Society for Historical Archaeology Annual Meeting, Albuquerque, NM.

Strauss, M., S. Dietler, and C. Ehringer. 2008. Death Lends a Hand: Archaeological Excavations of Los Angeles's City Cemetery. Oral paper presentation at the Society for Historical Archaeology Annual Meeting, Albuquerque, NM.

Ehringer, C. 2004. Roosters and Raptors: Cultural Continuity and Change at Big Dog Cave, San Clemente Island, California. Oral paper presentation at the Society for California Archaeology Annual Meeting, Riverside, CA.

Ehringer, C. 2000. Ceremony and Ritual at Big Dog Cave, San Clemente Island, California. Poster session, Student Research and Creative Activity Symposium, California State University, Northridge, CA.

Ehringer, C. 1992. Alternative Medicine and Herbal Remedies in Rural North Carolina. Oral presentation at the Southern Anthropological Society Annual

Relevant Experience (Continued)

Meeting, Saint Augustine, FL.

PUBLIC OUTREACH AND EDUCATION

2009. Candace developed and conducted an archaeological lab practicum for high school students during "Student at Work Day."

2007 to 2009. Candace served as the Society for California Archaeology liaison to the Society for American Archaeology. As a liaison, Candace attended SAA meetings as the SCA representative, prepared written reports for the SCA newsletter, and contributed to the SAA Council of Affiliated Societies semi-annual newsletter.

2006. Candace was a guest lecturer at Santa Monica College. She led a discussion on "The Archaeology of Religion" using the Gabrielino belief system as an example.

2004. Candace co-led and directed teams of volunteers surveying, mapping, and recording sites at Bierman Caves, China Lake Naval Air Weapons Station, CA.

BRIAN MARKS, PHD, RPA

Senior Associate I

Dr. Marks has worked on terrestrial and underwater archaeology projects in California, Florida and Georgia since 1997. Prior to joining ESA, his duties included the identification and determination of National Register of Historic Places (NRHP) eligibility of archaeological sites based type, age, composition, source of artifacts recovered at all levels of field investigation from reconnaissance to Phase III mitigation and data recovery for terrestrial and underwater projects in Florida and Georgia. He has surveyed, mapped, excavated, interpreted and analyzed artifacts, as well as published reports on a variety of diverse archaeological sites. Dr. Marks has experience gathering and interpreting remote sensing data, assessing and evaluating sites, and has overseen numerous terrestrial and underwater projects and tasks. He has an understanding of the pertinent laws and procedures necessary for compliance with various Federal and State regulatory agencies.

10 Years of Experience

Education

Ph.D. Anthropology, Florida State University

M.S. Anthropology, Florida State University

B.S. Underwater Archaeology, University of California at Davis

Registrations

Register of Professional Archaeologists (#15173)

Professional Affiliations

Society for American Archaeology

Florida Archaeological Council

Register of Professional Archaeologists since 2004

Merit Badge Councilor for Northeast Florida Boy Scouts - Archaeology, Oceanography, and Astronomy

Certifications

Commercial Class B drivers license with passenger and air brake endorsements

Boat US certification in small boat operation

OSHA Construction Site Safety Certified

AAUS Science Diver rated to 90 feet

NAUI Master Scuba Diver

Relevant Experience

D210676.00 Cities of Davis & Woodland Water Supply, *Lead Archaeologist* Dr. Marks conducted a cultural resources survey of the proposed Davis & Woodland Water Supply and was responsible for insuring the project meets Section 106 guidelines as well as CEQA regulations. As no resources were encountered during the survey, there will be no negative effect from this project.

D210586.00 VA Outpatient Clinic & Community Living, *Archaeologist* Dr. Marks conducted a cultural resources study on two potential sites for a VA outpatient clinic and community living center. He was responsible for surveying the proposed sites, and writing the technical reports.

D210541.00 Union Pacific Railroad Modernization Project, Lathrop, CA *Lead Archaeologist.* Dr. Marks conducted a cultural resources study of the proposed expansion of the UP Intermodal Facility in Lathrop. and was responsible for insuring the project meets CEQA guidelines, surveying the project area, and writing the cultural resources section of the EIR.

D209259.00 Mather Specific Plan at Mather Air Force Base, Rancho Cordova, CA. *Lead Archaeologist.* Dr. Marks conducted a cultural resources study of the former Mather Air Force Base and was responsible for insuring the project meets Section 106 guidelines, surveying the project area, and writing the cultural resources section of the EIS. The survey included the airport, a aircraft hanger, a former tarmac, a radar station, and two munitions storage areas. As most of the changes in land use will occur away from the actual airport used for training in WWI and WWII and as a staging point during all wars in the Pacific Theater, there will be no negative effect on the airport.

Relevant Experience (Continued)

Prior to Joining ESA

Eureka Lock Training Site, Department of Military Affairs, Florida Army National Guard, Eureka, FL. ***Project Supervisor and Co-Principal Investigator.*** Dr. Marks served as the project supervisor and co-principal investigator to survey an area around and including the Eureka Lock and Dam in Eureka, Florida along the Oklawaha River. The lock and dam complex was part of the ill-fated Cross-Florida Barge Canal and marks the terminus of that system in Eastern Florida. Dr. Marks lead a team that performed background research of the project area and conducted a Phase I Cultural Resources Assessment Survey which included pedestrian inspection and shovel tests placed at regular intervals. During consultation with the State Historic Preservation Officer (SHPO), it was determined that the structures surrounding the lock gates and the complex as a whole, while not 50 years old, would be eligible for the NRHP and were recorded with Florida Master Site File. Dr. Marks recorded these elements and prepared a report for the SHPO as part of National Environmental Policy Act (NEPA) Section 106 compliance.

Little Hazel Creek Mitigation Creek, Restoration Systems, LLC, Habersham County, GA. ***Cultural Resource Task Leader.*** Dr. Marks was a member of a multi-disciplinarily team involved with the restoration of a portion of Little Hazel Creek with Habersham County, Georgia. He was responsible for the cultural resources survey and conducted background research at the Georgia Master Site File (GMSF) lead the field crew that performed regular interval shovel testing along the proposed alignment and pedestrian inspection of the Area of Potential Effect. Dr. Marks prepared a cultural resources survey report for the United States Army Corps of Engineers' Office in Savannah, Georgia as part of NEPA Section 106 compliance.

Bear Creek Mitigation Bank, Mitigation Resources, Bay and Calhoun Counties, FL. ***Project Supervisor and Co-Principal Investigator.*** Dr. Marks served as project supervisor and co-principal investigator for the Bear Creek Mitigation Bank in the Panhandle area of Florida. The project was proposing to restore the natural drainage of the property and create wetlands within an area of silviculture. Dr. Marks performed the background research of the area at the Florida Master Site File (FMSF) and lead a field crew in the cultural resources survey. Shovel tests were placed within areas of proposed impact and areas exhibiting a high probability or containing cultural resources, and the area was subjected to pedestrian inspection. Dr. Marks prepared a cultural resources survey report for the Florida SHPO as part of Section 273 of the Florida Statues and NEPA Section 106.

Heather Island Mitigation Bank, Mitigation Resources, Marion County, FL. ***Project Supervisor and Co-Principal Investigator.*** Dr. Marks served as project supervisor and co-principal investigator for the Heather Island Mitigation Bank in Central Florida. The project was proposing to restore the natural drainage of the property and create wetlands within an area of silviculture. Dr. Marks performed the background research of the area at the FMSF and led a field crew in the cultural resources survey. Shovel tests were placed within areas of proposed impact and areas exhibiting a high probability or containing cultural resources, and the area was subjected to pedestrian inspection. The survey revealed several resources including a section of the Marjorie Carr Cross Florida Greenway, (originally the proposed route of the Cross Florida Barge Canal), several lithic scatters and a historic roadway. Dr.

Relevant Experience (Continued)

Marks documented these resources for the FMSF and prepared a cultural resources survey report for the Florida SHPO as part of Section 273 of the Florida Statues and NEPA Section 106.

Natural Bridge Battlefield, Florida State Parks, Leon County, FL. ***Project Supervisor and Lead Archaeologist.*** Dr. Marks was project supervisor and lead archaeologist for the cultural resources investigation of the Natural Bridge Battlefield Historic State Park in southern Leon County. The State of Florida purchased 50+ acres of land to expand the existing Natural Bridge Battlefield State Park, and required a cultural resources inventory of the property that contained a large portion of the original battlefield. In addition to background research, Dr. Marks lead a field crew in regular interval shovel testing, pedestrian inspection, and metal detection of the entire park. In addition, Dr. Marks assisted the park rangers in utilizing and organizing a force of over two hundred volunteers to assist archaeological investigation over a two day period. Following the survey, Dr. Marks assisted in lab analysis, artifact identification, and the preparation of the report for SHPO as part of Section 273 of the Florida Statues and NEPA Section 106.

AIRPORTS

Eagle Aviation Hangers at Craig Municipal Airfield, Jacksonville, FL. ***Lead Archaeologist.*** Brian served as lead archaeologist for a survey within the airport grounds for a new industrial warehouse to comply with state and county permitting requirements. While the airport was a historic resource, as this former WWII training field was the home of the Blue Angels first airshow in 1946, the Area of Potential Effects for the warehouse would not impact any significant portions of the airport, nor would it detract from the overall setting or function of the airport.

Shoremaster at Kay Larkin Airport, Palatka, FL. ***Lead Archaeologist.*** Brian conducted a survey within the airport grounds for a new commercial building to comply with local and state permitting requirements. While the building was constructed along a former runway utilized in WWII for training, that runway had been decommissioned and now supported several commercial buildings. The new building would be part of this complex and would not detract further from the airport's setting.

T-Hanger and Apron Lighting at New Smyrna Beach Airport. New Smyrna Beach, FL. ***Lead Archaeologist.*** Brian conducted two separate surveys within the grounds of the New Smyrna Beach Airport. Both projects involved construction and/or expansion of existing airport buildings (T-Hanger) or facilities (Apron Lighting),which would not detract from the setting or feeling of this WWII Naval Aviation training facility. No resources were found during testing and there would be no impacts to the nearby Nationally Registered Turnbull Canal.

Cell Towers at St. Augustine, Lake City, and Flagler County Airports, FL. ***Lead Archaeologist.*** As lead archaeologist, Brian conducted three separate surveys involving the placement of cell/communication towers within the airport property of the three airports. Both the St. Augustine and Lake City Airports were used as WWII training facilities, while the Flagler County Airport was built after the war. The towers were built outside the fence of the main airport, but on airport property. The

Relevant Experience (Continued)

towers would not affect air space and would not detract from the setting of the airports.

Responsibilities Prior to Joining ESA

Environmental Services, Inc., St. Augustine, Florida, Archaeologist. Brian's responsibilities have included the identification and determination of NRHP eligibility of archaeological sites based type, age, composition, source of artifacts recovered at all levels of field investigation from reconnaissance to Phase III mitigation and data recovery for terrestrial and underwater projects in Florida and Georgia. Functioning as a Principal Investigator, he was in frequent contact with the offices of the SHPO, DHR, and BAR, as well as Tribal Historic Preservation Officers, Florida Master Site File, Georgia Division of Natural Resources, and various county, city, and municipalities. In the lab, Brian analyzed artifacts and faunal remains to determine their place within the archaeological record, as well as perform cursory conservation when needed. Brian was also responsible for the GIS data management for most of the Florida and Georgia archaeology work for ESI. Additionally, he directed, coordinated and prepared time and cost estimates for cultural resources contracts, and compile information and standards for proposal requests.

National Park Service, Southeastern Archeological Center (SEAC) Tallahassee, Florida, Document Curator and Museum Technician. Brian handled the curation of documents, maps, and photographs from archaeological projects within the National Park Service, Southeast Section. His duties involved inventorying, cataloging, creating databases, and preparing documents for preservation. Additionally, documents that were deteriorating were copied on acid free paper for curation. Other duties included analyzing and cataloging artifacts recovered from archaeological excavation that occurred within the National Park System and entering artifact information into a database.

MONICA STRAUSS, RPA

Manager, Southern California Cultural Resources Group

Monica Strauss is Manager of ESA's Southern California Cultural Resources Group and is based in the Los Angeles office. She has 15 years of experience in cultural resources management and has directed numerous archaeological investigations throughout Southern California and the Channel Islands. She directs prehistoric and historic field and research projects for public agencies and private developers and is proficient in CEQA and Section 106 compliance. She manages a staff of cultural resources specialists who conduct various types of compliance work including phase I surveys, construction monitoring, Native American consultation, archaeological testing and treatment, historic resource significance evaluations, and large-scale data recovery programs. Monica has prepared technical documents meeting the requirements of federal, State, and local agencies in support of CEQA and Section 106 as well as cultural resources components for General and Specific Plans. She provides senior oversight and quality control of archaeological resources-focused documents for ESA staff throughout the State.

Education

MA, Archaeology , California State University, Northridge

BA, Anthropology, California State University, Northridge

AA, Humanities, Los Angeles Pierce College

Years of Experience: 15

Professional Affiliations

Register of Professional Archaeologists (RPA)

Society for California Archaeology (SCA)

Society for American Archaeology (SAA)

Specialized Experience

Treatment of Historic and Prehistoric Human Remains

Archaeological Monitoring

Complex Shell Midden Sites

Groundstone Analysis

Qualifications

Exceeds Secretary of Interior Standards

CA State BLM Permitted

Certified in CA BLM Protocol

Relevant Experience

Patterson Fish Screen Project. Stanislaus County, CA. ***Project Director.*** ESA is retained by Montogomery, Watson Harza Americas (MWH) to provide cultural resources services in connection with the installation of a fish screen in Patterson Irrigation District (PID). ESA cultural resources staff conducted a Phase 1 Assessment in support of an MND and provided mitigation measures in the event resources were encountered during project implementation. Monica is currently facilitating discussions amongst all relevant parties to develop a satisfactory treatment plan for resources recently discovered.

Helix Water District (HWD)-El Monte Valley. San Diego County, CA. ***Cultural Resources Principal Investigator***. ESA is providing professional Environmental Consulting services in support of the HWD's El Monte Mining, Reclamation, and Groundwater Recharge Project. The project includes mining of approximately 10 million tons of aggregate from the El Monte Valley in San Diego County. Monica is currently directing the cultural resources component of this project to insure it complies with CEQA, Section 106 and the County of San Diego, Guidelines for Determining Significance. Duties involve providing oversight to the managements team and coordination with the client on key issues including Section 106 requirements and Native American issues.

Metropolitan Air Park Project. San Diego, CA. ***Cultural Resources Principal Investigator.*** ESA is preparing a master development plan, EIR, and EA for Metropolitan Air Park at Brown Field Airport in the City of San Diego. The project involves a 50-year land lease from the City of San Diego for a 400-acre portion of the airport property to be developed into airport and non-airport related land uses. The project requires the approval of the City of San Diego and the Federal Aviation Administration, and is being processed as Master Planned

Relevant Experience (Continued)

Development Permit Project. Monica is currently directing the cultural resource component of this project. Her duties involve coordination with the City of San Diego to ensure compliance with the City of San Diego Historical Resources Guidelines and oversight of survey and identification methods and resource evaluations.

Sweetwater Reservoir Water Main Replacement. San Diego County, CA. ***Cultural Resources Principal Investigator.*** ESA was retained by Sweetwater Authority to prepare an IS/MND for the replacement of a 36-inch pipeline leading from Sweetwater Dam. Sweetwater Dam was originally constructed in the late 19th century and was subject to upgrades in 1917. ESA conducted a Phase 1 Cultural Resources Assessment including archival research, pedestrian, survey, historical research, Native American outreach, and the preparation of a technical report documenting archaeological and historic-architectural resources that might be impacted by the project. The study concluded that features that would be altered by the project that were contributing elements to the historic dam would need to be replaced in kind. Monica directed the team of researchers which conducted this work, assisted in evaluating project impacts to the dam, and facilitated in the development of appropriate mitigation.

Sunrise Powerlink Transmission Archaeological and Biological Monitoring Project. Imperial and San Diego counties, CA. ***Cultural Resources Project Manager.*** ESA was retained by Burns & McDonnell to conduct archaeological and biological monitoring during construction activities for a 120-mile long SDG&E transmission line. Monica is currently serving as lead archaeologist to a team of archaeological monitors who are attending compliance and field safety training and who will be on-call during construction activities.

Sorenson Park Gymnasium Archaeological Monitoring Project. Lake Los Angeles, CA. ***Cultural Resources Principal Investigator.*** ESA was retained by the County of Los Angeles, Department of Public Works to conduct archaeological and biological monitoring during ground disturbing activities associated with project construction. Monica is currently providing daily oversight to archaeological and Native American monitors, coordinated work schedules with the County Project Manager, and coordinated the details of the necessary monitoring work with the County Inspector and construction contractors. An Archaeological Resources Monitoring Report documenting the monitoring findings will be submitted, together with daily monitoring logs, at the close of the project

North San Pablo Bay Restoration and Reuse Project. Sonoma and Napa counties, CA. ***Cultural Resources Senior Oversight.*** ESA was retained by the Sonoma County Water Agency to prepare an EIR/EIS in connection with a project to expand the beneficial use of recycled water in the North Bay Region. To fulfill both NEPA and CEQA requirements, ESA conducted Extended Phase 1 cultural resources identification efforts to meet CEQA and Section 106

Relevant Experience (Continued)

requirements. Extending across multiple counties, the project required extensive archival research and pedestrian survey, sub-surface archaeological testing, and coordination with Native American representatives. The Section 106 component of the work was coordinated with the U.S. Bureau of Reclamation. Monica provided senior oversight to ESA archaeologists; provided quality control reviews of the survey report, testing work plan, and testing report; and helped facilitate successful coordination with the Bureau of Reclamation.

SFPUC Seismic Upgrade of Bay Division Pipeline No. 3 & 4. Alameda County, CA. ***Cultural Resources Senior Oversight.*** ESA was retained by the San Francisco Public Utilities Commission to provide on-call environmental services, including environmental analyses and regulatory permits. The project proposes to replace the existing BDPL No. 3 with a new parallel pipeline across the main trace and two secondary traces of the Hayward Fault, and to subject BDPL No. 4 to a minor seismic upgrade. Because the projects would result in an unavoidable adverse effects to a National Register-eligible archaeological site, ESA archaeologists are leading the work to conduct testing and data recovery to mitigate the effects. Monica has provided senior oversight of the preparation of an Archaeological Research Design and Historic Property Treatment Plan designed to mitigate the anticipated effects.

Sacramento County Airport System On-Call Natural Resources Advisory & Consulting Services. Sacramento County, CA. ***Cultural Resources Senior Oversight.*** ESA is providing on-call natural resources support and consulting services for the Sacramento County Airport System. ESA archaeologists provided archaeological monitoring and survey during ground disturbing activities associated with routine discing activities. Monica provided daily oversight to archaeological monitors and provided direction when potential cultural resources were identified.

City of Calabasas Archaeological Resources Mapping. Calabasas, CA ***Project Director.*** ESA was awarded an on-call contract by the City of Calabasas to provide environmental compliance services. The City requested that ESA conduct a city-wide archaeological records search and prepare confidential archaeological resources maps and materials to assist the city in planning and permitting endeavors. Maps and documents were linked electronically for quick reference to parcel information. Monica directed archaeologists and GIS staff in the mapping of resources and development of procedures for map usage.

Antelope Valley Water Bank Initial Recharge and Recovery Facility Improvement Project. Kern County, CA. ***Cultural Resources Principal Investigator.*** ESA was retained by GEI Consultants, Inc. to conduct a Phase 1 Archaeological resources Assessment in connection with a groundwater banking project designed to provide up to 500,000 acre-feet of total surface water storage capacity underground in a partially depleted aquifer. The project is being carried out by the Antelope Valley East Kern Water Agency with the assistance of a Challenge Grant from the Bureau of Reclamation. Monica directed

Relevant Experience (Continued)

archaeologists who conducted archival research, pedestrian survey, Native American outreach to identify the presence of archaeological resources. A technical report was prepared to meet CEQA and Section 106 compliance requirements.

Ocotillo Wind Farm Project EIR. Imperial County, CA. *Project Manager.* ESA has been retained by the Bureau of Land Management under an on-call contract to provide cultural resource services including compliance monitoring for projects under BLM jurisdiction. Monica is specially trained in BLM protocols and procedures. She is currently assisting BLM (El Centro Field Office) staff with general oversight of the 15,000-acre cultural resources study being carried out for the Ocotillo Wind Farm project. Monica has conducted peer-review of cultural resources documents to ensure conformance with BLM requirements and is providing oversight to survey staff who are conducting compliance monitoring of the survey effort.

LAUSD Central Los Angeles High School #9. Los Angeles, CA. *Project Director.* ESA is presently working on Date Recovery Report sections for LAUSD's Central High School #9, constructed in downtown Los Angeles. Between 2004 and 2009, Monica led a team of archaeological staff of ten who conducted archaeological monitoring and data recovery of archaeological materials in connection with the 19th century Los Angeles City Cemetery. She coordinated with the Los Angeles County Coroner and office of Vital Statistics to obtain disinterment permits and developed a mitigation plan incorporating components related to the future disposition of remains, artifact curation, and commemoration. She directed an extensive historical research effort to identify the human remains, and at the request of the client, participated in public outreach and coordination with media.

Bureau of Land Management Abandoned Mine Lands Archaeological Inventory. Lakeside, San Diego County, CA. *Project Manager.*
ESA has been retained to provide cultural resources services to the BLM in connection with the Abandoned Mine Lands program. BLM is proposing to close or remediate abandoned mines that pose a safety hazard. ESA prepared archaeological inventory reports documenting the abandoned mines, in compliance with Section 106 of the NHPA. Monica directed cultural resources staff in the survey, research, and evaluation of mining features identified in the areas proposed for remediation.

Bureau of Land Management On-Call Cultural Resources Services. Riverside County, CA. *Project Manager.* ESA has been retained by the Bureau of Land Management under an on-call contract to provide cultural resource services including compliance monitoring for projects under BLM jurisdiction. Monica is currently managing a number of projects for the BLM (Palm Springs South Coast Field Office) providing a wide range of cultural resources services for solar projects and other projects taking place on BLM

Relevant Experience (Continued)

lands in compliance with Section 106 and specified BLM protocols. Services that she and her staff provide under this contract include compliance monitoring and peer review, Phase 1 archaeological resources surveys, resource evaluations, the preparation of reports, and Native American consultation. Projects completed under this contract include Dos Palmas Phase 1 Survey and Archaeological Monitoring, National Monument Phase 1 Survey, Windy Pointe Archaeological Monitoring, and Fast and the Furious Phase 1 Survey.

West Kern Water District Groundwater Recharge Project EIR. Kern County, CA. *Cultural Resources Principal Investigator.* Monica managed a Phase 1 archaeological resources survey of a 500-acre Project area proposed for groundwater recharge basins and a 9-mile pipeline in Kern County. The Project was carried out in compliance with CEQA and Section 106 of the NHPA. The survey resulted in the identification of over 20 archaeological sites. She managed the preparation of a Phase 1 Archaeological Resources Survey Report and Cultural Resources EIR Section that addressed the potential for site eligibility and provided an impacts analysis and mitigation measures.

Canyon Hill Cultural Resources Assessment. Lake Elsinore, CA. *Cultural Resources Principal Investigator.* ESA was retained by Pardee Homes to prepare a cultural resources assessment for Phases 7 & 8 of the Canyon Hills Specific plan. ESA conducted a Phase 1 and Phase II Archaeological Resources Investigation, identifying resources that might be impacted by the project. Monica directed the Phase II Testing Program to determine California Register and National Register eligibility of a recorded prehistoric archaeological site. She co-authored the Phase II Testing Research Design and Phase II Testing Evaluation Report.

California Department of Water Resources On-Call Environmental Planning Services. East Branch Enlargement EIR. Antelope Valley, CA. *Cultural Resources Principal Investigator.* ESA was retained by the Department of Water Resources. Monica managed a Phase 1 archaeological resources survey for the enlargement of 100 miles of the California Aqueduct from the Tehachapi split through the Antelope Valley and Mojave River Basin to Silverwood Reservoir. The Project was carried out in compliance with CEQA and Section 106 of the NHPA. Monica managed the survey, report effort, and preparation of the EIR section that considered Project impacts to historic architectural and archaeological resources.

Morro Bay Cayucos Wastewater Treatment Plant, San Luis Obispo County, CA. *Cultural Resources Principal Investigator.* ESA was retained by the City of Morro Bay-Cayucos Sanitation District to prepare an EIR for the Morro Bay-Wastewater Treatment Plant upgrade. Monica directed a Phase 1 Cultural Resources Assessment to identify cultural resources that might be impacted by the project. The assessment included archival research, pedestrian survey, the relocation of a number of archaeological sites, coordination with interested Native American parties in the area, and the preparation of a Phase 1

Relevant Experience (Continued)

Cultural resources Technical Report. Monica facilitated in meeting with Native American tribal members and City representatives to address concerns about buried resources.

Irvine Ranch Water District Baker Treatment Plant. Orange County, CA. ***Cultural Resources Principal Investigator*****.** ESA was retained by the Irvine Ranch Water District to provide environmental compliance services. In support of an EIR for the upgrade of the IRWD's Baker Treatment Plant near Lake Forest, Orange County, ESA cultural resources staff conducted a Phase 1 Cultural Resources Assessment. Monica directed the archival research, a series of pedestrian surveys, and oversaw the preparation of Phase 1 Cultural resources Technical reports and the cultural resources section of the EIR.

CDFG Suction Dredging Permitting Project. Yolo County, CA., ***Cultural Resources Senior Oversight.***
ESA was retained by Horizon Water and Environment LLC. to conduct a cultural resources constraints study to identify cultural resources within areas that would be impacted by the project. ESA conducted archival research and prepared section for an Initial Study and EIR. Monica provided senior technical oversight of the work and provided quality control review of the documents.

CPUC Devers-Mirage Project. Palm Springs, CA. ***Cultural Resources Senior Oversight*****. ESA was retained by the California Public Utilities Commission to prepare** an EIR to evaluate the potential impacts from Southern California Edison's proposed Devers-Mirage 115 kV System Split project. ESA cultural resources staff reviewed and synthesized technical documents and prepared a cultural resources EIR section that provided an impacts analysis and mitigation measures. Because the project involved BLM lands, cultural resources studies were required to meet NEPA reequirements in addition to CEQA. Monica provided technical oversight of the cultural resources effort and conducted quality control review of the document.

Prior to ESA

Hellman Ranch Archaeological Resources Monitoring and Data Recovery Project. Seal Beach, CA. ***Field Director.*** John Laing Homes constructed the Heron Point housing development in Seal Beach. Monica directed a large-scale excavation and monitoring program under the terms of a Mitigation Plan approved by the California Coastal Commission. She coordinated the daily excavation and monitoring activities of over twenty archaeological field personnel over a period of two years. She worked closely with a staff of eight Native American monitors and assisted in the preparation of remains artifacts for reburial. She also oversaw identification and cataloging activities that took place simultaneously on the job site in a field laboratory. On-site activities

Relevant Experience (Continued)

included hand excavation at four archaeological sites, construction monitoring, wet and dry-screening, and laboratory analysis, and also involved the evaluation of complex shell midden deposits and appropriate treatment of human remains.

San Clemente Island Section 106 Archaeological Testing and Evaluation Program. Los Angeles, CA. ***Project Director.*** Working for the U.S. Navy, Southwest Division, Monica directed a team of archaeologists who conducted testing of nine prehistoric archaeological sites on the northern end of San Clemente Island. Testing was conducted in accordance with guidelines set forth by the U.S. Navy and in compliance with Section 106. She authored a comprehensive technical report which considered the results of the testing program in relation to current California coast and San Clemente Island research questions and evaluated the sites for eligibility for the National Register.

State Route 90 Connector Road and the Admiralty Way Widening Archaeological Resources Phase 1 Projects. Marina del Rey, ***CA. Project Director.*** Monica directed a Phase 1 Cultural Resources Study for the County of Los Angeles, Department of Public Works in compliance with Section 106. Monica worked closely with Caltrans archaeologists and Native American representatives to reach agreement over the impacts and the appropriate treatment of a significant archaeological site located in the project APE.

South Region Elementary School #1 Archaeological/Paleontological Monitoring Project, ***Los Angeles, CA. Project Director.*** Monica directed archaeological/paleontological monitoring conducted during school site construction for LAUSD. She managed archaeological/paleontological monitors, conducted client coordination, and responded to and evaluated discoveries including two early 20th century residential refuse deposits. She provided oversight to staff conducting artifact analysis and the preparation of an Archaeological Monitoring report documenting and evaluating the recovered materials.

Alameda Street Improvement Archaeological Monitoring and Assessment Project, ***Los Angeles CA. Project Director.*** Monica directed archaeological monitoring conducted during the construction of roadway improvements in downtown Los Angeles. She responded to the discovery of historic resources including the *Zanja Madre* and the historic brick Alameda Street. She developed mitigation recommendations to address impacts to these resources from the project including an adaptive re-use of the recovered brick materials in the landscape design of the project. Monica provided oversight to laboratory analysts who catalogued the artifact collection.

Metro Universal Phase 1 Archaeological Resources Project, ***North Hollywood, CA. Project Director.*** Working as a consultant for Thomas Properties Group, Monica directed archaeological resources assessment for the proposed Metro Universal project to be constructed adjacent the historic *Campo de Cahuenga* in North Hollywood. She conducted extensive literature review

Relevant Experience (Continued)

and archaeological survey and prepared and archaeological technical report and EIR section. Working with project engineers, she developed a scaled approach to identify varying degrees of cultural resources sensitivity across the project site and determined appropriate mitigation measures. She worked with engineers and landscape designers to inform the design to best enhance existing cultural resources. Monica attended monthly meetings with the *Campo de Cahuenga* Board of Representatives and the Thomas Properties team to address cultural resources concerns.

First Street Trunk Line Archaeological Monitoring and Assessment Project, *Los Angeles CA. Project Director.* As a consultant to the City of Los Angeles, Department of Water and Power, Monica directed archaeological and paleontological monitoring of utilities installations ona continuous basis for over one year. She responded to monitoring discoveries including historic-period utility pipes and determined the appropriate mitigation in the form of recordation.

Main Street Archaeological/Paleontological Monitoring and Assessment, *Los Angeles, CA. Project Director.* Working for the City of Los Angeles, Bureau of Engineering, Monica directed archaeological/paleontological monitoring during the construction of a police parking facility in downtown Los Angeles. She managed monitors and conducted client coordination. She responded to discoveries of over a dozen in tact historic building basements and other refuse deposits to determine appropriate treatment. She provided oversight to specialists conducting analysis of the artifacts recovered and managed the preparation of a report that documented the findings and evaluated the resources.

Olive View Medical Center Emergency Services Expansion Monitoring and Assessment Project, *Los Angeles, CA. Project Director.* Working for the City of Los Angeles, Department of Public Works, Monica directed archaeological monitoring and a Phase I cultural resources assessment in support of an EIR for medical center expansion in Sylmar. Two historic resources were identified and determined not significant under CEQA. Monica responded to a discoveries made by construction personnel and determined prehistoric artifacts were present in native soil within the project area.

Temple Street Widening Archaeological Monitoring and Assessment Project, *Los Angeles, CA. Project Director.* Working for the City of Los Angeles, Department of Public Works, Monica directed archaeological monitoring conducted during the widening of Temple Street in downtown Los Angeles. She conducted extensive coordination with general and sub contractors and responded to discoveries including and segment of the zanja irrigation ditch and a large historic refuse deposit to determine appropriate treatment. She developed mitigation and monitored the implementation of mitigation for the zanja including concrete capping and the installation of an interpretive plaque.

Relevant Experience (Continued)

Exposition Corridor Transit Project – Phase 2 Phase 1 Archaeological Assessment Project, *Los Angeles CA. Project Director.* Working for DMJM Harris, Monica directed archaeological, historic architectural, and paleontological resources assessment in compliance with CEQA and Section 106 regulations. Project involved archaeological, paleontological, and historic architectural survey of 6- mile alignment, production of APE maps, consultation with SHPO and the preparation of technical reports and EIR sections.

Van Norman Chloramination Station Archaeological/Paleontological Monitoring Project, *San Fernando CA. Project Director.* Working for the City of Los Angeles, Department of Water and Power, Monica directed archaeological/paleontological and Native American monitoring during project construction. Resources identified during monitoring were assessed for significance under CEQA.

Lang Ranch Community Park Phase 1 Archaeological Testing and Assessment Project, *Thousand Oaks, CA. Project Director.* Working for the Conejo Park and Recreation District, Monica directed a Phase I archaeological survey of the 46-acre project area. Project work involved the archaeological testing at two artifact isolate locations to determine presence of sub-surface deposits and coordination with Native American representatives. Monica prepared an Archaeological Resources Technical Report and EIR section with findings and recommendations for further work, pursuant to CEQA requirements.

Woodland Duck Farm Phase 1 Cultural Resources Assessment Project, *Avocado Heights, CA. Project Director.* As a consultant to the San Gabriel & Lower Los Angeles Rivers and Mountains Conservancy, Monica directed a Phase I cultural resources evaluation of the historic-era Woodland Duck Farm property. She conducted a California Register eligibility assessment for several duck farm buildings and archaeological features identified as a result of the survey. Monica directed extensive background research concerning the history of the duck farm and poultry farming in general and prepared a Cultural Resources Technical Report and MND section with findings and recommendations for further work, pursuant to CEQA requirements.

San Clemente Island Section 106 Archaeological Resources Testing and Evaluation Project, Los Angeles County, *CA. Project Director* Working for the U.S. Navy, Southwest Division, Monica designed a research strategy and directed a testing program in strict accordance with guidelines set forth by the U.S. Navy and in compliance with Section 106. She authored a comprehensive technical report which considers the results of the testing program in relation to current California coast and San Clemente Island research questions and evaluates the sites for eligibility for the National Register.

San Gabriel River Discovery Center at Whittier Narrows Phase 1 Cultural Resources Assessment Project, *Los Angeles County, CA. Project Director.*

Relevant Experience (Continued)

CLIENT: City of Los Angeles, Department of Public Works. Directed a Phase I cultural resources evaluation of the historic-era Discovery Center. Conducted a National Register and California Register eligibility assessment for several historic-era buildings identified as a result of the survey. Conducted background research concerning the history of the duck farm and poultry farming in general including consultation with local Native American representatives. Prepared a Cultural Resources Technical Report with findings and recommendations for further work, pursuant to NEPA and CEQA requirements.

Hellman Ranch Monitoring Project*, Orange County, CA. Archaeological Monitor.* Working for John Laing Homes, Monica conducted archaeological monitoring during the initial rough grade phases of construction at Hellman Ranch. She coordinated with a team of monitors and Native American representatives. She worked with equipment operators according to predetermined monitoring protocols

Home Depot Monitoring and Assessment Project – Lake Elsinore*, Riverside County, CA. Project Director.* As a consultant to Twining Laboratories, Monica directed archaeological monitoring of Caltrans road-widening in the vicinity of a historic cemetery and coordinated her findings with Caltrans.

Public Safety Facilities Master Plan Phase 1 Archaeological Resources Evaluation Project*, Los Angeles County, CA. Project Director.* Working for the City of Los Angeles, Department of Public Works, Monica directed a Phase I archaeological resources evaluation of an approximately five-square block area in downtown Los Angeles. Project work involved an extensive investigation of the area during the cities' early pueblo years and specifically the Zanja Madre irrigation system. Monica prepared a technical report with findings and recommendations for further work, pursuant to CEQA requirements.

Ivy Street Bridge Phase 1 and Extended Phase 1 Archaeological Resources Testing and Evaluation Project*, Murrieta, CA. Project Director.* Working for T.Y. Lin and the City of Murrieta on a project that proposed to construct a bridge over Murietta Creek, Monica directed an Extended Phase I Testing Program in compliance with Section 106 review. She coordinated with Caltrans to meet Section 106 compliance and evaluated project effects on a nearby ethnohistoric Native American site. Monica coordinated extensively with Native American representatives and developed appropriate mitigation to be carried out prior to and during construction.

Lake Hodges Archaeological Resources Evaluation Project*, San Diego County, CA. Research Assistant.* Working for the San Diego County Water Authority, Monica conducted laboratory analysis of the groundstone tool collection recovered as a result of testing at a number of sites near Lake Hodges. She prepared a report that documented the findings of her analysis.

Relevant Experience (Continued)

Haiwee Dam Phase 1 Archaeological Resources Evaluation Project*, Lone Pine, CA. Field Archaeologist.* Working for the City of Los Angeles, Department of Water and Power, Monica participated in archaeological field survey involving the identification and recording of prehistoric and historic archaeological sites and structures in preparation for the construction of a new dam.

Arroyo Seco Bike Path Phase 1 Cultural Resources Evaluation Project*, Los Angeles, CA. Project Director.* Working for the County of Los Angeles, Department of Public Works in connection with a project to make improvements to the Arroyo Seco Channel, Monica managed all aspects of Section 106 review in accordance with Caltrans Cultural Resources Environmental guidelines. Monica and her team evaluated the Arroyo Seco Channel, identified character-defining features, informed the design of channel improvements to retain such features, and addressed the channels' potential for eligibility as part of a larger Los Angeles Country water management district. She developed the research strategy, directed the field teams, and prepared cultural resources assessment documentation for approval by Caltrans and FHWA, as well as the cultural resources section for a Mitigated Negative Declaration.

LMXU Archaeological resources Evaluation Project*, San Diego County, CA. Archaeological Researcher.* CLIENT: Confidential. Working for a confidential client, Monica conducted artifact analysis of groundstone artifacts recovered during excavations at sites in San Diego County.

I-5 Manchester*, San Diego County, CA. Archaeological Researcher.* CLIENT: Dokken Engineering for the City of Encinitas. As a consultant to Dokken Engineering for the City of Encinitas, Monica participated in identifying and compiling historic properties within the project area.

North Baja Pipeline Project*, Imperial County, Ehrenberg, AZ to Mexican Border. Archaeological Surveyor/Excavator.* As a consultant to Pacific Gas & Electric, Monica conducted survey, mapping, and excavation of prehistoric sites for the installation of a natural gas pipeline from Blythe, California, to Yuma, Arizona.

Public Outreach and Education

2008. Public Outreach speaker at Chinese Historical Society meeting. Project: Central Los Angeles High School #9. Client: Los Angeles Unified School District.

2006. Guest lecturer at Laurel Hall Elementary and Middle School regarding archaeology in southern California, North Hollywood, CA.

2003. Volunteer lecturer and field advisor at San Clemente Island Field School.

Relevant Experience (Continued)

2003. Key speaker at Seal Beach Historical Society community outreach meeting regarding findings from the Hellman Ranch Archaeological Sites, Seal Beach, CA.

2002. Guest lecturer at Rosemead Elementary School regarding career opportunities in cultural resources management, Rosemead, CA.

1998–2000. Appointment at California State University, Northridge, Anthropology Department. Directed undergraduate peer student advisement center, counseled students regarding course selection graduation reparation, and employment opportunities.

Appendix B
Native American and Interested Parties Contact

ESA

STATE OF CALIFORNIA Arnold Schwarzenegger, Governor

NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-6251
Fax (916) 657-5390
Web Site www.nahc.ca.gov
ds_nahc@pacbell.net

November 12, 2010

Ms. Madeleine Bray, Cultural Resources
ESA Los Angeles
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017

Sent by FAX to: 213-599-4301
No. of Pages: 5

Re: Request for a Sacred Lands File Search and Native American Contacts list for the **"Cadiz Groundwater Conservation and Storage Project;"** located in the Cadiz, Cadiz Summit, Cadiz Lake, Calumet Mine, Chubbuck, Milligan, Danby Lake, Sablon and the Arica Mountains; San Bernardino County, California.

Dear Ms. Bray:

The Native American Heritage Commission (NAHC), the State of California 'Trustee Agency' for the protection and preservation of Native American cultural resources. The NAHC Sacred Lands File (SLF) search, **did Indicate** the presence of Native American cultural resources within one-half mile of the proposed project site (APE) in the Arica Mountains, but not in the other USGS coordinates you provided. However, there are Native American cultural resources in close proximity to the other APEs/USGS coordinates.

Also, this letter includes state and federal statutes relating to Native American historic properties of religious and cultural significance to American Indian tribes and interested Native American individuals as 'consulting parties' under both state and federal law. State law also addresses the freedom of Native American Religious Expression in Public Resources Code §5097.9.

The California Environmental Quality Act (CEQA – CA Public Resources Code 21000-21177, amendments effective 3/18/2010) requires that any project that causes a substantial adverse change in the significance of an historical resource, that includes archaeological resources, is a 'significant effect' requiring the preparation of an Environmental Impact Report (EIR) per the CEQA Guidelines defines a significant impact on the environment as 'a substantial, or potentially substantial, adverse change in any of physical conditions within an area affected by the proposed project, including ...objects of historic or aesthetic significance." In order to comply with this provision, the lead agency is required to assess whether the project will have an adverse impact on these resources within the 'area of potential effect (APE), and if so, to mitigate that effect.

Early consultation with Native American tribes in your area is the best way to avoid unanticipated discoveries once a project is underway. Culturally affiliated tribes and individuals may have knowledge of the religious and cultural significance of the historic properties in the project area (e.g. APE). We strongly recommend that you contact persons on the attached list of Native American contacts, including non federally recognized tribes/tribal representatives as they are persons with unique expertise in articulating Native American cultural resources.

Furthermore we suggest that you contact the California Historic Resources Information System (CHRIS) for pertinent archaeological data within or near the APE, at (916) 445-7000 for the nearest Information Center.

Consultation with tribes and interested Native American consulting parties, on the NAHC list, should be conducted in compliance with the requirements of federal NEPA (42 U.S.C 4321-43351) and Section 106 and 4(f) of federal NHPA (16 U.S.C. 470 *et seq*), 36 CFR Part 800.3 (f) (2) & .5, the President's Council on Environmental Quality (CSQ, 42 U.S.C 4371 *et seq.* and NAGPRA (25 U.S.C. 3001-3013) as appropriate. The 1992 *Secretary of the Interiors Standards for the Treatment of Historic Properties* were revised so that they could be applied to all historic resource types included in the National Register of Historic Places and including cultural landscapes. Also, federal Executive Orders Nos. 11593 (preservation of cultural environment), 13175 (coordination & consultation) and 13007 (Sacred Sites) are helpful, supportive guides for Section 106 consultation.

Also, Public Resources Code Section 5097.98 and Health & Safety Code Section 7050.5 provide for provisions for accidentally discovered archeological resources during construction and mandate the processes to be followed in the event of an accidental discovery of any human remains in a project location other than a 'dedicated cemetery'.

To be effective, consultation on specific projects must be the result of an ongoing relationship between Native American tribes and lead agencies, project proponents and their contractors, in the opinion of the NAHC. Regarding tribal consultation, a relationship built around regular meetings and informal involvement with local tribes will lead to more qualitative consultation tribal input on specific projects. Also, the 2006 SB 1059 the state enabling legislation to the Federal Energy Policy Act of 2005, does mandate tribal consultation for the 'electric transmission corridors.' This is codified in the California Public Resources Code, Chapter 4.3, and §25330 to Division 15, requires consultation with California Native American tribes, and identifies both federally recognized and non-federally recognized on a list maintained by the NAHC. Consultation with Native American communities is also a matter of environmental justice as defined by California Government Code §65040.12(e).

The response to this search for Native American cultural resources is conducted in the NAHC Sacred Lands Inventory, established by the California Legislature (CA Public Resources Code 5097.94(a) and is exempt from the CA Public Records Act (c.f. California Government Code 6254.10) although Native Americans on the attached contact list may wish to reveal the nature of identified cultural resources/historic properties. Confidentiality of "historic properties of religious and cultural significance" may also be protected under Section 304 of he NHA or at the Secretary of the Interior discretion if not eligible for listing on the National Register of Historic Places. The Secretary may also be advised by the federal Indian Religious Freedom Act (cf. 42 U.S.C., 1996) in issuing a decision on whether or not to disclose items of religious and/or cultural significance identified in or near the APE and possibility threatened by proposed project activity.

If you have any questions about this response to your request, please do not hesitate to contact me at (916) 653-6251.

Sincerely,

Dave Singleton
Program Analyst

Attachment: Native American Contact List

Native American Contacts
San Bernardino County
November 12, 2010

Ramona Band of Cahuilla Mission Indians
Joseph Hamilton, Chairman
P.O. Box 391670 Cahuilla
Anza , CA 92539
admin@ramonatribe.com
(951) 763-4105
(951) 763-4325 Fax

Chemehuevi Reservation
Charles Wood, Chairperson
P.O. Box 1976 Chemehuevi
Chemehuevi Valley CA 92363
chair1cit@yahoo.com
(760) 858-4301
(760) 858-5400 Fax

San Manuel Band of Mission Indians
James Ramos, Chairperson
26569 Community Center Drive Serrano
Highland , CA 92346
(909) 864-8933
(909) 864-3724 - FAX
(909) 864-3370 Fax

Fort Mojave Indian Tribe
Tim Williams, Chairperson
500 Merriman Ave Mojave
Needles , CA 92363
(760) 629-4591
(760) 629-5767 Fax

Twenty-Nine Palms Band of Mission Indians
Darrell Mike, Chairperson
46-200 Harrison Place Chemehuevi
Coachella , CA 92236
tribal-epa@worldnet.att.net
(760) 775-5566
(760) 775-4639 Fax

Colorado River Reservation
Ginger Scott, Acting Cultural Contact
26600 Mojave Road Mojave
Parker , AZ 85344 Chemehuevi
symi@rraz.net
(928) 669-9211
(928) 669-5675 Fax

Joseph R. Benitez (Mike)
P.O. Box 1829 Chemehuevi
Indio , CA 92201
(760) 347-0488
(760) 408-4089 - cell

AhaMaKav Cultural Society, Fort Mojave Indian
Linda Otero, Director
P.O. Box 5990 Mojave
Mohave Valley AZ 86440
lindaotero@fortmojave,
(928) 768-4475
(928) 768-7996 Fax

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code. Also, federal National Environmental Policy Act (NEPA), National Historic Preservation Act, Section 106 and fed eral NAGPRA. And 36 CFR Part 800.

This list is only applicable for contacting local Native Americans for consultation purposes with regard to cultural resources impact by the proposed Cadiz Groundwater Conservation and Storage Project; to provide a storage facility for the Santa Margarita Water District and other agencies; located 60 miles southwest of Needles and 40 miles northeast of Twentynine Plams; San Bernardino County for which a Sacred Lands File search was request

Native American Contacts
San Bernardino County
November 12, 2010

Morongo Band of Mission Indians
Michael Contreras, Cultural Heritage Prog.
12700 Pumarra Road Cahuilla
Banning , CA 92220 Serrano
(951) 201-1866 - cell
mcontreras@morongo-nsn.gov
(951) 922-0105 Fax

Fort Mojave Indian Tribe
Esadora Evanston, Environmental Coordinator
500 Merriman Ave Mojave
Needles , CA 92363
region9epa@ftmojave.com
(760) 326-1112
(760) 629-4591
(760) 629-5767 Fax

San Manuel Band of Mission Indians
Ann Brierty, Policy/Cultural Resources Departmen
26569 Community Center. Drive Serrano
Highland , CA 92346
(909) 864-8933, Ext 3250
abrierty@sanmanuel-nsn.gov
(909) 862-5152 Fax

Quenchan Indian Nation
Bridget Nash-Chrabascz, THPO
P.O. Box 1899 Quechan
Yuma , AZ 85366
b.nash@quechantribe.com
(928) 920-6068 - CELL
(760) 572-2423

Fort Mojave Indian Tribe
Nora McDowell, Cultural Resources Coordinator
500 Merriman Ave Mojave
Needles , CA 92363
g.goforth@fortmojave.com
(760) 629-4591
(760) 629-5767 Fax

Ah-Mut-Pipa Foundation
Preston J. Arrow-weed
P.O. Box 160 Quechan
Bard , CA 92222 Kumeyaay
ahmut@earthlink.net
(928) 388-9456

Serrano Nation of Indians
Goldie Walker
P.O. Box 343 Serrano
Patton , CA 92369

(909) 862-9883

Ernest H. Siva
Morongo Band of Mission Indians Tribal Elder
9570 Mias Canyon Road Serrano
Banning , CA 92220 Cahuilla
siva@dishmail.com
(951) 849-4676

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code. Also, federal National Environmental Policy Act (NEPA), National Historic Preservation Act, Section 106 and federal NAGPRA. And 36 CFR Part 800.

This list is only applicable for contacting local Native Americans for consultation purposes with regard to cultural resources impact by the proposed Cadiz Groundwater Conservation and Storage Project; to provide a storage facility for the Santa Margarita Water District and other agencies; located 60 miles southwest of Needles and 40 miles northeast of Twentynine Plams; San Bernardino County for which a Sacred Lands File search was request

Native American Contacts
San Bernardino County
November 12, 2010

MOAPA Paiute Band of the Moapa Reservation
Attn: Cultural Resources Department
P.O. Box 340 Paiute
Moapa , NV 89025
(702) 865-2787
(702) 865-2875 - FAX

Las Vegas Paiute Tribe
Attn: Cultural Resources Department
1 Paiute Drive Paiute
Las Vegas , NV 89106

(702) 386-3926
(702) 383-4019 - FAX

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code. Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code. Also, federal National Environmental Policy Act (NEPA), National Historic Preservation Act, Section 106 and fed eral NAGPRA. And 36 CFR Part 800.

This list is only applicable for contacting local Native Americans for consultation purposes with regard to cultural resources impact by the proposed Cadiz Groundwater Conservation and Storage Project; to provide a storage facility for the Santa Margarita Water District and other agencies; located 60 miles southwest of Needles and 40 miles northeast of Twentynine Plams; San Bernardino County for which a Secred Lands File search was request

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Ramona Band of Cahuilla Mission Indians
Joseph Hamilton, Chairman
PO Box 391670
Anza, CA 92539

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Chairman Hamilton:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

San Manuel Band of Mission Indians
James Ramon, Chairperson
26569 Community Center Drive
Highland, CA 92346

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Chairman Ramon:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Twenty-Nin Palms Band of Mission Indians
Darrell Mike, Chairperson
46-200 Harrison Place
Coachella, CA 92236

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Chairman Mike:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Joseph R. Benitez (Mike)
PO Box 1829
Indio, CA 92201

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Mr. Benitez:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Chemehuevi Reservation
Charles Wood, Chairperson
PO Box 1976
Chemehuevi Valley, CA 92363

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Chairman Wood:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Fort Mojave Indian Tribe
Tim Williams, Chairperson
500 Merriman Ave
Needles, CA 92363

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Chairman Williams:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Colorado River Reservation
Ginger Scott, Acting Cultural Contact
26600 Mojave Road
Parker, AZ 85344

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. Scott:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

AhaMaKav Cultural Society, Fort Mojave Indian
Linda Otero, Director
PO Box 5990
Mohave Valley, AZ 86440

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Director Otero:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Morongo Band of Mission Indians
Michael Contreras, Cultural Heritage Program
12700 Pumarra Road
Banning, CA 92220

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Mr. Contreras:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

San Manuel Band of Mission Indians
Ann Brierty, Policy/Cultural Resources Department
28669 Community Center Drive
Highland CA 92346

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. Brierty:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Fort Mojave Indian Tribe
Nora McDowell, Cultural Resources Coordinator
500 Merriman Ave
Needles, CA 92363

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. McDowell:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Serrano Nation of Indians
Goldie Walker
PO Box 343
Patton, CA 92369

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. Walker:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Fort Mojave Indian Tribe
Esadora Evanston, Environmental Coordinator
500 Merriman Ave
Needles, CA 92363

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. Evanston:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Quenchan Indian Nation
Bridget Nash-Chrabascz, THPO
PO Box 1899
Yuma, AZ 85366

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Ms. Nash-Chrabascz:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Ah-Mut-Pipa Foundation
Preston J Arrow-weed
PO Box 160
Bard, CA 92222

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Mr. Arrow-weed:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Ernest H Siva
Morongo Band of Mission Indians Tribal Elder
9570 Mias Canyon Road
Banning, CA 92220

Subject: Cadiz Groundwater Conservation and Storage Project

Dear Mr. Siva:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

MOAPA Paiute Band of the Moapa Reservation
Attn: Cultural Resources Department
PO Box 340
Moapa, NV 89025

Subject: Cadiz Groundwater Conservation and Storage Project

To Whom It May Concern:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

626 Wilshire Blvd
Suite 100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

November 17, 2010

Las Vegas Paiute Tribe
Attn: Cultural Resources Department
1 Paiute Drive
Las Vegas, NV 89106

Subject: Cadiz Groundwater Conservation and Storage Project

To Whom It May Concern:

ESA is conducting environmental studies for the Cadiz Groundwater Conservation and Storage Project (Project). The Project is a water supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed in the eastern Mojave Desert for the purposes of developing a new reliable water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. Groundwater extraction wells would be constructed on land owned by Cadiz, Inc. within the Fenner Gap area and a 44-mile pipeline would be installed connecting the wellfield to the Colorado River Aqueduct. The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see attached map).

In an effort to address any potential impact to archaeological or ethnographic resources, we are seeking comments from Native American representatives; your name was supplied to us by the Native American Heritage Commission as a contact for this area. We would appreciate your comments concerning any knowledge you would like to share regarding archaeological or traditional cultural resources that may be pertinent to this project.

Thank you for your time and cooperation regarding this matter. Please contact me at 213.599.4300 or mbray@esassoc.com if you have any questions.

Sincerely,

Madeline Bray

Madeline Bray
Cultural Resources Associate

Attachment

ESA

626 Wilshire Boulevard
Suite 1100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

telephone notes

project	Cadiz	project no.	210324
date	January 20, 2011	time	12:05
present	Joseph R. Benitez, Monica Strauss		
route to			

contact	Joseph R. Benitez
title	Chemehuevi Tribal Elder
agency	
phone	760-347-0488
subject	Cadiz cultural resources concerns

action required

Instigated call and spoke with Joseph Benitez at 760-347-0488 at 12:05 PM on Jan 20, 2011. He indicates that the Old Mountain range is a sacred site and that the general project area was likely used prehistorically by the Chemehuevi to traverse to and from the Lake Havasu area. Indicates that there could be a possibility of archaeological sites, especially near watercourses. I explained that the pipeline survey (in RR ROW) did not result in the identification of any prehistoric sites and that the wellfield still needed to be surveyed. He asked that he be kept informed of the project as it progresses. I indicated that his comments would be noted in the EIR and that he would be added to the distribution list.

ESA

626 Wilshire Boulevard
Suite 1100
Los Angeles, CA 90017
213.599.4300 phone
213.599.4301 fax

www.esassoc.com

telephone notes

project	Cadiz	project no.	210324
date	February 2, 2011	time	8:45 AM
present	Bridget Nash, Monica Strauss		
route to			

contact	Bridget Nash
title	Quechan Tribe Historic Preservation Officer
agency	
phone	760-572-2423
subject	Cadiz cultural resources concerns

action required

Bridget Nash returned my call from a couple of weeks ago. The tribe is concerned that there may be prehistoric archaeological sites, pictographs and petroglyphs in the vicinity of the project. They would like an archaeological survey to be conducted and would like an opportunity to review the report. Also, the tribe is concerned about visual impacts that the project might have on the cultural traditional significance associated with the Old Woman Mountains. They would like to see these visual impacts taken into consideration .

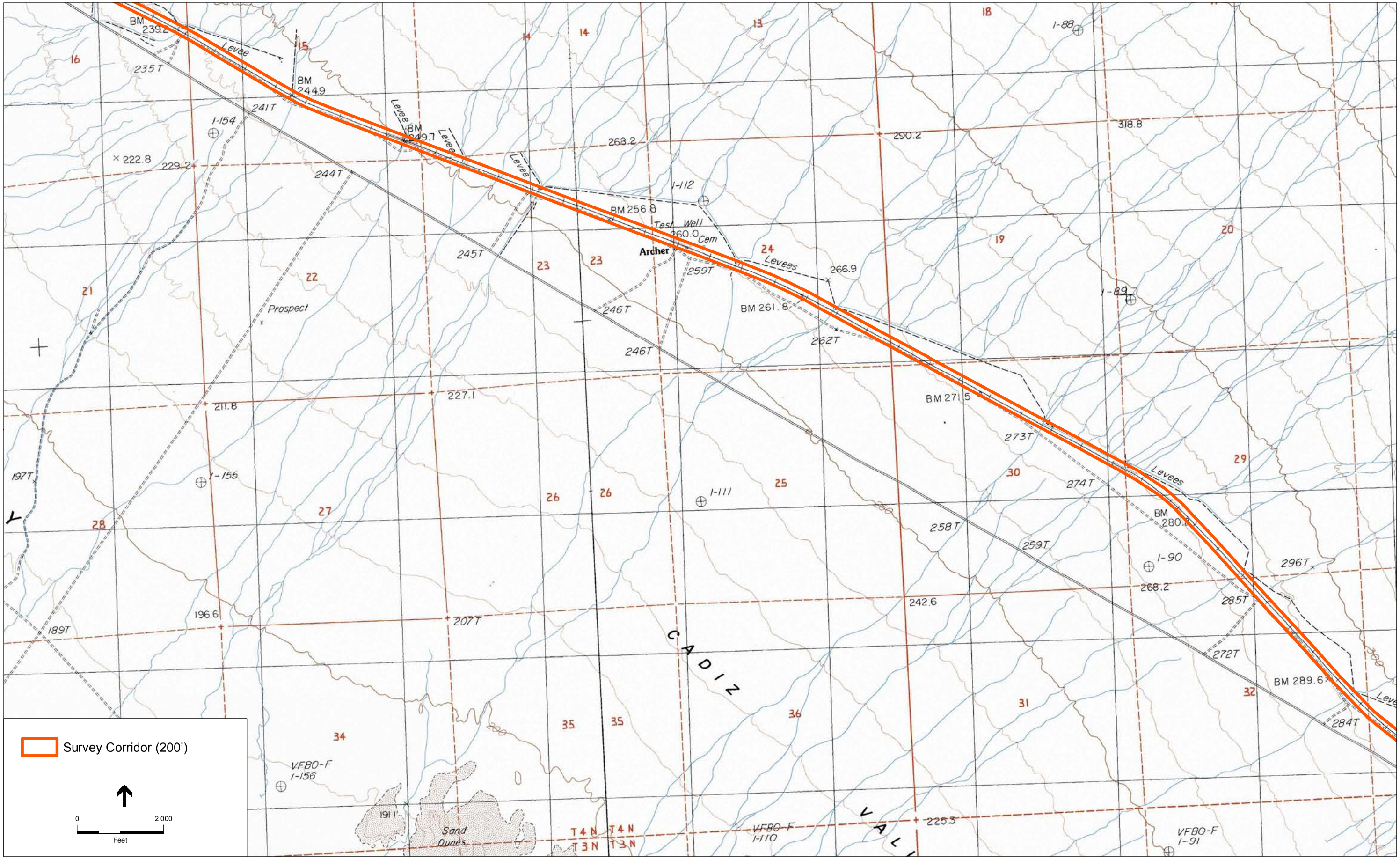
I gave her an update that we had completed the survey of the pipeline component and that no prehistoric sites or isolates were identified, only historic-period sites. I explained that the pipeline would be installed within the RR ROW. She seemed more concerned with the well field component and the scale of the project on the landscape.

I let her know that we would document her concerns in our technical report (pipeline portion of the project only) and that the well field would be subject to separate technical study at a future date presently unknown. I indicated that we were adding the Quechan, along with all others on the NAHC list, to the distribution list for the project.

Appendix C
Survey Coverage on USGS Topographic Maps (1:24000)

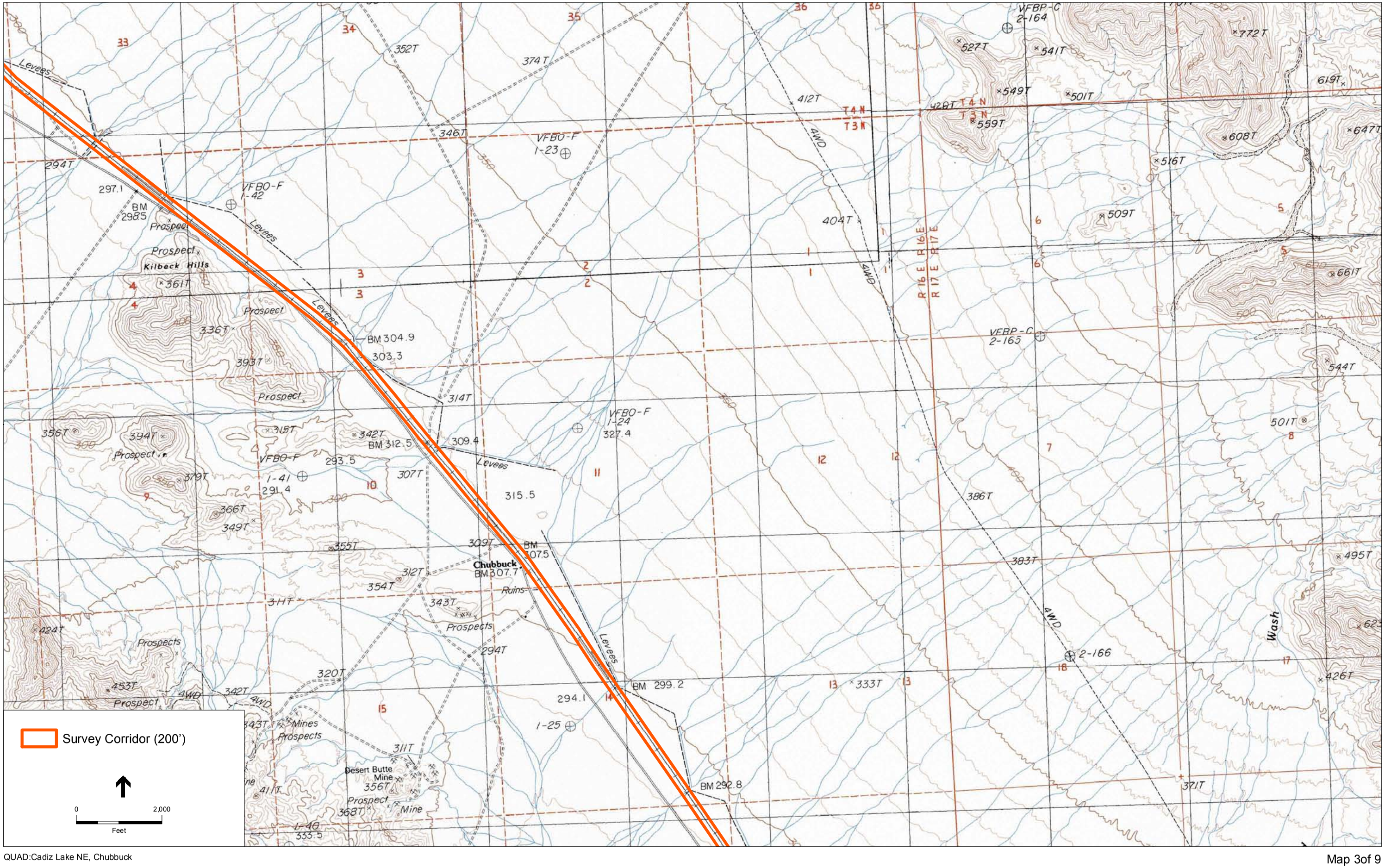
QUAD: Cadiz Lake NW

Map 1of 9
Survey Coverage on USGS Topographic Maps (1:24000)

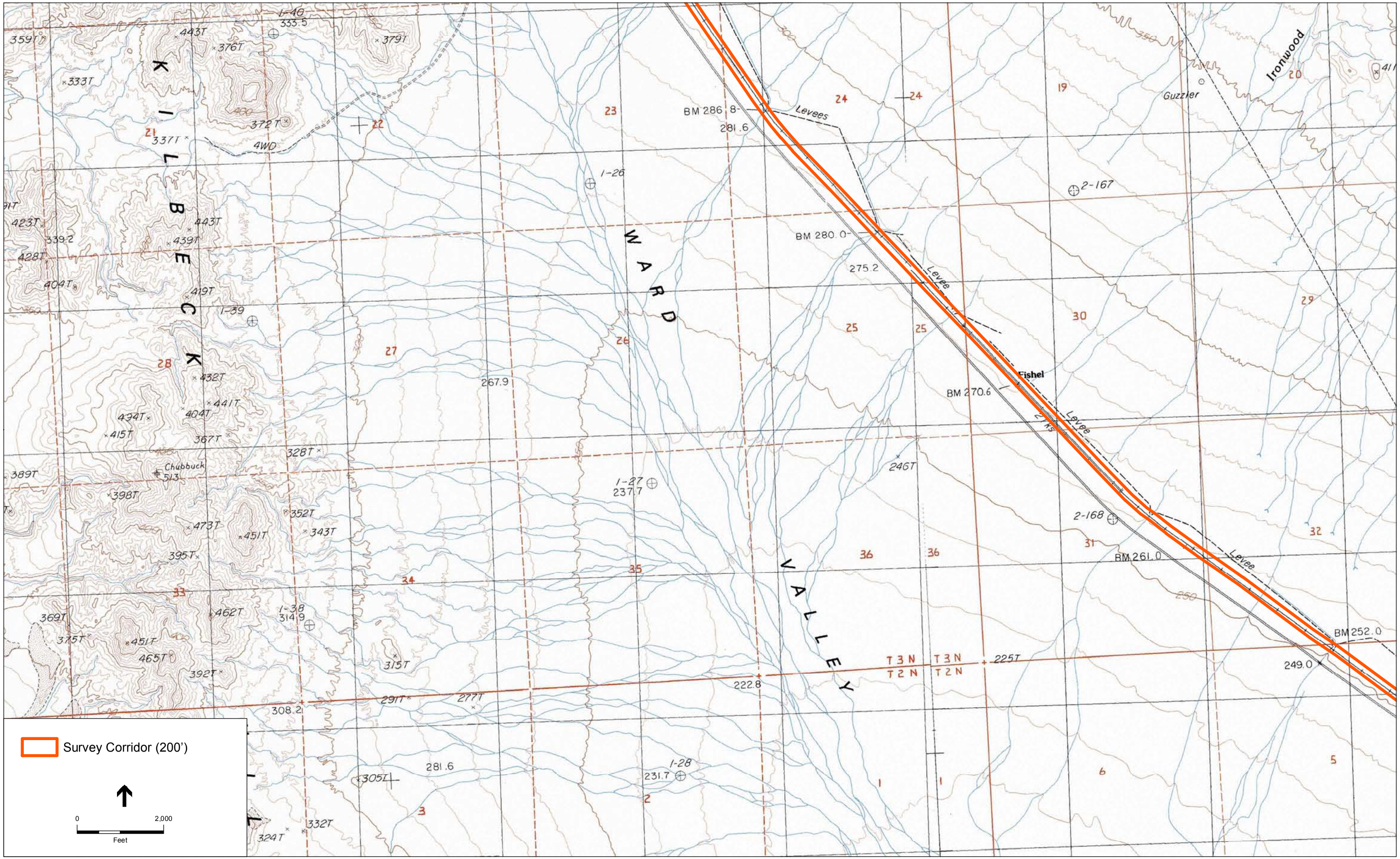


QUAD: Cadiz Lake NW, Cadiz Lake NE

Map 2of 9
Survey Coverage on USGS Topographic Maps (1:24000)



QUAD:Cadiz Lake NE, Chubbuck

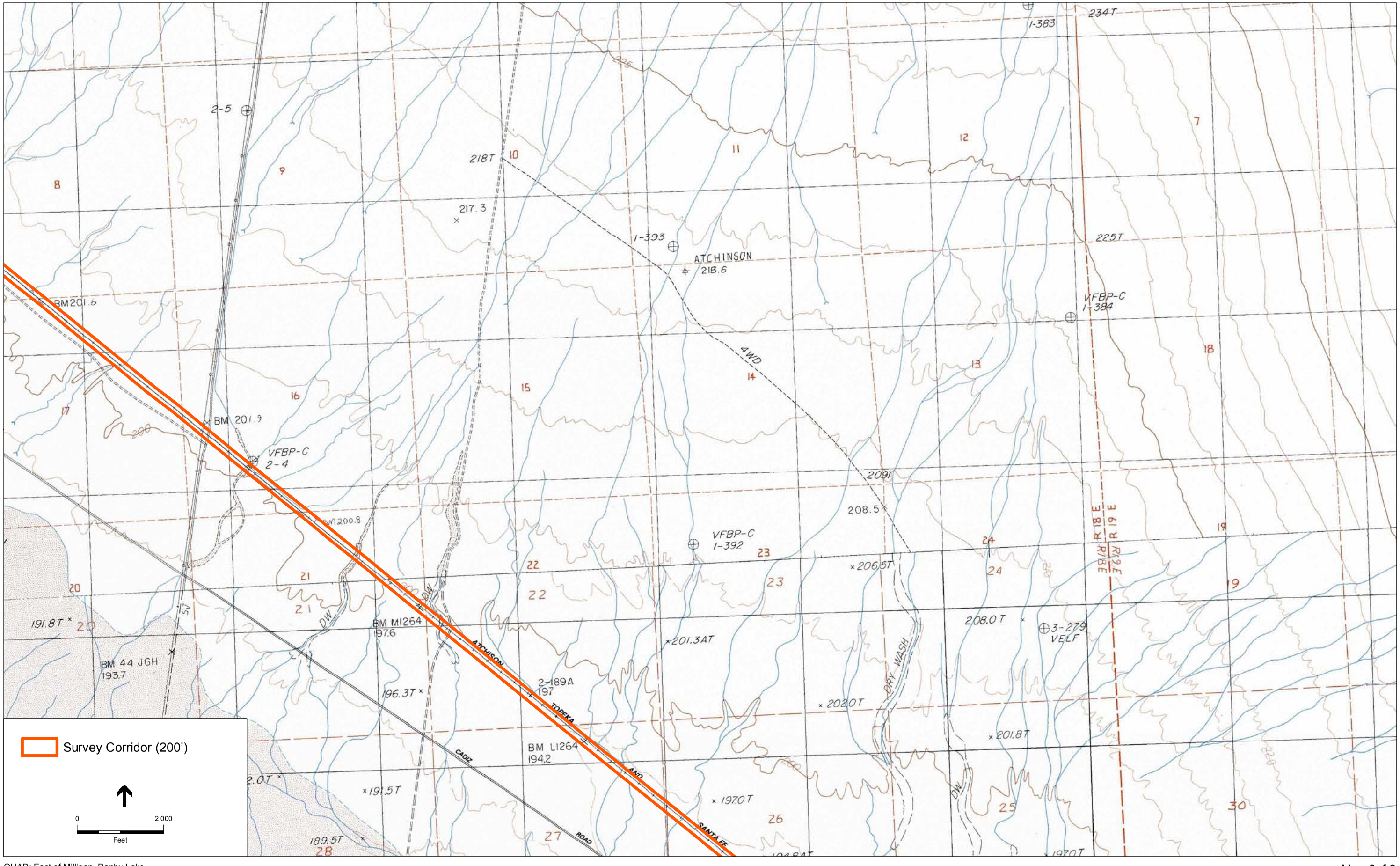


Survey Corridor (200')

0 2,000
Feet

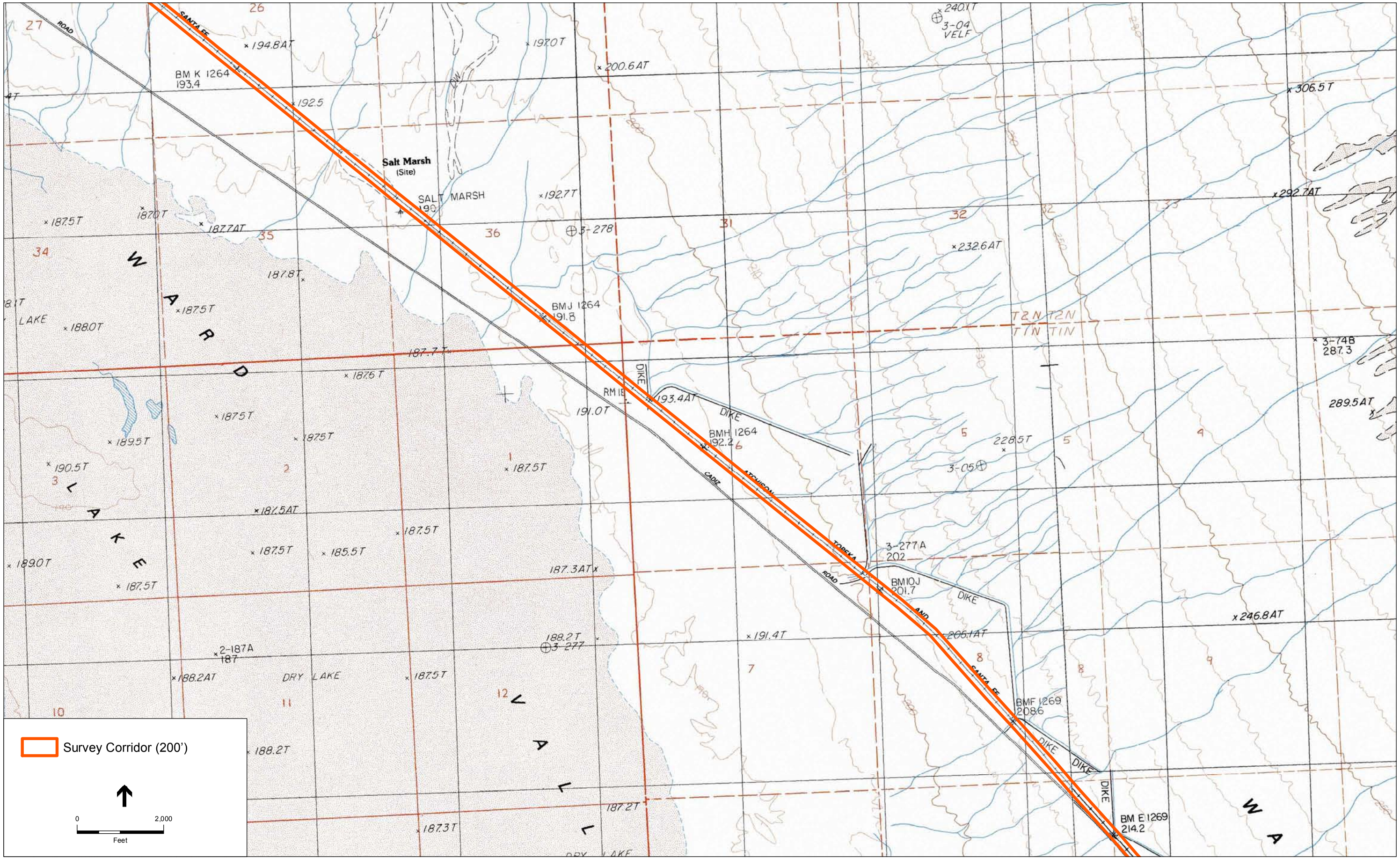
QUAD: Chubbuck, Milligan

QUAD: Milligan, East of Milligan

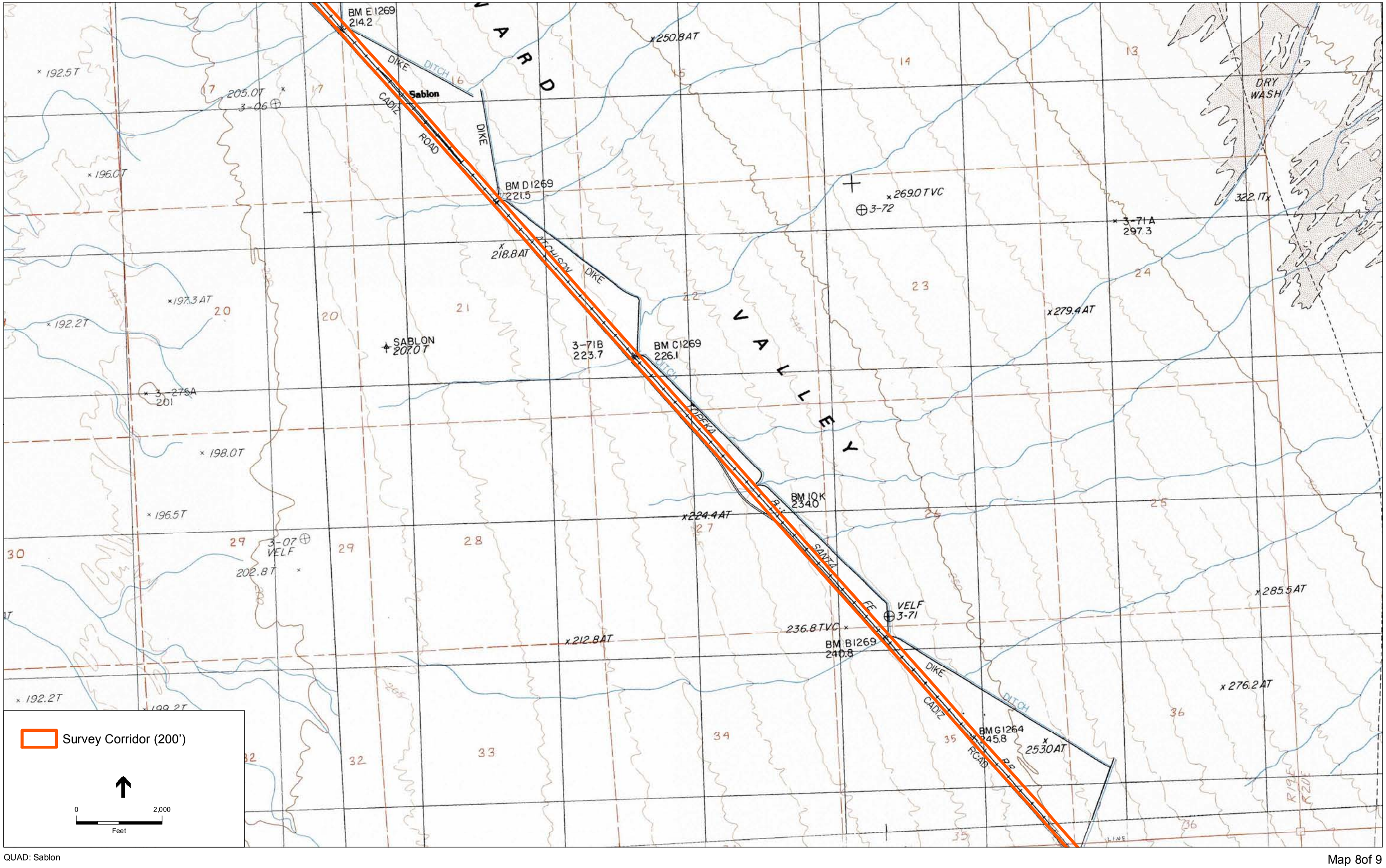


QUAD: East of Milligan, Danby Lake

Map 6of 9
Survey Coverage on USGS Topographic Maps (1:24000)

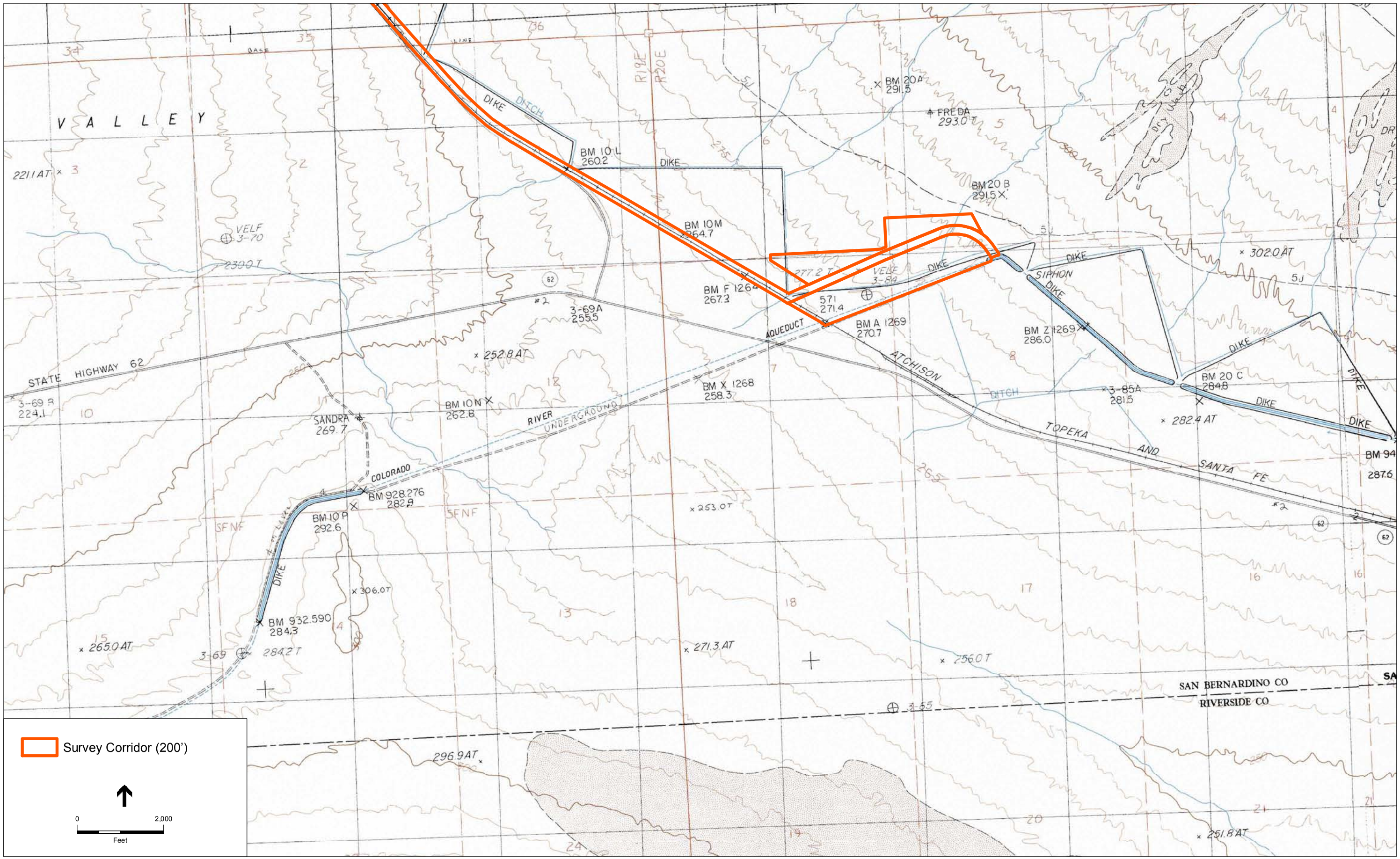


QUAD: Danby Lake, Sablon



QUAD: Sablon

Map 8of 9
Survey Coverage on USGS Topographic Maps (1:24000)



QUAD: Arica Mountains

Map 9of 9
Survey Coverage on USGS Topographic Maps (1:24000)

Appendix D (Confidential)

Cultural Resources Location Map
(Figure 4)

ESA

Appendix E (Confidential)
DPR Forms

PALEO SOLUTIONS
Paleontological & Archaeological Compliance & Consulting Services
2035 Placentia Ave • Suite D • Costa Mesa • CA 92627

Paleontology Survey and Assessment for the Cadiz Valley Water Conservation, Recovery, and Storage Project

San Bernardino County, California

Submitted to:

Tom Barnes
ESA | Water
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017-2934

Prepared for:

Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA

Prepared by:

Paleo Solutions, Inc.
2035 Placentia Ave, Suite D
Costa Mesa, CA 92627
(562) 818-7713

Authors:

Geraldine Aron, Principal Investigator

and Jennifer Kelly, Staff Paleontologist

geraldine@paleosolutions.com

April 2011

TABLE OF CONTENTS

PALEONTOLOGICAL RESOURCES 4

1.0 REGULATORY REQUIREMENTS 4

1.1 CEQA SIGNIFICANCE THRESHOLDS 5

2.0 RESOURCE ASSESSMENT CRITERIA 8

3.0 LITERATURE AND MUSEUM RECORDS SEARCH RESULTS 12

3.1 GEOLOGIC SETTING 12

3.2 GEOLOGY AND PALEONTOLOGY 14

3.2.1. SURFICIAL SEDIMENTARY DEPOSITS OF QUATERNARY AGE 23

4.0 FIELD SURVEY RESULTS 25

5.0 RECOMMENDED MITIGATION MEASURES 25

6.0 REFERENCES 29

TABLE OF FIGURES

Figure 1. Location map of the proposed Project. The pipeline was surveyed for paleontological resources in 2010. 7

Figure 2 Geologic map of the northern portion of the proposed Project (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations. 17

Figure 3. Geologic map of the middle portion of the proposed Project (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations. 18

Figure 4. Geologic map of the southern portion of the proposed Project (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations. 19

Figure 5. Paleontological sensitivity map of the northern portion of proposed Project. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1).....20

Figure 6. Paleontological sensitivity map of the middle portion of the proposed Project. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1)...21

Figure 7. Paleontological sensitivity map of the southern portion of the proposed Project. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1)...22

PALEONTOLOGICAL RESOURCES

This section presents the findings of the paleontological resources analysis completed for the Cadiz Valley Water Conservation, Recovery, and Storage Project (proposed Project), located in eastern San Bernardino County, California. The analysis includes a review of pertinent scientific literature and unpublished technical reports, published geologic maps, museum fossil locality records, and a field survey.

The field survey included all areas of proposed surface disturbance resulting from project construction. This includes the 200-foot-wide Arizona and California Railroad Company (ARZC) right-of-way (ROW) from the Cadiz Inc. property in Section 36, Township T5N, Range R14E, and an approximately 200-foot-wide corridor northeast of the intersection of the ARZC ROW and the Colorado River Aqueduct (CRA), extending approximately 4,300 feet east from the ARZC ROW to the CRA canal, parallel to the CRA (referred to herein as the proposed pipeline alignment). Only one Project configuration was analyzed for impacts on paleontological resources (Figure 1), and field surveys of the project wellfield and conceptual spreading basin areas were not conducted because these facilities are still undergoing conceptual development. Paleontological surveys of these areas were completed as part of the previous EIS/EIR (2001), and numerous fossil localities were documented at that time. These areas will be evaluated herein at the programmatic level, because additional information regarding the specific location of the proposed wellfield expansion and spreading basin areas will be needed in order to fully evaluate potential impacts to paleontological resources. When the project design plans are finalized, and prior to implementing the Imported Water Storage Component, a further paleontological resources review consistent with CEQA shall be completed, including additional field surveys if appropriate. Based on the previous EIS/EIR (2001), a survey should be completed and could be done during the preconstruction phase of this project.

Based on the results of the analysis, mitigation measures were developed to reduce potential adverse impacts to paleontological resources as a result of proposed Project construction to a less than significant level.

1.0 REGULATORY REQUIREMENTS

The paleontological analysis for the proposed Project is a requirement of the California Environmental Quality Act (CEQA). The procedures, types of activities, persons, and public agencies required to comply with CEQA are defined in: Guidelines for the Implementation of CEQA, as amended March 18, 2010 (Title 14, Chapter 3, California Code of Regulations: 15000 et seq.). One of the questions listed in the CEQA Environmental Checklist (Section

15023, Appendix G, Section XIV, Part A) is: "Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?"

The State of California Public Resources Code (Chapter 1.7), Section 5097.5 and 30244, includes additional state level requirements for the assessment and management of paleontological resources. These statutes requires reasonable mitigation of adverse impacts to paleontological resources resulting from development on state lands, define the removal of paleontological "sites" or "features" from state lands as a misdemeanor, and prohibit the removal of any paleontological "site" or "feature" from state land without permission of the applicable jurisdictional agency. These protections apply only to State of California land. The proposed Project will be constructed entirely on privately-owned lands and within existing private easements. No portion of the project will occur on federal or state land.

No other state or local laws and regulations are believed to be applicable to the proposed Project.

1.1 CEQA SIGNIFICANCE THRESHOLDS

As stated in the Cadiz Groundwater Storage and Dry Year Supply Program Final EIS/EIR (MWD, 2001), paleontological resources are nonrenewable resources of important scientific value, which include fossils and fossiliferous deposits. For purposes of CEQA, a project would be considered to result in a significant adverse impact related to paleontological resources if it results in the disturbance or destruction of rock formations determined to have high potential for significant nonrenewable fossiliferous resources, as defined by the Society of Vertebrate Paleontology. The proposed Project area contains fossiliferous formations, and prior paleontological surveys in the general area, as well as museum records, reflect the potential for the presence of significant paleontological resources within Pleistocene age formations in the proposed Project area. Because these formations have high potential for containing important paleontological resources, the disturbance of Pleistocene age sediments would be considered a significant adverse impact resulting from the proposed Project because disturbance would have the potential to directly or indirectly destroy a unique paleontological resource or site or unique geologic feature (Section 15023, Appendix G, Section XIV, Part A). According to guidelines of the San Bernardino County Museum, fossils are considered to be of significant scientific interest if one or more of the following apply:

- The fossils provide data on the evolutionary relationships and developmental trends among organisms, both living and extinct;

- The fossils provide data useful in determining the age(s) of the rock unit or sedimentary stratum, including data important in determining the depositional history of the region and the timing of geologic events therein;
- The fossils provide data regarding the development of biological communities or interaction between paleobotanical and paleozoological biotas;
- The fossils demonstrate unusual or spectacular circumstances in the history of life; and
- The fossils are in short supply and/or in danger of being depleted or destroyed by the elements, vandalism or commercial exploitation, and are not found in other geographic locations.

As defined, significant paleontologic resources are determined to be fossils or assemblages of fossils which are unique, unusual, rare, uncommon, diagnostically or stratigraphically important, and/or those which add to an existing body of knowledge in specific areas-stratigraphically, taxonomically and/or regionally. They can include fossil remains of large to very small aquatic and terrestrial vertebrates, remains of plants and animals previously not represented in certain portions of the stratigraphy, and assemblages of fossils that might aid in stratigraphic corrections, particularly those offering data for the interpretation of tectonic events, geomorphologic evolution, paleoclimatology and the relationships of aquatic and terrestrial species.

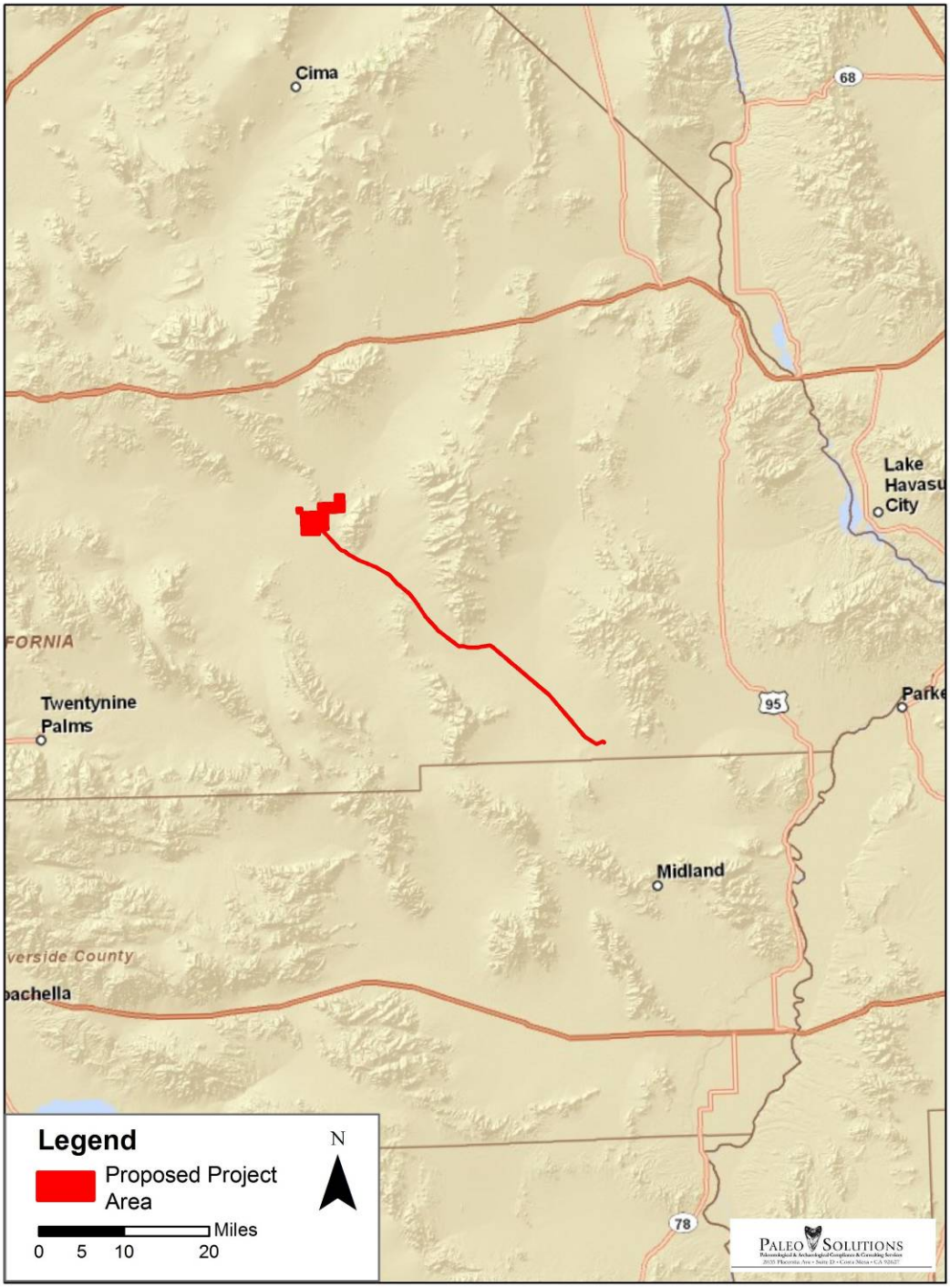


Figure 1. Location map of the proposed Project. The proposed pipeline alignment was surveyed for paleontological resources in 2010.

2.0 RESOURCE ASSESSMENT CRITERIA

This paleontological resources analysis utilizes the Potential Fossil Yield Classification System (PFYC). This system is accepted by most federal and many state agencies and is widely utilized by professional paleontologists for the purpose of paleontological resource management. The PFYC follows, and is excerpted directly from BLM IM 2008-009 (2007):

Occurrences of paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

However, it is impossible to predict the specific types of fossils that will be found or their exact locations in a geologic formation.

Using the PFYC system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential. This classification is applied to the geologic formation, member, or other distinguishable unit, preferably at the most detailed mappable level. It is not intended to be applied to specific paleontological localities or small areas within units. Although significant localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment.

The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered at an intermediate point in the analysis, and should be used to assist in determining the need for further mitigation assessment or actions.

The descriptions for the classes below are written to serve as guidelines rather than as strict definitions. Knowledge of the geology and the paleontological potential for individual units or preservational conditions should be considered when determining the appropriate class assignment. Assignments are best made by collaboration between land managers and knowledgeable researchers.

Class 1 – **Very Low**. Geologic units that are not likely to contain recognizable fossil remains.

•Units that are igneous or metamorphic, excluding reworked volcanic ash units.

•Units that are Precambrian in age or older.

(1) Management concern for paleontological resources in Class 1 units is usually negligible or not applicable. (2) Assessment or mitigation is usually unnecessary except in very rare or isolated circumstances.

The probability for impacting any fossils is negligible. Assessment or mitigation of paleontological resources is usually unnecessary. The occurrence of significant fossils is non-existent or extremely rare.

Class 2 – **Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

•Vertebrate or significant invertebrate or plant fossils not present or very rare.

•Units that are generally younger than 10,000 years before present.

•Recent aeolian deposits.

•Sediments that exhibit significant physical and chemical changes (i.e., diagenetic

alteration).

(1) Management concern for paleontological resources is generally low. (2) Assessment or mitigation is usually unnecessary except in rare or isolated circumstances.

The probability for impacting vertebrate fossils or scientifically significant invertebrate or plant fossils is low. Assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist, but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

Class 3 – **Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.

•Often marine in origin with sporadic known occurrences of vertebrate fossils.

•Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low. (or)

•Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Class 3a – **Moderate Potential.** Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for hobby collecting. The potential for a project to be sited on or impact a significant fossil locality is low, but is somewhat higher for common fossils.

Class 3b – **Unknown Potential.** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this Class may eventually be placed in another Class when sufficient survey and research is performed. The unknown potential of the units in this Class should be carefully considered when developing any mitigation or management actions.

(1) Management concern for paleontological resources is moderate; or cannot be determined from existing data. (2) Surface-disturbing activities may require field assessment to determine appropriate course of action.

This classification includes a broad range of paleontological potential. It includes geologic units of unknown potential, as well as units of moderate or infrequent occurrence of significant fossils. Management considerations cover a broad range of options as well, and could include pre-disturbance surveys, monitoring, or avoidance. Surface-disturbing activities will require sufficient assessment to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources. These units may contain areas that would be appropriate to designate as hobby collection areas due to the higher occurrence of common fossils and a lower concern about affecting significant paleontological resources.

Class 4 – **High**. Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface disturbing activities may adversely affect paleontological resources in many cases.

Class 4a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres. Paleontological resources may be susceptible to adverse impacts from surface disturbing actions. Illegal collecting activities may impact some areas.

Class 4b – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a

protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

•Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.

•Areas of exposed outcrop are smaller than two contiguous acres.

•Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.

•Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action. (2) A field survey by a qualified paleontologist is often needed to assess local conditions. (3) Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered. (4) Class 4 and Class 5 units may be combined as Class 5 for broad applications, such as planning efforts or preliminary assessments, when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation, and other management considerations are similar at this level of analysis, and impacts and alternatives can be addressed at a level appropriate to the application.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation considerations must include assessment of the disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access resulting in greater looting potential. If impacts to significant fossils can be anticipated, on-the-ground surveys prior to authorizing the surface disturbing action will usually be necessary. On-site monitoring or spot-checking may be necessary during construction activities.

Class 5 – **Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface disturbing actions. Unit is frequently the focus of illegal collecting activities.

Class 5b – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

•Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.

•Areas of exposed outcrop are smaller than two contiguous acres.

•Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.

•Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 5 areas is high to very high. (2) A field survey by a qualified paleontologist is usually necessary prior to surface disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions. (3) Official designation of areas of avoidance, special interest, and concern may be appropriate.

The probability for impacting significant fossils is high. Vertebrate fossils or scientifically significant invertebrate fossils are known or can reasonably be expected to occur in the impacted area. On-the-ground surveys prior to authorizing any surface disturbing activities will usually be necessary. On-site monitoring may be necessary during construction activities.

3.0 LITERATURE AND MUSEUM RECORDS SEARCH RESULTS

A records search was conducted for the proposed Project area and vicinity. Surficially, the Project occurs mostly on alluvium and lake deposits of Quaternary (Holocene and Pleistocene age). Igneous and metamorphic bedrock units of Precambrian to Mesozoic age also occur (Bishop, 1963; Howard, 2002; Bedford et al, 2010). For the purpose of this analysis, geologic maps with the highest resolution (smallest scale) were used when possible. These include the geologic map of the Amboy 30' x 60' Quadrangle (Bedford et al., 2010), and the geologic map of the Sheep Hole Mountains 30' x 60' Quadrangle (Howard, 2002). The geologic map of the Needles 1 x 2 Degree Quadrangle (Bishop, 1963) was used for portions of the Project area that are not covered by the 30' x 60' maps.

3.1 GEOLOGIC SETTING

The proposed project is located to the west of the Old Women Mountains and north of the Iron Mountains, mostly adjacent to lake playas, which include the Cadiz, Danby, and Bristol dry lakes. The proposed project is approximately 40 miles northeast of Twenty Nine Palms and 60 miles west of the California-Arizona border in San Bernardino, County. It is situated in the Mojave Desert in the southwestern-most part of the Basin and Range Province (Norris and Webb, 1990; Sharp, 1976). The Mojave Desert is roughly 65,000 square kilometers in size, landlocked, and bordered on the southwest by the San Andreas Fault, the Transverse Ranges and the Garlock Fault on the north. Its arbitrary eastern border is defined as the Nevada-California and Arizona-California state lines (Norris and Webb, 1990). The Mojave region is dominated by broad alluvial basins generally receiving

sediments that have been shed from adjacent hills and mountain ranges (Norris and Webb, 1990).

Precambrian/Late Proterozoic basement rocks in this area are often overprinted by subsequent geologic actions, including mid to high-level metamorphism and orogenic-related thrust-and-fold belts, which generally date from 1,700 (Ivanpah Orogeny) or 1,400 million years ago (Anderson et al, 1993; Burchfiel and Davis, 1980). The Precambrian crystalline basement rocks of the Mojave area were also intruded by granitic rocks from approximately 1,400 to 1,200 million years ago (Burchfiel and Davis, 1980).

At the end of the Paleozoic Era (approximately 250 million years ago), the passive margin that was the westernmost border of what is now North America became a more active margin, resulting in significantly increased tectonism and igneous activity (Glazner et al, 2002). This region was part of an evolving and shifting magmatic arc complex that is thought to be the result of shifting convergent plate boundaries along the then-western border of the continent (Burchfiel and Davis, 1980).

During the Mesozoic Era (approximately 250 million to 65 million years ago), the basement rocks of the area were intruded again by significant amounts of igneous, silicic-granitic plutons that are exposed to the north of the Project area in the Old Woman Mountains, as well as a small pluton in the Chubbuck area. Some of the Proterozoic/Precambrian basement rocks were locally metamorphosed by these intrusions and ductile tectonic thrust-fault activity, which accompanied these intrusions (Karlstrom et al, 1993). Triassic (250-200 million years ago) and Jurassic (200-145 million years ago) plutonic rocks are exposed adjacent to the Project area, and the proposed pipeline alignment passes through Jurassic age quartz diorite and granite in the Chubbuck area, as well as Triassic schist and gneiss adjacent to the Old Woman Mountains. These rocks are the result of eastward Andean-type convergent tectonic activity (Burchfiel and Davis, 1980, Glazner et al, 2002a).

Active subduction continued through Triassic, Jurassic and Cretaceous times, though by the end of the Cretaceous the intrusions were generally granitic. As the east-subducting Farallon plate continued to subduct under the North American plate, igneous activity continued (Norris and Webb, 1990). However, in the mid-Cenozoic, the eastern-directed subduction of the Farallon plate largely ceased, as the spreading center that drove the subduction was itself subducted. This caused the westernmost portion of what is now California to 'hang', and the resultant stresses between the plates created the San Andreas Fault. Simultaneously, subduction to the west ceased, and this caused the volcanic activity in this area to largely cease as well (Norris and Webb, 1990). Tectonic activity in the Mojave Desert region is now largely controlled by the San Andreas Fault and its related faults. Volcanism in the area, however, continued sporadically until the Late Pleistocene, as shown by the Amboy Lava Fields just to the north of the Project area (Norris and Webb,

1990). The age of the Amboy fields is debated, with many young-appearing cones in the center of this complex dating via K-Ar and fission-track methods to around 2 million years old. However, Amboy Crater, which lies upon the sediments of prehistoric Bristol Lake, may be less than 10,000 years old - a relatively recent date of 6,000 years is possible, depending on the timing of the last major depositional event in Bristol Lake (Hazlett, 1992).

The linear, north to-northeast trending valleys and mountains in the vicinity of the Project area are characteristic of the Basin and Range province, and these valleys contain alluvial sediments that may exceed 3,500 feet in thickness (MWD, 2001). The valleys were partially formed during the middle Miocene from the extensional tectonics that produced portions of the Basin and Range's distinctive geology (Miller et al., 1982; Glazner et al, 2002b). The basins that contain the dry lake deposits in this area are thought to have been part of a trough complex running from prehistoric Lake Manix to the southeast along these fault-delineated valleys and mountain ranges (Reynolds and Reynolds, 1992).

The Cadiz, Danby and Bristol dry lakes are theorized to have been part of an extensive, permanent lake system of Pleistocene age that drained into the Colorado River (Reynolds and Reynolds, 1992) and was sourced from the Pleistocene-aged Mojave River (Sharp, 1976) that is currently intermittently active depending on water flow. These dry lake beds, including the area designated for the Cadiz Groundwater Project Well Field, consist in part of Pleistocene age playa lake sediments including carbonate evaporite beds interbedded with fine silts. These Cadiz Playa deposits are known contain numerous Pleistocene (Blancan to Irvingtonian North American Land Mammal "Age") vertebrate fossil localities (MWD, 2001; Scott, 2010). The Cadiz Playa is referenced in the Cadiz Groundwater Storage and Dry-Year Supply Program EIR/EIS (MWD, 2001) as occurring on Cadiz Company lands east of Bristol Lake and north of Cadiz Lake.

3.2 GEOLOGY AND PALEONTOLOGY

This portion of the analysis applies to both the Phase I (Project Level) Facilities and the Phase II (Programmatic) Facilities. Based on the geologic map review completed for this analysis, the proposed Project area contains 19 mapped geologic units (see Table 1). In areas of overlap, the Amboy 30' x 60' Quadrangle (Bedford et al., 2010) and the Sheep Hole Mountains 30' x 60' Quadrangle (Howard, 2002) were used preferentially over the Needles 1 x 2 Degree Quadrangle (Bishop, 1963) because these quadrangles were mapped at a smaller, higher resolution scale.

The findings of this analysis are consistent with the previously completed paleontological resource review (MWD, 2001). Four of the geologic units within the Project area have very low paleontological sensitivity (PFYC Class 1) because they consist of igneous or metamorphic rocks that were formed at extremely high temperatures or high pressures, and do not typically contain recognizable fossil remains. Six of the geologic units have low

paleontological sensitivity (PFYC Class 2) because they consist of surficial sedimentary deposits that were formed during the Holocene (less than 10,000 years ago), and as such, are too young to contain in-situ fossil remains. It should be noted that although PFYC Class 2 units have low paleontological sensitivity at the surface, they are often underlain at varying depths by older Pleistocene surficial deposits that may contain scientifically significant fossil remains, and these deposits and contained fossils can be adversely impacted by ground disturbing projects that penetrate through the overlying low sensitivity Holocene age deposits. Because of their low potential to produce scientifically significant fossil remains, the PFYC Class 1 geologic units are not discussed further in this section. Three geologic units are considered to have moderate paleontological sensitivity (PFYC Class 3) because they consist of Holocene and Pleistocene age sedimentary deposits (and other lithologies, see Table 1) that were deposited on hillslopes or consist of older stabilized sand dunes, and thus have lower sensitivity than other sedimentary deposits of Pleistocene age such as alluvium. Note that for geologic units that are mapped as being both Pleistocene and Holocene age, the PFYC Class for the higher sensitivity Pleistocene deposits is applied to the entire unit. Four geologic units have high paleontological sensitivity (PFYC Class 4) because they consist of Pleistocene age sedimentary deposits including alluvial deposits that regularly produce scientifically significant fossil remains in the general vicinity of the Project area and elsewhere in southern California. The PFYC Class 3 and Class 4 geologic units have moderate to high potential to produce scientifically significant fossils respectively, and are discussed in greater detail below (see Section 3.2.1).

The distribution of geologic units within the proposed Project area is shown in Figures 2-4. The PFYC classes listed in Table 1 were assigned using the results of the paleontological literature and museum record searches. The results were used to prepare paleontological sensitivity maps (figures 5-7). Note that the sensitivity rankings on Figure 3 apply only to surface geologic units, and units with higher (or lower) sensitivity may be encountered at a shallow depth beneath the surface.

Table 1. Geologic units within the proposed Project area using the Potential Fossil Yield Classification System (see Section 2). Geologic map abbreviations follow Bedford et al. (2010), Bishop (1963), and Howard (2002). Note that the sensitivity rankings apply only to surface geologic units, and units with higher (or lower) sensitivity may be encountered at a shallow depth beneath the surface.

Map Abbreviation	Geologic Unit	Age	PFYC Class (potential for fossils)
Bedford et al., 2010, Amboy 30' x 60'Quadrangle			
Qya	Young alluvial fan deposit	Holocene and latest Pleistocene	4* (high)
Qyaf	Young alluvial fan composed of fine-grained deposits	Holocene and latest Pleistocene	4* (high)
Qyv	Young valley-axis deposit	Holocene and latest Pleistocene	4* (high)
Qia	Intermediate alluvial fan deposit	Late to middle Pleistocene	4* (high)
Qha/ca	Abundant hillslope deposits and "carbonate rocks"	Holocene and Pleistocene	3* (moderate)
Qha/mi	Abundant hillslope deposits and "metamorphic rocks"	Holocene and Pleistocene	3* (moderate)
Howard, 2002, Sheep Hole Mountains 30' x 60' Quadrangle			
Qy	Youngest alluvium	Holocene	2** (low)
Qya	Younger alluvium	Holocene	2** (low)
Qps	Playa deposit, silt and clay	Holocene	2** (low)
Qwo	Older windblown sand, stabilized (fossil) dunes	Holocene and Pleistocene	3* (moderate)
Jd	Diorite and Quartz diorite	Jurassic	1 (very low)
TrRb	Buckskin Formation, schist and gneiss	Triassic	1 (very low)
Xk	Kilbeck Gneiss	Early Proterozoic	1 (very low)
Bishop, 1963, Needles 1 x 2 Degree Quadrangle			
Qal	Quaternary alluvium	Recent/Holocene	2 (low)
Ql	Quaternary lake deposits	Recent/Holocene	2 (low)
Qs	Dune sand	Recent/Holocene	2 (low)
pC	Undivided metamorphic rocks	Precambrian	1 (very low)
pC-gr	Undivided granitic rocks	Precambrian	1 (very low)
gr	Granitic rocks	Mesozoic	1 (very low)

*Holocene age deposits are too young to contain fossils, although Pleistocene deposits have high paleontological sensitivity. Highest PFYC ranking is applied to entire map unit for units mapped as containing both Holocene and Pleistocene age sediments.

**Holocene age deposits are considered to have low paleontological sensitivity, but may be underlain at depth by Pleistocene age deposits with moderate or high paleontological sensitivity.

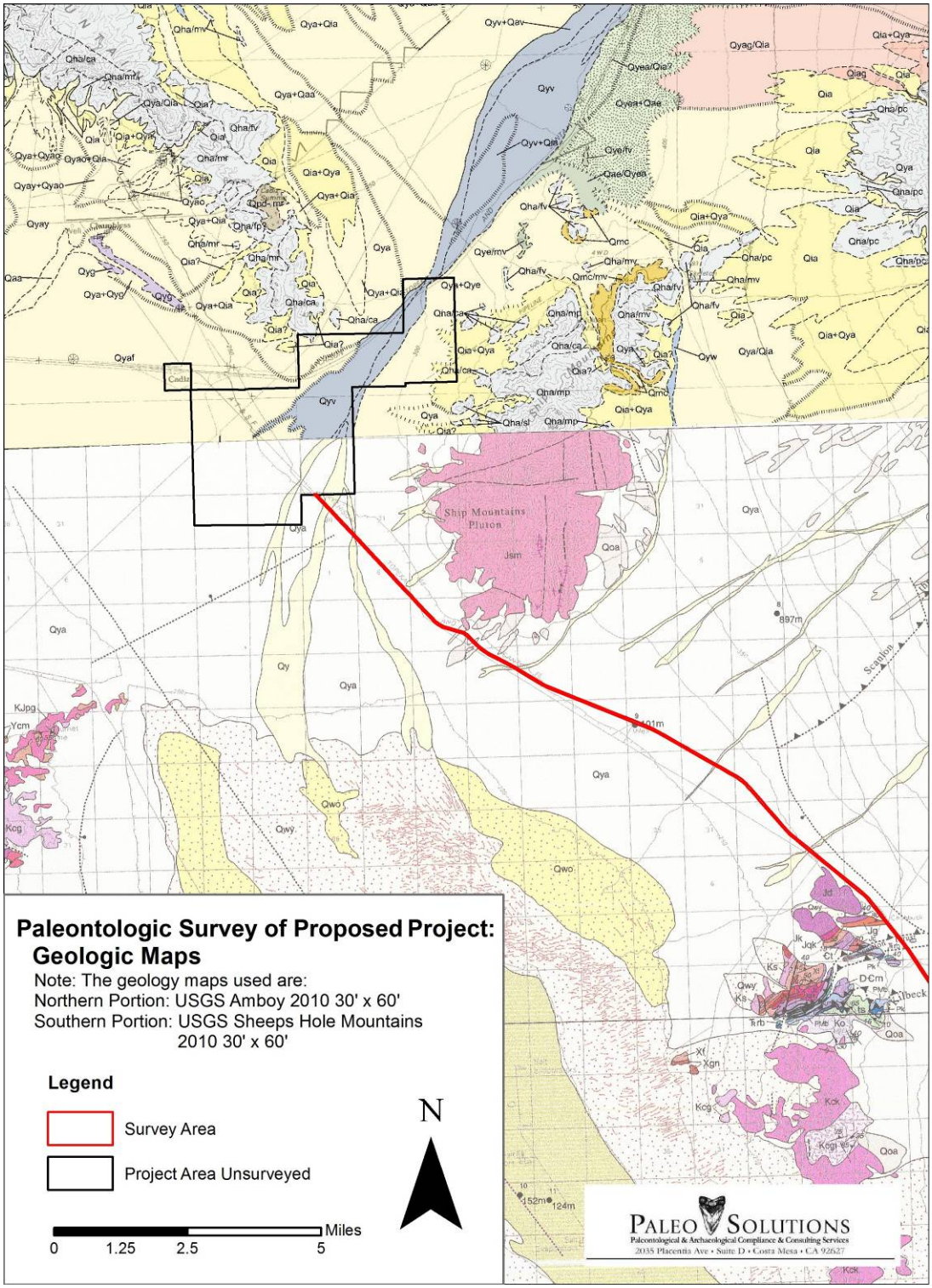


Figure 2 Geologic map of the northern portion of the proposed Project area (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations.

Paleontological Resources

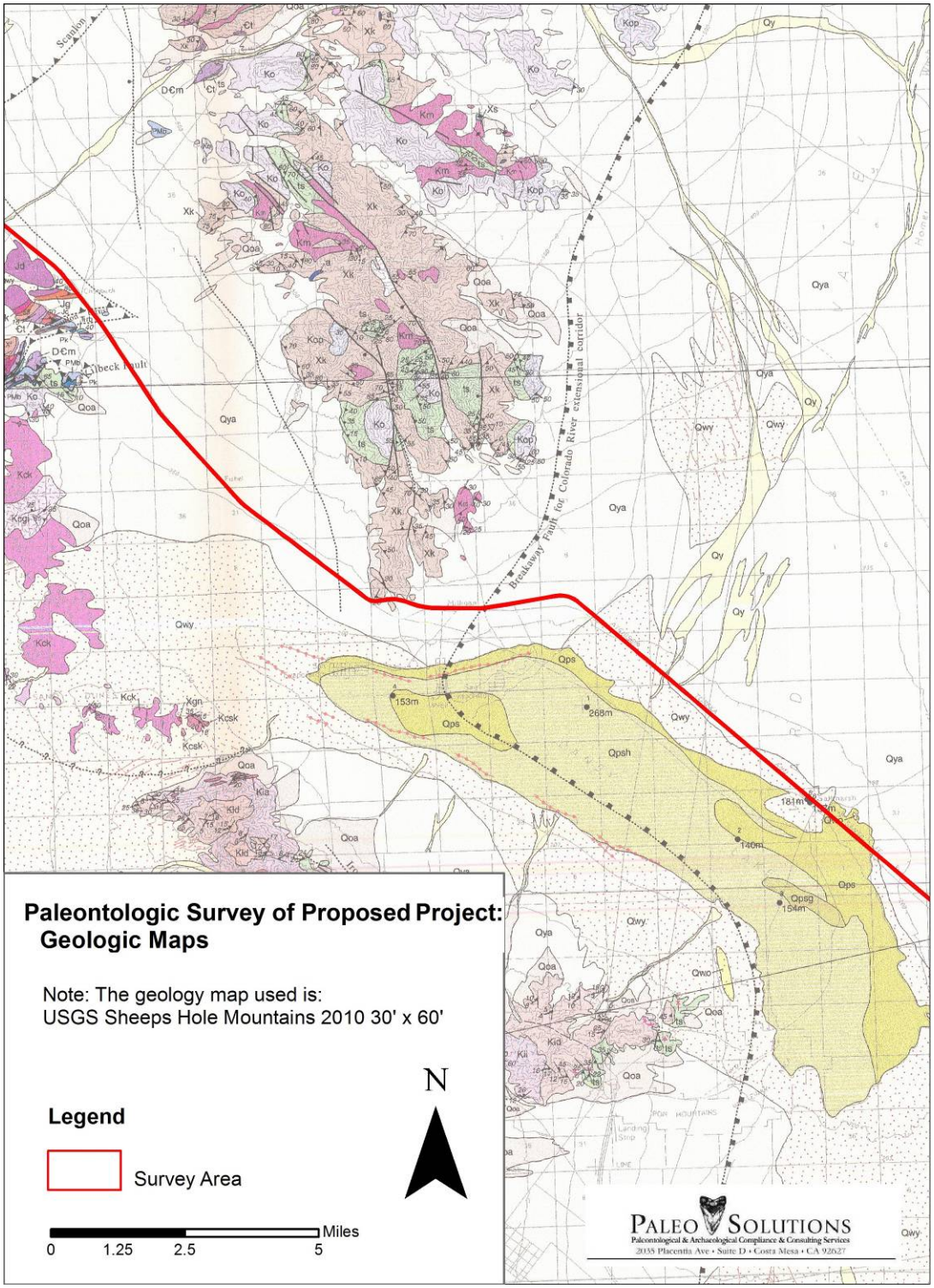


Figure 3. Geologic map of the middle portion of the proposed Project area (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations.

Paleontological Resources

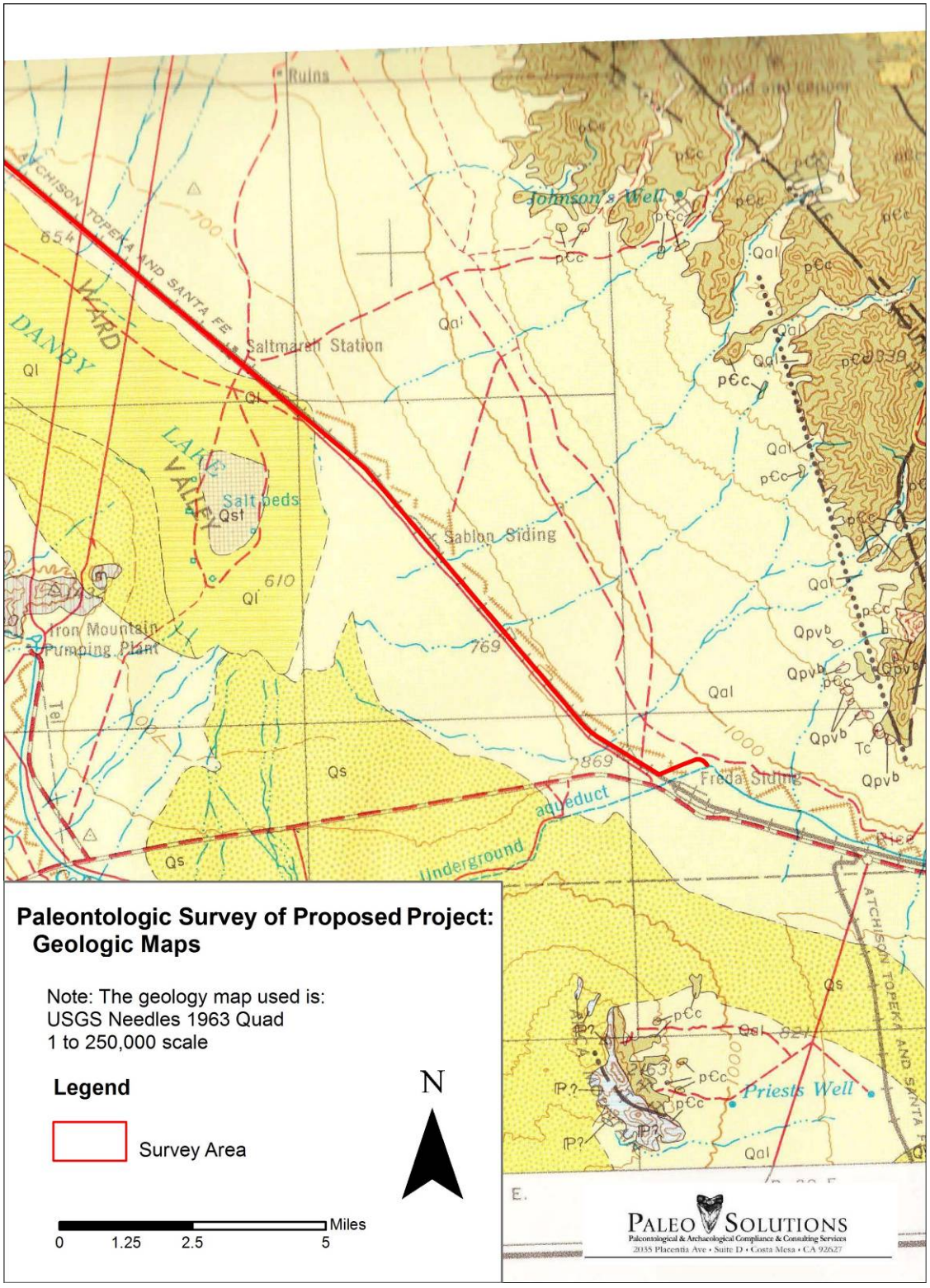


Figure 4. Geologic map of the southern portion of the proposed Project area (from Bedford et al., 2010; Bishop, 1963; and Howard, 2002). See Table 1 for geologic unit abbreviations.

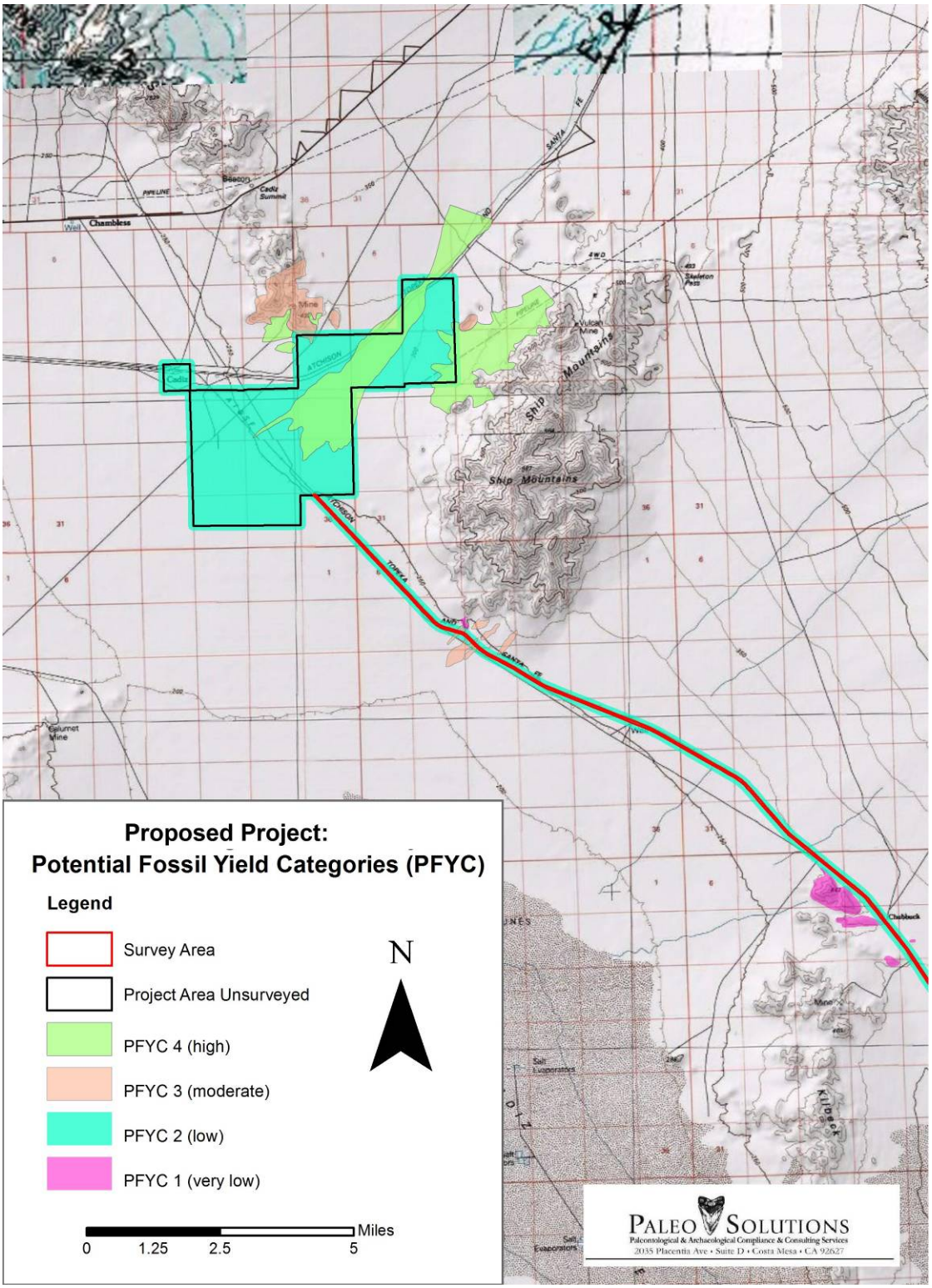


Figure 5. Paleontological sensitivity map of the northern portion of proposed Project area. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1)

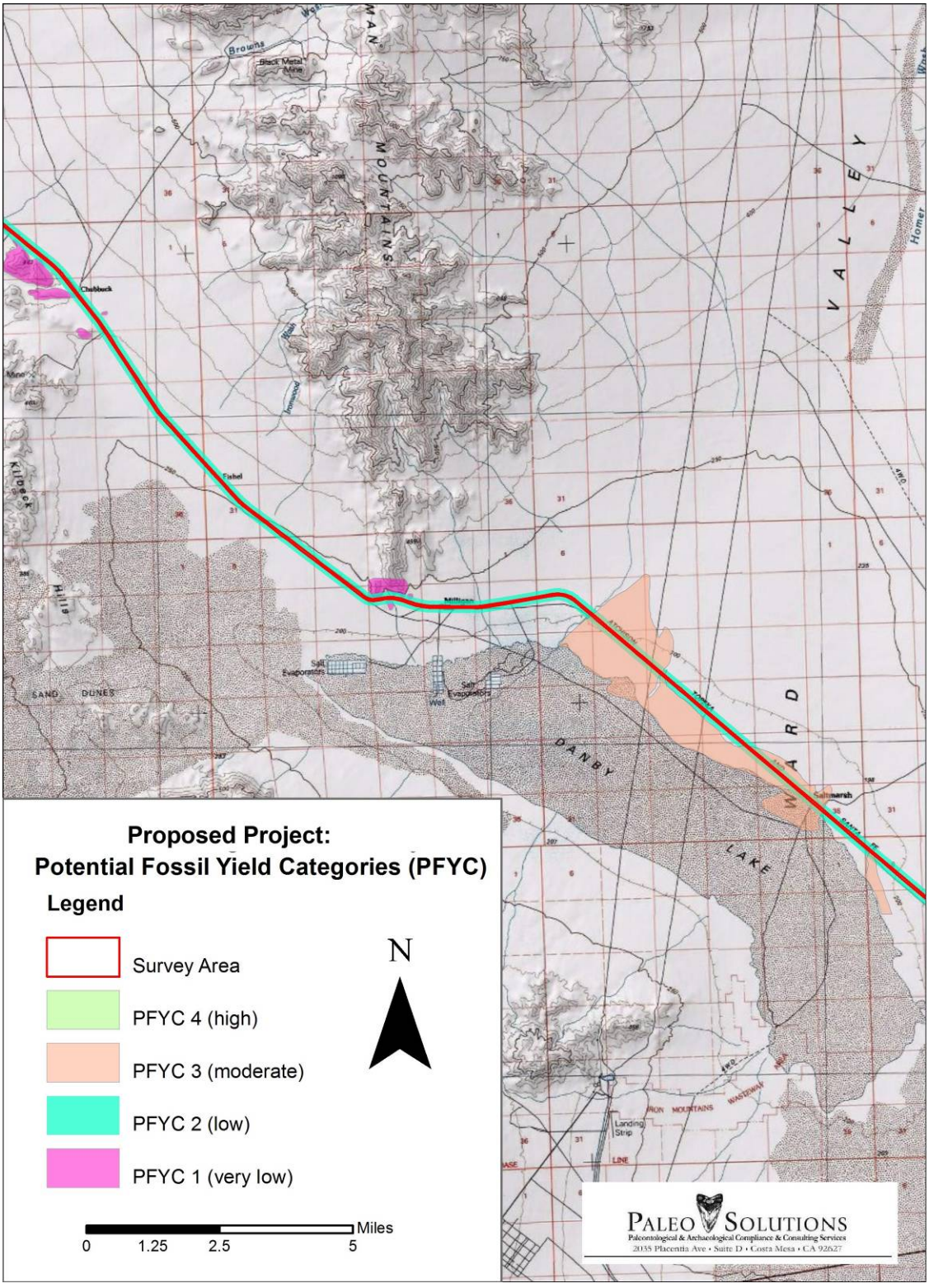


Figure 6. Paleontological sensitivity map of the middle portion of the proposed Project area. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1).

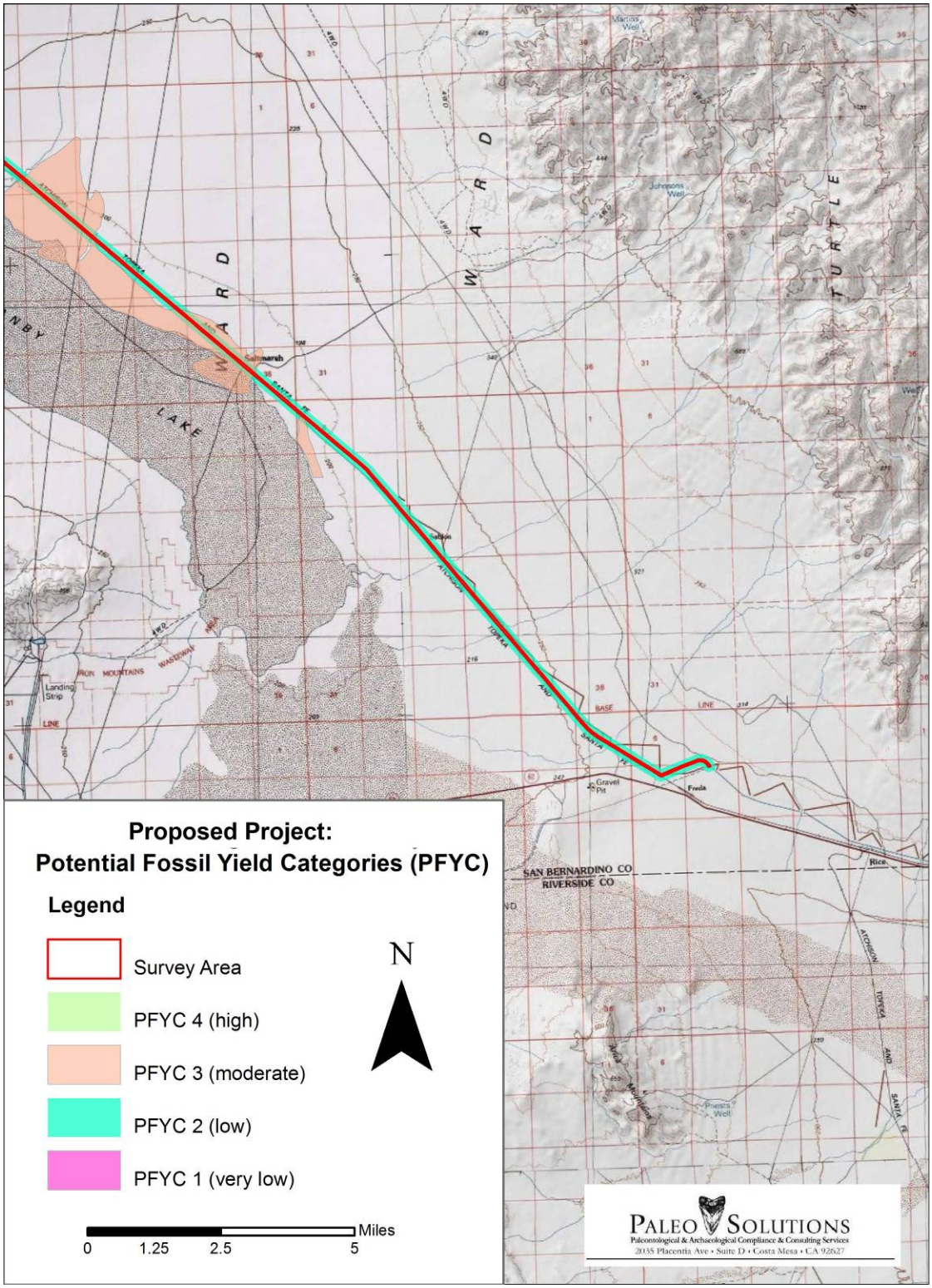


Figure 7. Paleontological sensitivity map of the southern portion of the proposed Project area. Note that this sensitivity map and Table 1 applies only to surface geology, and not subsurface geology. Subsurface deposits may have higher sensitivity in even shallow excavations (see Section 3.2.1).

3.2.1. SURFICIAL SEDIMENTARY DEPOSITS OF QUATERNARY AGE

Most of the substrate within the proposed Project area is composed of surficial sedimentary deposits of Pleistocene and Holocene age. As discussed previously, none of the igneous and metamorphic basement rocks (PFYC Class 1) located within the Project area are likely to contain scientifically significant fossil remains.

In terms of geographic extent, most of the Project area includes surficial sedimentary deposits that are of both Pleistocene and Holocene age (see Table 1). It is critical to note that although deposits of Holocene age that are too young to produce in-situ fossils, these deposits are known to be underlain at a shallow depth at many locations in the Mojave Desert by Pleistocene age deposits that do contain scientifically significant fossils and that document the paleoenvironments and paleoecology of this area during the Pleistocene "ice age." Thus, in areas mapped as Holocene in age, Project excavations that are at or close to existing grade are unlikely to impact paleontological resources. However, deeper excavations may disturb older (Pleistocene), especially in alluvium and lake deposits, and less likely in hillslope, alluvial fan, and sand dune deposits. Specifically, older lake deposits underlie and encompass a larger geographic area than the current extent of Danby Dry Lake and Cadiz Dry Lake. Note that because of the natural variability of the thickness of younger surficial sediments and the resulting variability in the depth at which older Pleistocene surficial sediments occur, it is not possible to predict the depth at which Pleistocene deposits will be encountered without extensive geotechnical analysis.

Pleistocene alluvium contains locally abundant and well preserved fossil remains, and is regarded as having high paleontological sensitivity in southern California. Most of these fossils are housed at museums including the LACM, SBCM, Page Museum (La Brea Tar Pits), San Diego Natural History Museum, Ralph Clark Park, and other regional venues. Pleistocene taxa from older non-marine alluvium include a wide variety of amphibians including frog and salamander; reptiles including turtle, lizard, and snake; birds including raptor, duck, quail, secretary bird, and songbirds; and mammals. The most taxonomically diverse vertebrate group in terms of Pleistocene fossils, mammals include mammoth, mastodon, bison, deer, camel, horse, saber-tooth cat, coyote, weasel, dire wolf, ground sloth, tapir, antelope, camel, capybara, shrew, bat, ground sloth, jack rabbit, cottontail rabbit, ground squirrel, pocket gopher, pocket mouse, kangaroo rat, deer mouse, mouse, wood rat, vole, and muskrat (Graham and Lundelius, 1994; Jefferson, 1991; Lundelius et al., 1987). Fossil invertebrates and plants also occur locally in non-marine Pleistocene sedimentary deposits. The SBCM has documented numerous fossil remains of mammoth, mastodon, ground sloths, dire wolves, saber-toothed cats, large and small horses, camels, and bison throughout San Bernardino and Riverside counties and the Inland Empire.

A record search was conducted as part of the prior paleontological analysis for the Cadiz Groundwater Storage and Dry Year Supply Program EIR/EIS (MWD, 2001) that identified

179 previously recorded fossil localities in the project vicinity. Field surveys were conducted in March, April, and June 1999 of proposed wellfield, reservoir, and spreading basin areas in the Cadiz-Fenner valleys; an approximately 35-mile-long pipeline alignment from the Cadiz-Fenner valleys to the CRA, including several alternative routes and a proposed pumping plant location near the existing Iron Mountain Pumping Plant; and a powerline alignment north of the Riverside/San Bernardino county line. Although the results of the prior paleontological analysis were based on a different project configuration, they indicate the potential for scientifically significant fossils to be present within the Quaternary deposits in the Project area.

For example, the former pipeline route ran parallel to the ARZC railroad for a short distance and then split into two sections at the eastern end of the Cadiz Dunes Wilderness Area: a western pipeline alignment that truncated at the West Portal Iron Mountain Tunnel and the CRA, and an eastern pipeline alignment that truncated at the Iron Mountain Pumping Area at the eastern end of the CRA. However, approximately 21 miles of the currently-proposed water conveyance pipeline (the northern portion) and portions of the currently-proposed wellfield area overlap with the area that was surveyed in 1999.

The 1999 field surveys documented 24 newly recorded fossil localities along the former pipeline alignment and alternative routes. Fossils recovered along the former alignment alternatives consisted largely of fragments of mammalian longbones and one rabbit bone. The variety of fossils collected from the project wellfield area included flamingo, Canada goose, mammoth, camel, two kinds of horse, coyote, dwarf pronghorn antelope, jackrabbit, ground squirrel, kangaroo rat and freshwater snail. The EIR/EIS reported that most of the former project area consisted of lake beds, paleosols and carbonate beds with a high potential for subsurface paleontological resources. The paleontological results from the 1999 surveys emphasize the high potential for scientifically significant paleontological resources in Pleistocene age lake beds within the currently-proposed footprint associated with the proposed Project.

In conjunction with this analysis conducted for the proposed Project, museum fossil locality record searches were completed by staff at the two major regional museums that are likely to have fossil collections from the vicinity of the proposed Project area. These include the Natural History Museum of Los Angeles County (LACM) and the San Bernardino County Museum (SBCM). The purpose of these record searches was to determine whether any previously recorded fossil localities occur within the proposed Project area analyzed herein, or are located elsewhere, but were found in the same geologic units that occur within the Project area.

The LACM has no previously recorded fossil localities within the Project area. However, in the general vicinity of the proposed Project area (Rhue, 2010) there are three LACM fossil

localities. LACM 5977 produced a fossil specimen of the pocket mouse *Perognathus* found in Quaternary deposits located to the south-southwest of the proposed Project area along Interstate 10 on the southwest side of Ford Dry Lake. LACM (CIT) 208 and LACM 3414 yielded specimens of tortoise (*Gopherus*), horse (*Equus*), and camel (*Camelops* and *Tanupolama stevensi*) found in Quaternary deposits to the west-southwest of the Project area between the Eagle Mountains and the Coxcomb Mountains.

The SBCM has four previously recorded fossil localities along the proposed pipeline alignment and in other localities in the general vicinity (Scott, 2010). SBCM 141.2 was discovered at Danby Dry Lake, and produced fossil horse (*Equus* sp.), camel (*Camelops* sp.), jack rabbit (*Lepus* sp. Cf. *L. californicus*), kangaroo rat (*Dipodomys*), fox (*Vulpes*), and badger (*Taxidea taxus*). SBCM 141.8 also produced fossil remains of Rancholabrean North American Land Mammal "Age" from Danby Dry Lake, but the type of fossil(s) was not specified in the record search results. SBCM 142.2 produced plant remains (Tracheophtyta) and kangaroo rat (*Dipodomys*) from Cadiz Lake. SBCM 142.8 produced fossil remains of Rancholabrean North American Land Mammal "Age" from Cadiz Dry Lake, but the type of fossil(s) was not specified in the record search results. The SBCM also reports that the Danby and Cadiz areas have produced fossils of extinct horse (Equus sp.), large camel (cf. *Camelops* sp.), and pronghorn (?*Tetrameryx*), as well as mollusks, toads, tortoises (including the giant tortoise *Hesperotestudo*), lizards, snakes, birds, rabbits, and rodents (Reynolds and Reynolds, 1992; Scott, 2010; Scott and Cox, 2008).

4.0 FIELD SURVEY RESULTS

A paleontological field survey of the proposed pipeline alignment (Phase I, Project Level Facilities) was conducted on October 18 through October 26, 2010. No fossils were observed during the field survey. Detailed field survey notes, including observed geology and photographs of the substrate along the water pipeline route, are available upon request. Surveys were not conducted in the proposed wellfield or conceptual spreading basin areas (see Section 6.0) (Phase II, Programmatic Facilities).

5.0 RECOMMENDED MITIGATION MEASURES

Based on the field surveys of the proposed pipeline alignment and tie-in to the CRA, these Phase I (Project Level) Facilities are considered "cleared" for surface paleontological resources, and above ground staging and construction activities can proceed in these areas. However, ground-disturbing activities along the pipeline corridor that involve digging/disturbance of subsurface soils should be addressed as part of a paleontological mitigation plan, the basic parameters of which are outlined below.

Although most of the surface of the Project area is covered by a thin veneer of younger (Holocene) sediments (mostly alluvium, lake beds, sand dunes), older (Pleistocene)

sediments and scientifically significant fossils are known to occur at certain locations on the surface as evidenced by surveys completed in 1999 for the previous EIR/EIS (MWD, 2001), LACM locality records (Rhue, 2010), SBCM locality records (Scott, 2010), and subsurface based on superpositional relationships of the Quaternary deposits in the general region of the Project. Thus, there is a high likelihood that paleontological resources will be encountered in even shallow Project excavations. Prior to construction, and using available geotechnical information and project design plans in combination with geologic mapping, a detailed paleontological resources mitigation plan should be developed that reflects the final project footprint and identifies specific paleontological monitoring locations based as defined by areas where Pleistocene age sediments may be impacted during construction. Recommended paleontological mitigation measures are described below, and should be included in the detailed paleontological resources mitigation plan. The detailed paleontological mitigation plan should identify specific monitoring locations, procedures for fossil salvage, data collection, and procedures to follow if construction personnel find fossils in an area in which fossils were not anticipated, and no paleontological monitor is present.

Proposed Mitigation – Qualifications of Personnel

The detailed paleontological mitigation plan, and all subsequent paleontological resource work for the proposed Project, should be completed by a qualified vertebrate paleontologist. The County of San Bernardino (Development Code §82.20.040) defines a qualified vertebrate paleontologist as meeting the following criteria:

Education: An advanced degree (Masters or higher) in geology or paleontology, biology or related disciplines (exclusive of archaeology).

Professional Experience: At least five years professional experience with paleontologic (not including cultural) resources, including the collection, identification and curation of the resources.

Proposed Mitigation: Phase II (Programmatic) Facilities

The project wellfield and spreading basin areas, which were previously surveyed in 1999, should be re-surveyed prior to construction because in the time elapsed since 1999, it is likely that additional scientifically significant fossils have eroded onto the surface. However, surveys of the wellfield and spreading basin areas can be limited to individual disturbance areas, such as the area surrounding each well, pipeline corridors associated with the pipeline manifold system, associated access roads, and power distribution facilities, as determined in the final Project design plans. Previously surveyed areas that are not within the final Project footprint will not require additional survey, nor will areas

within the final Project footprint in which no surface or subsurface disturbance will occur. A report should be prepared summarizing the results of the additional surveys, or the survey results can be integrated into the paleontological mitigation plan.

Proposed Mitigation – Phase I (Project Level) Facilities

No additional field surveys for the project level facilities evaluated herein are recommended. The detailed construction mitigation plan should identify specific locations where project construction is anticipated to disturb sediments of Pleistocene age that occur on the surface, or where ground disturbance will penetrate overlying Holocene age sediments to a depth at which disturbance to Pleistocene sediments will occur. As stated previously, there is no way to accurately predict this depth, and in the absence of geotechnical data, a qualified paleontologist should be available to spot check shallow excavations (less than three feet deep) to examine the sediment profile bones and other remains that may be unearthed in order to guide the monitoring level of effort in areas with Holocene age sediments mapped at the surface. All excavations greater than three feet deep should be continuously monitored unless it is determined by the on-site paleontologist that the depth of Pleistocene age sediments is deeper, at which point the monitoring level of effort should be adjusted accordingly.

Paleontological monitors must be experienced and be working under the direct supervision of a qualified paleontologist as defined above. Only fossils deemed to have scientific significance should be collected (see Section 1.1 for definition of scientific interest). Paleontological monitoring involves the systematic inspection of graded pad surfaces, cut slopes, excavation sidewalls, and spoils piles for unearthed fossils. When fossils are discovered, they and associated data must be collected quickly and professionally in order to prevent construction delays. Fossil salvage procedures should include the collection of bulk matrix samples if scientifically significant microfossils are believed to be present based on field evidence. Monitors should have the authority to temporarily divert construction crews in order to facilitate fossil salvage activities.

All fossils collected during monitoring should be transferred to a secure facility for laboratory preparation and identification. Laboratory preparation includes stabilization, matrix removal, and conservation of individual fossil specimens, and screenwashing and picking of bulk matrix samples. Fossils should be prepared to the point of curation (not display) and identified by technical specialists as needed to the lowest possible taxonomic level.

Following preparation, the fossils and associated data and a copy of the final paleontological mitigation report should be transferred to a public museum

(paleontological repository) where they will be available for the benefit of current and future generations.

The results of the wellfield and spreading basin surveys, construction monitoring, and subsequent laboratory work, shall be compiled in a final paleontological mitigation report authored by the qualified paleontologist for the Project. The final report should include all Project data and a copy of the receipt of specimens from the paleontological repository.

6.0 REFERENCES

Anderson, J.L., Wooden, J.L., and Bender, E. E., 1993, Mojave Province of Southern California and vicinity: The Geology of North America, Precambrian: Conterminous U.S. Geological Society of America, p. 176-188.

Bedford, D.R., Miller, D.M., and Phelps, G.A., 2010, Surficial geologic map data and physical properties for the Amboy 30 x 60 minute Quadrangle, California: U.S. Geological Survey Open-File Report 2006-1165, 33 p., scale 1:100,000, *http://pubs.usgs.gov/of/2006/1165*.

Bishop, C.C., 1963, Geologic map of California: Needles Sheet: California Division of Mines and Geology, scale 1:250,000.

Bureau of Land Management, 2007, Potential Fossil Yield Classification System: BLM Instruction Memorandum No. 2008-009 (PFYC revised from USFS, 1996).

Burchfiel, B.C. and G.A. Davis, 1980, Mojave Desert and surrounding environs: In, Ernst, W.G. (editor): The Geotectonic Development of California, Englewood Cliffs, NJ: Prentice-Hall.

Metropolitan Water District of Southern California (MWD) and US Bureau of Land Management (BLM), 2001, Cadiz Groundwater Storage and Dry Year Supply Program, Final EIR, 2001, http://www.pacinst.org/reports/cadiz/feir/.

Metropolitan Water District of Southern Califonia (MWD) Environmental Documentation for the Cadiz Water Storage and Dry-Year Supply Program, 1999, Paleontological Resource Draft Assessment Report.

Glazner, A.F., Walker, J.D., Bartley, J.M., and Fletcher, J.M., 2002a, Late Paleozoic to Mesozoic evolution of the Mojave block in Southern California: In, Glazner, A.F., and Bartley, J.M. (editors), Geologic Evolution of the Mojave Desert and the Southwestern Basin and Range. Geological Society of America, Memoir 195, p. 1-18.

Glazner, A.F., Walker, J.D., Bartley, J.M., and Fletcher, J.M., 2002b, Cenozoic evolution of the Mojave block in Southern California: In, Glazner, A.F., and Bartley, J.M. (editors), Geologic Evolution of the Mojave Desert and the Southwestern Basin and Range. Geological Society of America, Memoir 195, p. 9-41.

Graham, R.W., and Lundelius, E.L., 1994, FAUNMAP: A database documenting the late Quaternary distributions of mammal species in the United States: Illinois State Museum Scientific Papers, vol XXV, no. 1, 287 p.

Hazlett, R.W., 1992, Some thoughts on the development of Amboy Crater: In, Old Routes to the Colorado. San Bernardino County Museum Association Special Publication, 92-2.

Howard, K.A., 2002, Geologic Map of the Sheep Hole Mountains 30'x 60' quadrangle, San Bernardino and Riverside Counties, California. U.S. Geological Survey Miscellaneous Field Investigations Map, MF-2344, scale 1:100,000.

Jefferson, G.T., 1991, A catalog of late Quaternary vertebrates from California: Natural History Museum of Los Angeles County, Technical Reports 7:1-129.

Karlstrom, K.E., C.F. Miller, J.A. Kingsbury and J.L. Wooden, 1993, Pluton emplacement along an active ductile thrust zone, Paiute Mountains, Southeastern California: Interaction Between Deformation and Solidification Processes. Geological Society of America Bulletin, v. 105, p. 213-230.

Lundelius, E. L., Jr., C. S. Churcher, T. Downs, C. R. Harington, E. H. Lindsay, G. E. Schultz, H. A. Semken, S. D. Webb, and R. J. Zakrewski. 1987, The North American Quaternary sequence: In, M. O. Woodburne (ed.), Cenozoic Mammals of North America Geochronology and Biostratigraphy. University of California Press, Berkeley, Los Angeles, London, pp. 211-235.

Miller, D.M., Howard, K.A., and John, B.E., 1982, Preliminary geology of the Bristol Lake region, Mojave Desert, California: In, Cooper, J.D. (compiler), Geologic Excursions in the Mojave Desert, Volume and Guidebook. Geological Society of America Cordilleran Section 78th Annual Meeting, Fullerton, California, California State University, pp. 91-100.

Norris, R.M., and Webb, R.W., 1990, Geology of California, Second Edition. John Wiley and Sons, Inc., New York, p. 55-59, 183-191, 220-244, 453-454.

Reynolds, R. E. and Reynolds, R.L., 1992, Pleistocene faunas in the Bristol-Danby Trough: In, San Bernardino County Museum Special Publication 92-2 (Old Routes to the Colorado*)*. San Bernardino County Museum Association, Redlands, p. 83-86.

Rosen, M.R., 1992, The Depositional Environment and Evolution of Bristol Lake Basin, Eastern Mojave Desert, California: In, Old Routes to the Colorado. Special Publication 92-2, San Bernardino County Museum Association, Redlands.

Rhue, V.R., 2010, Paleontological resources for the proposed Cadiz Groundwater Storage Project, San Bernardino County, California, project area: Unpublished record search prepared by the Natural History Museum of Los Angeles County, 2 p.

Scott, E., 2010, Paleontological literature and records review, Cadiz Groundwater Project, Cadiz Region, San Bernardino County, California: Unpublished record search prepared by San Bernardino Natural History Museum, 15 p.

Scott, E., and Cox, S.M., 2008, Late Pleistocene distribution of *Bison* (Mammalia, Artiodactyla) in the Mojave Desert of southern California and Nevada: In, X. Wang and L.G. Barnes (editors), Geology and Vertebrate Paleontology of western and southern North America in honor of David P. Whistler. Natural History Museum of Los Angeles County Science Series no. 41, p. 359-382.

Scott, E., and Springer, K., 2008, CEQA and fossil preservation in southern California: The Environmental Monitor, Fall 2003, p. 4-10, 17.

Sharp, R.P., 1976, Geology Field Guide to Southern California: Kendall-Hunt Publishing Company, Dubuque, Iowa, p 28-24, 52-60.

VOLUME 1:
REPORT

Cadiz Groundwater Modeling and Impact Analysis

September 1, 2011

Prepared for: Brownstein Hyatt Farber Schreck, LLP

Prepared by:

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS

TABLE OF CONTENTS

VOLUME 1 - REPORT

ABBREVIATIONS AND DEFINITIONS 1

1.0 EXECUTIVE SUMMARY 5

2.0 INTRODUCTION 14

2.1. Purpose and Scope 14

2.2. Description of Study Area 14

2.3. Previous Investigations 15

2.4. Recent Supplemental Geohydrologic Investigations 16

2.5. Sources of Data 17

3.0 GEOLOGY 18

3.1. Geologic Setting 18

3.2. Geologic Units 19

3.2.1. Alluvium 19

3.2.2. Tertiary Volcanics and Fanglomerates 20

3.2.3. Archaen and Jurassic Granitic and Metamorphic Bedrock 21

3.3. Geologic Structure 21

3.3.1. Overview of Geologic History and Structure 21

3.3.2. Geologic Structure in Fenner Gap 22

4.0 HYDROLOGY 24

4.1. Precipitation 24

4.2. Groundwater Occurrence and Movement 24
4.3. Aquifer Systems 25
4.4. Groundwater Storage 26
4.5. Groundwater Quality 26

5.0 MODEL DEVELOPMENT AND CONSTRUCTION 27
5.1. Conceptual Model 27
5.2. Computer Code 27
5.3. Model Domain, Grid and Time Discretization 28
5.4. Boundary Conditions 29
5.5. Aquifer Parameters 29
5.5.1. Lithologic Model in the Fenner Gap Area 29
5.5.2. Layer Elevations 31
5.5.3. Effective Porosity and Storativity 32
5.5.4. Hydraulic Conductivity 32
5.5.5. Vertical Leakance 34
5.5.6. Initial Groundwater Elevations 34
5.5.7. Dispersivity 34
5.5.8. Elastic and Inelastic Storage Coefficients 34
5.5.9. Preconsolidation Stress 35
5.6. Recharge and Discharge 35
5.6.1. Natural Recharge and Artificial Recharge 35
5.6.2. Groundwater Pumping 36
5.6.3. Evapotranspiration 36

6.0 MODEL CALIBRATION AND SENSITIVITY ANALYSIS....38

6.1. Model Calibration Approach....38

6.2. Steady State Model Calibration....39

6.3. Transient Model Calibration....41

6.4. Sensitivity Analysis....43

7.0 MODEL PREDICTIVE SCENARIOS....44

7.1. Description of Model Scenarios....44

7.2. Project Pumping....45

7.3. Natural Recharge....45

7.4. Project Extraction Wells....46

7.4.1. Wellfield Configuration....46

7.4.2. Conceptual Drill Site Layout and Wellfield Manifold System....47

7.4.3. Well Cross-Section....47

7.5. Initial conditions....48

8.0 IMPACT ANALYSIS....49

8.1. Groundwater Elevations....49

8.2. Drawdown Analysis....49

8.2.1. Regional Drawdown....49

8.2.2. Drawdown during Dry Year, Wet Year and Average Year Conditions....50

8.3. Depth to Groundwater....51

8.4. Saline Water/Freshwater Interface....52

8.5. Groundwater in Storage....53

8.6. Potential Land Subsidence....54

9.0 FINDINGS 56

10.0 MODEL LIMITATIONS AND UNCERTAINTY 61

11.0 REFERENCES 62

FIGURES, TABLES, APPENDICES (VOLUMES 2 AND 3)

FIGURES

No.	Description
1	General Project Location
2	2009 Groundwater Elevations
3	Total Dissolved Solids Concentrations
4	Cadiz Groundwater Model Boundary
5	Cadiz Groundwater Model Grid
6	Boundary Conditions of the Cadiz Groundwater Model
7	Fenner Gap Lithologic Model Boundary
8a	Lithologic Model Results – Cross Section 3-3’
8b	Lithologic Model Results – Cross Section 3-3’ Legend
9	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 4
10	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 5
11	Bottom Layer Elevations of the Cadiz Groundwater Model
12	Layer Thickness of the Cadiz Groundwater Model
13	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 32,000 acre-ft/yr
14	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 16,000 acre-ft/yr
15	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 5,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
16	Vertical Leakance of the Cadiz Groundwater Model
17	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 32,000 acre-ft/yr
18	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 16,000 acre-ft/yr
19	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 5,000 acre-ft/yr
20	Inelastic Storage Coefficient and Clay Thickness (ft) of the Cadiz Groundwater Model
21	Areal Distribution of Natural Recharge Rate of 32,000 acre-ft/yr
22	Annual Groundwater Pumping of Cadiz Agricultural Wells
23	PEST Hydraulic Conductivity Pilot Points
24	Location of Wells with Water Level Data Used for Steady State Model Calibration
25	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
26	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr
27	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
28	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
29	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
30	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
31	Location of Wells with Water Level Data Used for Transient Model Calibration
32	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
33	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
34	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
35	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
36	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
37	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
38	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
39	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
40	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
41	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
42	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
43	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
44	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
45	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
46	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
47	Normalized Sensitivity of Selected Model Parameters
48	Cadiz Conservation Project Scenario Wellfield Configuration A
49	Cadiz Conservation Sensitivity Scenarios Wellfield Configuration B
50	Cadiz Groundwater Conservation and Storage Project Annual Pumping for Project Conservation Scenario
51	Conceptual Drill Site Layout
52	Cadiz Conservation Project Scenario Schematic of Proposed Manifold System
53	Conceptual Well Design Diagram
54	Initial Groundwater Elevations for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
55	Initial Groundwater Elevations for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
56	Initial Groundwater Elevations for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr
57	Initial TDS Concentrations for Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2
58	Model-Calculated Groundwater Elevations at the End of 50 Years – Project Scenario
59	Model-Calculated Groundwater Elevations at the End of 100 Years – Project Scenario
60	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 1
61	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 1
62	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 2
63	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 2
64	Regional Drawdown at the End of 50 Years – Project Scenario
65	Regional Drawdown at the End of 100 Years – Project Scenario
66	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 1
67	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 1
68	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 2
69	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 2

FIGURES (CONTINUED)

No.	Description
70	Model Calculated Drawdown at Selected Locations
71	Model Calculated Depth to Water at Selected Locations
72	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Project Scenario
73	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 1
74	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 2
75	Model Calculated TDS Concentrations at Selected Locations
76	Cumulative Annual Changes in Groundwater Storage - Conservation Scenarios
77	Model-Calculated Potential Land Subsidence – Project Scenario
78	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 1
79	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 2
80	Model-Calculated Potential Land Subsidence at Selected Locations

TABLES

No.	Description
1	Groundwater Pumping for the Transient Model Calibration – 1986 to 2009
2	Groundwater Budget for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
3	Groundwater Budget for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr
4	Groundwater Budget for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr

APPENDICES

Ltr.	Description

VOLUME 2 – APPENDIX A

A	Cadiz Groundwater Conservation and Storage Project – Prepared by CH2M Hill

VOLUME 3 – APPENDICES B-G

B	Geologic Structural Evaluation of the Fenner Gap Region Located between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. Prepared by Dr. Miles Kenney
C	Geohydrologic Assessment of the Fenner Gap Area. Prepared by GEOSCIENCE Support Services, Inc.
D	Timeline – Chronology for Estimates of Natural Recharge to the Cadiz Project Area
E	Hydrographs for Transient Model Calibration with Natural Recharge of 32,000 acre-ft/yr
F	Hydrographs for Transient Model Calibration with Natural Recharge of 16,000 acre-ft/yr
G	Hydrographs for Transient Model Calibration with Natural Recharge of 5,000 acre-ft/yr

ABBREVIATIONS AND DEFINITIONS

acre-ft/yr	acre-feet per year.
Alluvial	A geologic term describing beds of sand, gravel, silt, and clay deposited by flowing water.
amsl	above mean sea level
Antiform	Arch-shaped rock structure which, by definition, closes (i.e. arches) upward. Antiforms are usually accompanied by synforms, which are oppositely shaped.
Aquifer	A geologic formation or group of formations which store, transmit, and yield significant quantities of water to wells and springs.
Archean	An eon of geologic time extending from about 3.9 billion years ago to 2.5 billion years ago.
bgs	below ground surface
Carbonate	A rock consisting primarily of a carbonate mineral such as calcite or dolomite, the chief minerals in limestone and dolostone, respectively.
CDMG	California Division of Mines and Geology
CRA	Colorado River Aqueduct
DEM	Digital Elevation Model
Detachment Fault	A nearly horizontal fault at the base of a fault system associated with large-scale extensional tectonics.
Dispersivity	A geometric property of a porous medium which determines the dispersion characteristics of the medium by relating the components of pore velocity to the dispersion coefficient.
Drawdown	The change in hydraulic head or water level relative to a background condition.
DWR	California Department of Water Resources

Effective Porosity	A fraction of the void spaces which forms part of the interconnected flow paths through the medium, per unit volume of porous medium (excluding void space in isolated or dead-end pores). Also known as "specific yield."
Evapotranspiration	The combined loss of water from a given area by evaporation from the land and transpiration from plants.
Fanglomerate	A sedimentary rock of heterogeneous materials that were originally deposited in an alluvial fan and have since become cemented into rock.
Fault	A fracture in the earth's crust, with displacement of one side of the fracture with respect to the other.
Formation	A geologic term that designates a body of rock or rock/sediment strata of similar lithologic type or combination of types.
ft	feet, foot
ft/day	feet per day
gpm	gallons per minute
Groundwater	Water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.
Hangingwall	Of the two sides of a fault, the side above the fault plane. It is called the hanging wall because where inactive faults have been "filled in" with mineral deposits and then mined, this is the side on which miners can hang their lanterns.
Head	Energy, produced by elevation, pressure, or velocity, contained in a water mass.
Holocene	An epoch of the Quaternary period extending from the end of the Pleistocene, approximately 11,000 years ago, to the present time.
Hydraulic Conductivity	The measure of the ability of the soil to transmit water, dependent upon both the properties of the soil and those of the fluid.
ID	inside diameter
in.	inch
Inselberg	An isolated residual knob or hill rising abruptly from a lowland erosion surface.

Jurassic	The second period of the Mesozoic era extending from approximately 200 to 145 million years ago.
Land Subsidence	The lowering of the natural land surface due to extraction of fluids and/or gas from the subsurface.
Leakage	The vertical movement (either downward or upward) of ground water from one aquifer to another.
Listric Fault	Listric faults can be defined as curved normal faults in which the fault surface in concave upwards; its dip decreases with depth. These faults also occur in extension zones where there is a main detachment fracture following a curved path rather than a planar path. Hanging wall blocks may eitherrotate and slide along the fault plane (eg slumps), or they may pull away from the main fault, slipping instead only along the low dipping part of the fault. Roll-over anticlines will often form between bedding planes and the main fault plane as a result of the flexing between the two.
Mesozoic	An era of geologic time extending from approximately 250 to 65 million years ago.
Metamorphic	A rock changed from its original form and/or composition by heat, pressure, or chemically active fluids.
mg/l	milligrams per liter
Miocene	An epoch of the early Tertiary period extending from approximately 23 to 5.3 million years ago.
MODFLOW-2000	A modular finite-difference flow model developed by the United States Geologic Survey (USGS) to solve the groundwater flow equation.
MT3DMS	A modular three-dimensional solute transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems.
Normal Fault	A fault characterized by predominantly vertical displacement in which the hanging wall is moved downward with respect to the footwall of the fault. Generally, this kind of fault is a sign of tectonic extension.
OD	outside diameter
Paleozoic	An era of geologic time extending from approximately 542 to 250 million years ago.

Permeability	The capability of soil or other geologic formations to transmit water. The term is used to separate the effects of the medium from those of the fluid on the hydraulic conductivity.
PEST	Parameter ESTimation software
Pleistocene	An epoch of the Tertiary period extending from approximately 2.6 million years ago to 11,000 years ago.
Preconsolidation Stress	The maximum stress to which a deposit has been subjected, and which it can withstand without undergoing additional permanent deformation.
Proterozoic	An eon of geologic time extending from approximately 2.5 billion years ago to 542 million years ago.
Quaternary	The second period of the Cenozoic era extending from approximately 2.6 million years ago to 5,000 years ago.
Saline Water	Water characterized by a total dissolved solids concentration in excess of 1,000 milligrams per liter.
SEAWAT-2000	Developed by the USGS to simulate three-dimensional, variable density, groundwater flow and solute transport in porous media. The source code for SEAWAT Version 4 was developed by combining MODFLOW and MT3DMS into a single program that solves the coupled flow and solute transport equations
Specific Yield	See “Effective Porosity”
Storativity	The volume of water that an aquifer releases or takes into storage per unit change in hydraulic head.
Synform	A structure formed by the downward bending of rock strata onto earlier and steeper folds of smaller size. Synforms are usually accompanied by antiforms, which are oppositely shaped.
TDS	total dissolved solids
Tertiary	The second period of the Cenozoic era extending from approximately 65 to 2.6 million years ago.
USGS	United States Geological Survey
Volcanic	Pertaining to the activities, structures, or rock types of a volcano.
yr(s)	year or years

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS

1.0 EXECUTIVE SUMMARY

The Cadiz Groundwater Conservation and Storage Project (Project) is a water conservation supply and conjunctive use storage project that would allow for management of the groundwater basin within the Fenner Watershed and the Orange Blossom Wash in the Eastern Mojave Desert. The Project will develop a new water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. The first phase of the Project, the Conservation Component, would extract and convey an average of approximately 50,000 acre-ft/yr from a wellfield in Fenner Gap via a pipeline to the Colorado River Aqueduct (CRA). The second phase of the Project, the Storage Project, would involve managing the groundwater basin as a conjunctive use project. Water belonging to water agencies would be conveyed to the Fenner Watershed (Fenner Gap area) from the CRA through the pipeline constructed under the Conservation Component of the Project. This water would be recharged into the aquifer system via spreading basins.

The purpose of this study was to evaluate the impacts of the proposed conservation project. Groundwater modeling was conducted to assess the impacts of the conservation project on existing groundwater levels, on the existing freshwater/saline water interface and groundwater quality, and on subsurface sediments - specifically the potential for the occurrence of subsidence. The following is a brief summary of the analysis.

The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms. The conservation project is located in Fenner Gap which is located between the Marble and Ship Mountains east of Cadiz. Fenner Gap lies within a topographically closed drainage system that includes three main watersheds and associated groundwater basins: Bristol, Cadiz, and Fenner.

One of the first investigations of the area is a United States Geological Survey (USGS) publication on “The Mojave Desert Region” by Thompson (1929). This pioneering investigation includes numerous geohydrologic data in the area. A 1967 investigation by the California Department of Water Resources (DWR) (Moyle, 1967) presents useful water well data and geologic map. A report prepared by Shafer (1964) also includes valuable hydrogeologic data.

In 1998 and 1999, Metropolitan Water District of Southern California (MWD), in conjunction with the Cadiz, Inc. evaluated the feasibility of operating a groundwater storage and transfer project near Cadiz. Comprehensive field testing was conducted in and around the Fenner Gap to characterize the geologic and hydrologic properties. The field testing program included installation of a deep 16-inch-diameter production well and a total of ten groundwater monitoring wells, drilled and installed in the Fenner Gap area prior to construction of the pilot spreading basin, followed by an 8-month large-scale artificial recharge test (GEOSCIENCE, 1999). In addition, a groundwater flow and solute transport model was developed to assess the potential impacts on groundwater levels and water quality due to the project.

Several geohydrologic investigations were conducted from between late 2009 and 2011 to provide supplemental geohydrologic properties for the Project. CH2M Hill (2010) provides an updated assessment of potential recoverable water that could be conserved over the long-term and groundwater in storage in the Fenner Valley and northern Bristol Valley area. This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model of the Fenner Gap area (see Appendix A). This report was prepared in July 2010 and updated in August 2011 to include additional field data that were collected and analyzed since the original report was published. Dr. Miles Kenney (2011) provided a geologic map and eight cross-sections in the Fenner Gap area (see Appendix B). The geologic map and cross-sections were constructed utilizing data obtained from field mapping bedrock exposures within hills and mountain ranges, Google Earth imagery, evaluation of well cores and samples, interpretation of a seismic reflection line, geologic structural principles, and well documented structural characteristics associated with extensional tectonics and igneous intrusions. GEOSCIENCE (2011) provides an updated evaluation of the geohydrology in the Fenner Gap area considering recent exploratory drilling and testing performed in late 2009 and early 2010. In conjunction with this task, independent analyses of pumping test data were made and aquifer parameters evaluated (see Appendix C).

The Cadiz groundwater model is a six-layer flow and solute transport model constructed to simulate the aquifer systems within Fenner Valley and Fenner Gap and the aquifer system that underlies a portion of the Bristol and Cadiz Dry Lakes. Recent geologic mapping, interpretive geologic cross-sections and lithologic logs from exploratory borings and water wells were used to develop the six model layers. The model layers consist of the following:

- Layer 1 - Upper Alluvium
- Layer 2 - Alluvium beneath the Upper Alluvium to a depth of approximately 1,200 ft

- Layer 3 - Alluvium beneath a depth of 1,200 ft
- Layer 4 - Fanglomerate, carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 5 - Carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 6 - A Detachment Fault Zone (approximately 200 ft thick) in the Fenner Gap area, and weathered granitic rocks

Groundwater flow is assumed to occur horizontally within each of the model layers while the layers maintain hydraulic connection to each other through vertical leakance. Bedrock beneath model layer 6 was considered as non-water bearing. The sources of recharge in the Cadiz groundwater model include natural recharge and artificial recharge during the pilot infiltration test conducted in 1999 (GEOSCIENCE, 1999). The discharge terms include evapotranspiration from the Bristol and Cadiz dry lakes, and Cadiz agricultural pumping.

Model calibration is performed to compare model-simulated groundwater levels to field-measured values. The method of calibration used by the Cadiz groundwater model was the industry standard "history matching" technique, including steady state and a transient calibration. For the steady state calibration, the model was calibrated against water levels measured in 1964. The transient model calibration covers the period from 1986 through 1990 with an annual stress period and from January 1991 through December 2009 with a monthly stress period. To assist in the trial-and-error adjustment of parameters for "history matching", the software PEST (Parameter ESTimation) (Doherty, 2004) was used to aid in the calibration of the groundwater flow model during the steady state model calibration. After the initial calibration, regularization, in combination with pilot points (Doherty, 2004), was used to improve the model calibration. Regularization provides smoothing of parameter estimates, so that each model cell is not considered to have a unique independent value and there is a "smooth transition" across the model cells from high to low values. Three versions of the model were developed, representing a range of recharge (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr and 5,000 acre-ft/yr).

The relative error of the water residuals (i.e., standard deviation of the residuals divided by the observed head range) was calculated to quantitatively evaluate the model calibration. Common modeling practice is to consider a good fit between historical and model predicted data if the relative error is below 10% (Spitz and Moreno, 1996; and Environmental Simulations, Inc., 1999). The relative error for steady state model calibration was 0.15% for each calibration run, well below the recommended relative error of 10%. For the transient calibration runs (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr), the model-calculated water levels match very

well with observed data. The relative error of the water level residuals is 1.7% for each transient calibration run, well below the recommended error of 10%.

After the model was calibrated, three model runs were simulated for a period of 100 years with an annual stress period. The predictive model runs include one Project scenario and two sensitivity scenarios. The purpose of the sensitivity scenarios was to evaluate the potential ranges of worst case impacts by: (1) reducing the amount of available natural recharge, and (2) increasing the distances between the wells within the proposed Project wellfield. Two wellfield configurations were used for the sensitivity analysis. Wellfield Configuration A consists of wells clustered around Fenner Gap and Wellfield Configuration B consists of wells spread out southwest from Fenner Gap. Wellfield Configuration B, coupled with lower natural recharge volumes, presents a worst-case scenario in terms of the potential impact to Bristol Dry Lake from Project pumping. Additionally, Wellfield Configuration B presents a worst-case scenario for impacts related to migration of saline water from Bristol Dry Lake as the wells are located closer to the saline water/freshwater interface. The model scenarios and the assumptions used for each are provided in the following table:

Model Scenario	Assumptions			
	Natural Recharge	Wellfield Configuration	Average Annual Groundwater Pumping from Years 1 to 50	Average Annual Groundwater Pumping from Years 51 to 100
	[acre-ft/yr]		[acre-ft/yr]	[acre-ft/yr]
Project Scenario	32,000	Clustered around Fenner Gap (Configuration A)	50,000	0
Sensitivity Scenario 1	16,000	Spread Out from Fenner Gap (Configuration B)	50,000	0
Sensitivity Scenario 2	5,000	Spread Out from Fenner Gap (Configuration B)	50,000	0

The following findings and recommendations are based on the results of the groundwater model and impact analyses:

Groundwater Elevations

- Model-calculated groundwater elevations at the end of 50 years (i.e., end of Project pumping) under Project Scenario and Sensitivity Scenario conditions indicate that the lowest water levels (i.e., greatest potential impact) would occur at the center of the wellfield in the vicinity of Fenner Gap.
- Under Project pumping conditions, groundwater would flow toward the proposed wellfield from Fenner, Bristol and Cadiz valleys.
- At the end of 100 years (i.e., 50 years following cessation of Project pumping), water levels in the wellfield recover and groundwater flow directions would be similar to current conditions (i.e., groundwater flow within the Bristol watershed flows toward, and terminates in, Bristol Dry Lake; groundwater flow within the Cadiz watershed flows toward, and terminates in, Cadiz Dry Lake; groundwater flow within the Fenner watershed flows from Fenner Valley through Fenner Gap and terminates at Bristol and Cadiz Dry Lakes).

Groundwater Level Drawdown

- Predicted regional drawdown at the end of 50 years (i.e., end of Project pumping) under Project Scenario and Sensitivity Scenario conditions indicate that a maximum groundwater level drawdown (i.e., greatest potential impact) of 260 to 270 ft (under natural recharge conditions of 5,000 acre-ft/yr) would occur at the center of the wellfield in the vicinity of Fenner Gap.
- Groundwater levels in the Bristol and Cadiz Dry Lakes would decline as a result of interception of natural recharge by the Project, consequently reducing or eliminating groundwater currently lost to evaporation from the surface of the dry lakes.
- Drawdown within the wellfield, including the center of the wellfield and the area of the existing Cadiz wells, corresponds to hydrologic conditions and amount of natural recharge.
- The maximum single year drawdown would be 22.1 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2) and dry year conditions (i.e., pumping of

75,000 acre-ft/yr). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), there would be very little change in drawdown during single dry, wet and average years.

- Maximum drawdown within the wellfield during multiple dry year conditions (i.e., pumping of 75,000 acre-ft/yr; hydrologic years 1988 to 1992) would be 65.9 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.3 ft.
- Maximum drawdown within the wellfield during multiple wet year conditions (i.e., pumping of 25,000 acre-ft/yr; hydrologic years 1980 to 1984) would be -39.4 ft (groundwater level rise) under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.9 ft.
- Maximum drawdown within the wellfield during multiple average year conditions (i.e., pumping of 50,000 acre-ft/yr; hydrologic years 1964 to 1968) would be 25.1 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.8 ft.

Depth to Groundwater

- Depth to groundwater at the end of 50 years (end of Project pumping under Project Scenario conditions) would range from 197 to 435 ft bgs in the vicinity of the wellfield, 50 to 68 ft bgs at Bristol Dry Lake, and 21 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 50 years (end of Project pumping under Sensitivity Scenario 1 conditions) would range from 241 to 486 ft bgs in the vicinity of the wellfield, 63 to 95 ft bgs at Bristol Dry Lake, and 59 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 50 years (end of Project pumping under Sensitivity Scenario 2 conditions) would range from 315 to 627 ft bgs in the vicinity of the wellfield, 54 to 118 ft bgs at Bristol Dry Lake, and 72 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Project Scenario conditions) would range from 154 to 351 ft bgs in the vicinity of the wellfield, 33 to 42 ft bgs at Bristol Dry Lake, and 10 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Sensitivity Scenario 1 conditions) would range from 181 to 371 ft bgs in the vicinity of the wellfield, 62 to 74 ft bgs at Bristol Dry Lake, and 17 ft bgs at Cadiz Dry Lake.

- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Sensitivity Scenario 2 conditions) would range from 219 to 412 ft bgs in the vicinity of the wellfield, 79 to 108 ft bgs at Bristol Dry Lake, and 68 ft bgs at Cadiz Dry Lake.

Saline Water/Freshwater Interface

- The location of the current saline water/freshwater interface for this Project is defined by the location of the 1,000 mg/L TDS concentration contour.
- Results of the modeling indicate the saline water/freshwater interface in the Bristol Dry Lake area would move a maximum distance of approximately 10,400 ft northeast during Project pumping (years 1 to 50) under Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). The saline water/freshwater interface would move a maximum of approximately 9,700 ft and 6,300 ft to the northeast during the same period of time under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr) and Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr), respectively.
- Following Project pumping for all scenarios, the saline water/freshwater interface in the Bristol Dry Lake area continues to move towards the northeast to reach a distance of 11,500 ft, 11,100 ft, and 9,200 ft for the Project Scenario conditions (under natural recharge conditions of 32,000 acre-ft/yr), Sensitivity Scenario 1 (under natural recharge conditions of 16,000 acre-ft/yr), and Sensitivity Scenario 2 (under natural recharge conditions of 5,000 acre-ft/yr), respectively.

Groundwater in Storage

- The cumulative annual change in groundwater storage would reach a maximum of -1,090,000 acre-ft (a negative sign represents a decline in groundwater storage) in year 50 under the Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). This decline in groundwater storage is approximately 3% to 6% of the total groundwater in storage.
- The groundwater in storage would begin to recover following the cessation of Project pumping in year 50. The cumulative annual change in groundwater storage would be approximately -220,000 acre-ft in year 100 under Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the

groundwater storage would fully recover in year 117 (i.e., 67 years after Project pumping stopped).

- The cumulative annual change in groundwater storage would reach a maximum of -1,680,000 acre-ft in year 50 under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr). This decline in groundwater storage is approximately 5 to 10% of the total groundwater in storage.
- The cumulative annual change in groundwater storage would be approximately -870,000 acre-ft in year 100 under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 153 (i.e., 103 years after Project pumping stopped).
- The cumulative annual change in groundwater storage would reach a maximum of -2,160,000 acre-ft in year 50 under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr). This decline in groundwater storage is approximately 6 to 13% of the total groundwater in storage.
- The cumulative annual change in groundwater storage would be approximately -1,870,000 acre-ft in year 100 under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 440 (i.e., 390 years after Project pumping stopped).

Potential Land Subsidence

- In general, the amount of land subsidence corresponds to the magnitude of water level decline and the thickness of the clay layers.
- The maximum model-predicted land subsidence is 2.7 ft at the center of Bristol Dry Lake at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).
- The maximum model-predicted land subsidence ranges from 0.7 to 1.5 ft in the vicinity of the Cadiz wellfield at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).

- The maximum model-predicted land subsidence is 0.6 ft at the edge of Cadiz Dry Lake at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).
- Predicted subsidence would occur gradually over time and be dispersed laterally over a large area from Fenner Gap to the Bristol and Cadiz Dry Lakes.

Consideration of the Cadiz Groundwater Modeling and Impact Analysis report will be incorporated into the Groundwater Management Plan.

2.0 INTRODUCTION

2.1. Purpose and Scope

The Cadiz Groundwater Conservation and Storage Project (Project) is a water conservation supply and conjunctive use storage project that would allow for management of the groundwater basin within the Fenner Watershed and the Orange Blossom Wash in the Eastern Mojave Desert (see Figure 1). The Project will develop a new water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. The first phase of the Project, the Conservation Component, would extract and convey an average of approximately 50,000 acre-ft/yr from a wellfield in Fenner Gap via a pipeline to the Colorado River Aqueduct (CRA). The long-term average annual natural recharge of the Bristol, Cadiz and Fenner Watersheds has been calculated to be approximately 32,000 acre-ft/yr (CH2M Hill, 2010; see Appendix A). In addition to this amount, the Project would extract 18,000 acre-ft/yr to create and maintain a groundwater trough that would ensure that groundwater flowing from Fenner Valley would be drawn to the wellfield in order to capture the long-term sustainable yield. The second phase of the Project, the Storage Project, would involve managing the groundwater basin as a conjunctive use project. The trough created by extracting more than the annual natural recharge amount of 32,000 acre-ft will create supplemental storage space within the basin, optimizing the conservation and conjunctive use of water. Water belonging to water agencies would be conveyed to the Fenner Watershed (Fenner Gap area) from the CRA through the pipeline constructed under the Conservation Component of the Project. This water would be recharged into the aquifer system via spreading basins. Under terms that would protect the beneficial uses of the groundwater basin, participating water agencies could extract previously recharged water from the basin when needed. Under the Storage Component of the Project, up to 1 million acre-ft of dewatered capacity would be managed and made available for groundwater banking.

The purpose of this study was to evaluate the impacts of the proposed conservation project. Groundwater modeling was conducted to assess the impacts of the conservation project on existing groundwater levels, on the existing freshwater/saline water interface and groundwater quality, and on subsurface sediments - specifically the potential for the occurrence of subsidence. This report summarizes the groundwater modeling results of the Phase I Conservation Scenarios of the Project.

2.2. Description of Study Area

The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of

Twentynine Palms (see Figure 1). The conservation project is located in Fenner Gap which is located between the Marble and Ship Mountains east of Cadiz (see Figure 1). Fenner Gap lies within a topographically closed drainage system that includes three main watersheds and associated groundwater basins: Bristol, Cadiz, and Fenner. These watersheds are considered to be one drainage system because all surface and groundwater drains to a central lowland area at Bristol and Cadiz Dry Lakes. The Bristol, Cadiz, and Fenner watersheds are separated from the surrounding watersheds by topographic divides (generally mountain ranges).

The total area of the Bristol, Cadiz and Fenner watersheds is approximately 2,710 square miles. The Bristol Watershed is 1,170 square miles, the Cadiz Watershed is 540 square miles, and the Fenner Watershed is 1,000 square miles. Groundwater flow within the Bristol watershed flows toward, and terminates in, Bristol Dry Lake. Groundwater flow within the Cadiz watershed flows toward, and terminates in, Cadiz Dry Lake. Groundwater flow within the Fenner watershed flows from Fenner Valley through Fenner Gap and terminates at Bristol and Cadiz Dry Lakes (see Figure 2).

2.3. Previous Investigations

One of the first investigations is a United States Geological Survey (USGS) publication on "The Mojave Desert Region" by Thompson (1929). This pioneering investigation includes numerous geohydrologic data in the area. A 1967 investigation by the California Department of Water Resources (DWR) (Moyle, 1967) presents useful water well data and geologic map. A report prepared by Shafer (1964) also includes valuable hydrogeologic data.

In 1998 and 1999, Metropolitan Water District of Southern California (MWD), in conjunction with the Cadiz, Inc. evaluated the feasibility of operating a groundwater storage and transfer project near Cadiz. Comprehensive field testing was conducted in and around the Fenner Gap to characterize the geologic and hydrologic properties. The field testing program included installation of a deep 16-inch-diameter production well and a total of ten groundwater monitoring wells, drilled and installed in the Fenner Gap area prior to construction of the pilot spreading basin, followed by an 8-month large-scale artificial recharge test (GEOSCIENCE, 1999). As part of the study, all available published and unpublished geologic and hydrologic reports, maps, and data relative to the project area were collected, compiled, and reviewed. In addition, a groundwater flow and solute transport model was developed to assess the potential impacts on groundwater levels and water quality due to the project.

2.4. Recent Supplemental Geohydrologic Investigations

Several geohydrologic investigations were conducted from between late 2009 and 2011 to provide supplemental geohydrologic properties for the Project. These investigations include:

- Cadiz Groundwater Conservation and Storage Project. Prepared by CH2M Hill. (see Appendix A),
- Geologic Structural Evaluation of the Fenner Gap region located between the southern Marble Mountains and Ship Mountains, San Bernardino County, California. Prepared by Dr. Miles Kenney (see Appendix B), and
- Geohydrologic Assessment of the Fenner Gap Area. Prepared by GEOSCIENCE Support Services, Inc. (see Appendix C).

CH2M Hill's study provides an updated assessment of potential recoverable water that could be conserved over the long-term and groundwater in storage in the Fenner Valley and northern Bristol Valley area. This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model of the Fenner Gap area (see Appendix A). This report was prepared in July 2010 (see Appendix A). Appendix A of this report has been updated in August 2011 to include additional field data that were collected and analyzed since the original report was published. Note that geology and hydrology have not been updated to reflect the additional geologic assessments provided by Dr. Miles Kenny (see Appendix B).

Kenney's study provides a geologic map and eight cross-sections in the Fenner Gap area (see Appendix B). The geologic map and cross-sections were constructed utilizing data obtained from field mapping bedrock exposures within hills and mountain ranges, Google Earth imagery, evaluation of well cores and samples, interpretation of a seismic reflection line, geologic structural principles, and well documented structural characteristics associated with extensional tectonics and igneous intrusions.

GEOSCIENCE's study provides an updated evaluation of the geohydrology in the Fenner Gap area considering the recent exploratory drilling and testing performed in late 2009 and early 2010. In conjunction with this task, independent analyses of pumping test data were made and aquifer parameters evaluated (see Appendix C). This report was prepared in April 2010 and updated in August 2011 to include additional field data that were collected and analyzed since the original report was published, and additional geologic assessments provided by Dr. Miles Kenny (see Appendix B).

2.5. Sources of Data

Data used for this study were obtained from multiple sources. The primary sources include the documents discussed in the Section 2.3 (i.e., Previous Investigations) and Section 2.4 (i.e., Recent Supplemental Geohydrologic Investigations) of this report. A complete list of references is provided in Section 11.0 of this report.

3.0 GEOLOGY

3.1. Geologic Setting

The study area is located in the Basin and Range Geomorphic Province, characterized by a series of structural and topographic basins bounded by relatively linear mountain ranges. The Basin and Range Geomorphic Province is present throughout Nevada, eastern and southeastern California, and western to southern Arizona. The alternating mountains and valley topography primarily resulted from extensional (pulling apart) tectonics that occurred during the Miocene (Wernicke, 1992). Most valleys within the Basin and Range Geomorphic Province are enclosed basins. That is to say, flow within basin drainages remain within the basins, creating dry lakes where surface flows gather and evaporate. Sediments eroding from the local mountain ranges deposit relatively locally within the immediate valley (basin). Groundwater flow within closed basins moves from the mountain front into the valley where it evaporates through the surface of the playa lake. The project area is located within portions of the Bristol, Cadiz, and Fenner Valley watersheds in the Eastern Mojave Desert of California. Together the Bristol and Cadiz watersheds form a broad valley-like depression that has been referred to in literature as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). All surface and groundwater flow terminate at the Bristol and Cadiz dry lakes, which are the low points of the regional watershed, (Bassett et al., 1959; Handford, 1982; Rosen, 1989). As such, it is considered to be a hydraulically closed system. The depression that forms Bristol Dry Lake is thought to be 6-10 million years old (Rosen, 1989)--having formed as a result of movement on a system of regional faults. This movement resulted in the relative raising of the mountain ranges and lowering of the basin floor.

Until recently, geologic mapping conducted by the California Division of Mines and Geology (CDMG, 1964) has served as the basis for understanding local geologic conditions in Fenner Gap. Prior to this investigation, detailed geologic mapping of the project area had not been conducted. Recent geologic mapping of the southeastern portion of the Marble Mountains, Fenner Gap, and the northwestern portion of the Ship Mountains was conducted for this investigation by Dr. Miles Kenney. This detailed mapping was conducted to allow interpretation of the geologic structure in Fenner Gap in order to determine potential groundwater flow paths and rates. Dr. Kenney's report entitled "Draft Geologic Structural Evaluation of the Fenner Gap region located between the southern Marble Mountains and Ship Mountains, San Bernardino County, California" is presented as Appendix B of this report and formed the basis for construction of the groundwater flow model described in this report.

The age of the rocks in the study area, range from Archean[1] (1.4 Billion years old), to currently depositing alluvial sediments of Quaternary age. Thus the geologic history of the site covers approximately 1.4 billion years (see Plate 2 Kenney, 2011 [Appendix B] for the areal distribution of geologic units within the study area. Using detailed geologic mapping, coupled with evaluation of the subsurface data collected from borings, geologic cross-sections were constructed to interpret the geologic structure across and through the axis of Fenner Gap. The geologic cross-sections are presented on Plate 3 and Plate 4 of Appendix B.

3.2. Geologic Units

Geologic formations found in the Bristol, Cadiz, and Fenner watersheds can be grouped into four broad categories:

1. Archean to Jurrassic granitic and metamorphic rock of the mountain ranges and watershed margins;
2. Tertiary volcanic and fanglomerate units;
3. Pleistocene to Holocene alluvial sediments weathering from the flanks of the surrounding hills and mountains; and
4. Fine-grained (i.e., silt and clay) sediments and evaporite (i.e., salt and gypsum) deposits underlying Bristol and Cadiz dry lakes (see Figure 2 of Appendix C).

A brief description of the geologic units present in the study area is presented below. See Appendix B for a complete description of the geologic units present within the study area.

3.2.1. Alluvium

Sediments eroding from the bedrock are deposited as alluvium on the flanks of the hills and mountains, and over time, have largely filled the valleys between the mountain ranges. Geophysical evidence indicates that the depth of alluvium locally exceeds 3,500 ft below ground surface (bgs) in the area between Bristol Dry Lake and Fenner Gap in the vicinity of the irrigation wellfield (Maas, 1994). Based on recent drilling, the depth of alluvial sediments in Fenner Gap is known to reach 1,500 ft. It is

[1] The Archean is an eon of geologic time extending from approximately 3.9 billion years ago to 2.5 billion years ago. Recent mapping has found that rocks within the study area are actually younger, and part of the Proterozoic. However, in the interest of consistency with previous mapping/literature, the Archean terminology is retained.

believed that most of the groundwater in the Bristol, Cadiz, and Fenner watershed area is stored within these alluvial sediments. However, permeable bedrock lying beneath the alluvium may contain an appreciable amount of groundwater within secondary porosity features.

Alluvial sediments are primarily composed of layers of gravel, sand, silt, and clay in varying proportions (Koehler, 1983; Freiwald, 1984). The grain size of the alluvium is generally coarse on the upper parts of the alluvial slopes with more fine-grained deposits down slope (Dibblee, 1980b; Koehler, 1983; Freiwald 1984). However, significant layers of coarse-grained material (including cobbles and boulders) have been noted in Fenner Gap and as far down slope as Bristol Dry Lake (Rosen, 1989). Most of the exposed alluvial sediments were deposited from 10,000 years ago to the present. However, deposits older than 10,000 years have been noted in some areas (Dibblee, 1980, Kenney, 2011).

3.2.2. Tertiary Volcanics and Fanglomerates

Volcanic rocks are found primarily on the northeast side of the Marble Mountains, the north side of the Ship Mountains, and in the Clipper Mountains.

Volcanic Terrain in the Foreground and the Northern Ship Mountains in the Background

Fanglomerates are exposed in the northeastern Ship Mountains (see Plate 2 of Appendix B for locations). The Fanglomerate unit may be at least 1,000 feet thick and consists of sediments deposited into the basins prior to and during local Miocene extension. The basal members of the fanglomerate contain exotic and well-rounded clasts (conglomerates), very well sorted sedimentary members, and few volcanic deposits or clasts. According to Kenney (2011) there is an "…increase in proximal clasts, interbedded volcanic members, increase in grain size, grain angularity (conglomerate to breccia) and progressively shallower dips…" higher in the section which are the result of ongoing geologic structural

changes. The Fanglomerate unit was penetrated by a number of the borings within Fenner Valley, during this investigation, and was found to consist of consolidated sediments of sand, gravel, and cobbles (see Plates 2, 3, and 4 of Appendix B).

3.2.3. Archaen and Jurassic Granitic and Metamorphic Bedrock

The bedrock exposed in the mountain ranges surrounding these regional watersheds consists of Archaen (up to 1.4 billion years old; Silver et al., 1963), and in some areas, Mesozoic (167 to 151 million years old) granitic and metamorphic rocks. Paleozoic (570 to 240 million years old) meta-sedimentary rocks consisting of quartzite, shale, limestone, and dolomite are present in the Marble Mountains and on the northwestern and northern flanks of the Ship Mountains. The general distribution of the bedrock units are shown on Figure 2 of Appendix C. The detailed distribution, of these units is shown on Plate 2 of Appendix B.

3.3. Geologic Structure

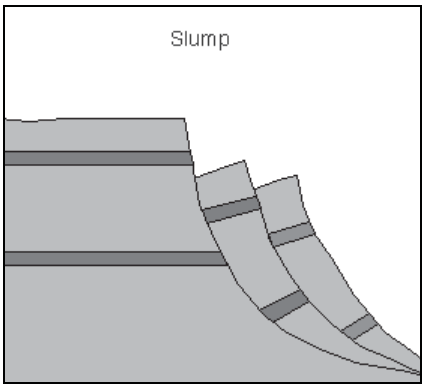
3.3.1. Overview of Geologic History and Structure

The brief overview of the geologic structure in the study area is presented below. For a complete description of the geologic history and structure in the study area, please refer to Appendix B of this report.

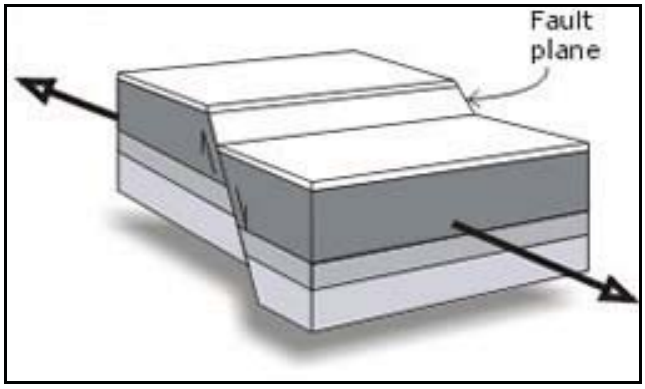
The geologic structure in the study area, as well as the Basin and Range Geomorphic Province in general, is the result of two main geologic events. Initially, Paleozoic sediments were deposited on Archaen cratonal crust during a relatively quiet geologic time period. During the Jurrassic, intrusive rocks were emplaced at depth resulting in folding and metamorphism of some of the older rocks into which they intruded. As an example within the study area, Paleozoic Rocks in the Marble Mountains are unmetamorphosed but are moderately folded and faulted—recent geologic mapping indicates that only a few granitic sills are present in the southern Marble Mountains area. The Paleozoic sedimentary units exhibit an average northward strike and dip approximately 30 degrees to the east. In contrast, most of the Ship Mountains are dominated by intrusions from the Jurassic Igneous and Metamorphic Suite. In this area, the Paleozoic rocks are uplifted, metamorphosed, eroded away, and folded by the Jurassic igneous intrusions.

The second and most dominating event was the occurrence of the Miocene extension which formed the arrangement of mountains and valleys making up the Basin and Range Geomorphic Province. During

the Miocene crustal extension, detachment faults developed as a basal slip surface to accommodate the movement of the upper portions of the crust with respect to the lower portions. An imbricated series of listric faults (i.e. Faults 1-9 shown on Plate 2 of Appendix B) developed above the detachment faults as the area was pulled apart. Highland and adjacent lowland areas (i.e., horsts and grabens) formed from movement of the listric faults.



Example of Listric Fault



Example of Normal Fault

The development of high angle normal faults occurs subsequent to extension and can extend through and offset the detachment faulting (i.e., Cross Faults CF-A through CF-L, shown on Plate 4 of Appendix B). The result of these processes in the study area, are highly faulted, tilted, and rotated blocks of Paleozoic sediments and Mesozoic granitic rocks (see Plates 3 and 4 of Appendix B). Movement along faults created highland areas (mountains) from which sediments were eroded, and basins (valleys) into which sediments were deposited, forming the fanglomerate units described previously. Volcanic rocks which are typically associated with the Miocene extensional period were deposited following the deposition of the fanglomerate units (see Plate 2 of Appendix B for the distribution of volcanic units exposed within the study area). From the Miocene period of extension and continuing to the present, the basin areas were filled with sediments which continued to erode from the adjacent highland areas creating thick sequences of basin fill. The geologic structure and depth of alluvium through Fenner Gap, as based on subsurface boring data and geologic mapping, is shown on Plates 3 and 4 of Appendix B.

3.3.2. Geologic Structure in Fenner Gap

In general, the geologic structure in Fenner Gap is characterized by highly faulted and folded bedrock overlain by Tertiary fanglomerates and Pleistocene to Holocene alluvial units. Plates 3 and 4 of Appendix B show the dominance of normal faults and the Jurrasic intrusives in development of the

geologic structure in the Fenner Gap area. In general, the southern portion of Fenner Gap is underlain primarily by faulted Archaen and Jurassic intrusive rock on the western side of the Gap and by faulted Paleozoic limestones on the eastern side of the Gap. Due to faulting an increase in Paleozoic limestone units are interpreted to occur beneath Fenner Gap further up the valley. Paleozoic units (i.e., limestones and quartzites) are faulted, tilted, and folded. An antiform and synform is shown to be present near the center of Fenner Gap as a means to explain the distribution and bedding dip angles of the Paleozoic units. Both the normal faults and the detachment fault are shown to have a zone of fractures on the hanging wall of the fault (above the fault plane) which are approximately 150 to 400 feet thick. The existence and zone of faulting is based on geologic exposures of some of these faults in the study area. With respect to the movement of groundwater through Fenner Gap, the existence of extensive faulting, tilting, and folding of both Paleozoic and Jurassic bedrock units, along with accompanying joint and fracture systems, provide extensive secondary groundwater flow paths within the bedrock.

4.0 HYDROLOGY

The hydrology of the Project area is summarized in the following sections. A more detailed description of the hydrology is provided in the Appendices A and C.

4.1. Precipitation

Most of the precipitation in the Eastern Mojave Desert accumulates during the late Fall and Winter months from November through March. Early summer and late fall are typically periods of little rainfall. The amount of precipitation in the Bristol, Cadiz, and Fenner basins vary with differences in altitude. Average annual precipitation ranges from approximately 3 inches on the Cadiz and Bristol dry lakes (elevations of 545 to 595 ft above mean sea level [amsl]) to over 12 inches in the Providence and New York mountains (elevations over 7,000 ft amsl). However, most of the study area receives, on the average, 4 to 6 inches of rain annually. A more detailed discussion of precipitation patterns in the study area can be found in Section 2.2 of CH2M Hill, 2010.

4.2. Groundwater Occurrence and Movement

The primary sources of replenishment to the groundwater system in the Project area include direct infiltration of precipitation (both rainfall and snowfall) into fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the watershed (see Appendix A). The source of most of the groundwater recharge within the regional watershed occurs in the higher elevations since the higher elevations receive the higher volumes of precipitation (see Appendix A).

A conceptualization of groundwater occurrence and movement is provided in Figure 2-13 of Appendix A. A schematic cross-section showing groundwater in fractured bedrock in the mountain ranges that is recharged by precipitation is shown in Figure 2-14 of Appendix A. As shown, precipitation flows down the mountain slopes by infiltrating into rock fractures or overland if the volume of flow is sufficient to overcome infiltration. In some cases in the higher elevations, the infiltrating water may be diverted to the land surface or groundwater may intersect the land surface creating a spring, but only at the higher elevations of the mountain slopes. Ultimately, this infiltrating water moves vertically downward into the alluvial materials and fractured bedrock of the regional groundwater system, tens of feet below the ground surface. Groundwater continues to flow downgradient through the principal aquifer systems.

In Bristol and Cadiz watersheds, groundwater flows toward the dry lakes from Fenner Gap and the surrounding hills and mountains (see Figure 2). In Orange Blossom Wash, groundwater flows southeasterly from the Granite Mountains through the wash, and then southwestward into Bristol dry lake. In the Fenner Watershed, groundwater generally flows southwestward and southward from the New York and Providence Mountains into the main part of Fenner Valley, and then south-southwesterly through Fenner Gap. Some of the groundwater flowing through Fenner Gap flows toward Bristol dry lake and some of the groundwater flows toward Cadiz dry lake.

4.3. Aquifer Systems

Based on available geologic and geophysical data, the principle geologic deposits in the Project area that can store and transmit groundwater (i.e., aquifers) can be divided into three units: an upper alluvial aquifer, a lower alluvial aquifer, and a bedrock aquifer consisting of Tertiary fanglomerate, Paleozoic carbonates and fractured and faulted granitic rock. In general, these three units are in hydraulic continuity with each other and the separation is primarily due to stratigraphic differences.

The upper alluvial aquifer consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967). The thickness of this aquifer varies from approximately 200 to 800 feet. To the west of Fenner Gap, the upper aquifer is separated from the lower aquifer system by discontinuous layers of silt and clay. The average thickness of the upper aquifer in Fenner Gap is approximately 500 feet. The upper aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more to wells with less than 20 feet of drawdown.

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of late Tertiary to early Quaternary age (Moyle, 1967; Bassett and Kupfer, 1964). The maximum thickness of the lower aquifer is unknown but may reach over 6,000 feet in the vicinity of Bristol dry lake (Maas, 1994). Where these materials extend below the water table, they yield water freely to wells but are generally less permeable than the upper aquifer sediments (Moyle, 1967). The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm.

Based on findings from recent drilling in the Fenner Gap area, Tertiary fanglomerate, fractured and faulted granitic rock, and Paleozoic carbonates, located beneath the lower alluvial aquifer, contain groundwater and are considered a third aquifer unit. Groundwater movement and storage within the carbonate bedrock aquifer primarily occurs within secondary porosity features (i.e., fracture zones associated with faulting and cracks, and cavities developed within the rocks over time).

4.4. Groundwater Storage

The volume of groundwater in storage was estimated to be about 17 million to 34 million acre-feet in the alluvium of the Fenner Valley, Orange Blossom Wash, and northern Bristol Valley area (see Appendix A). It is this geographic area that the Project would utilize for the conservation and storage Project. It is important to note that this storage estimate does not include water contained within the carbonate and fractured portion of the bedrock beneath the alluvial units. Recent drilling has revealed that these units also store groundwater. As such, the estimated volume of groundwater in storage is a conservative underestimate; the actual volume of groundwater in storage is larger by some unknown amount.

4.5. Groundwater Quality

The quality of the groundwater in the Fenner Gap and Fenner Valley area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L). At Bristol and Cadiz dry lakes, surface water and shallow groundwater evaporation concentrates dissolved salts in the water, resulting in TDS concentrations as high as 298,000 mg/L in these areas (Shafer, 1964). In general, as groundwater moves toward the dry lakes from Fenner Gap and the surrounding mountains, it becomes more saline and mineralized in the immediate vicinity of the dry lakes as the "fresh" groundwater mixes with the more saline lake water. The freshwater/saline water interface, as defined by TDS concentrations greater than 1,000 mg/L, is located near the margins of the dry lakes as shown on Figure 3. For more detailed groundwater quality information, see GEOSCIENCE, 1999.

5.0 MODEL DEVELOPMENT AND CONSTRUTION

5.1. Conceptual Model

The Cadiz groundwater model is a six-layer flow and solute transport model constructed to simulate the aquifer systems within Fenner Valley and Fenner Gap and the aquifer system that underlies a portion of the Bristol and Cadiz Dry Lakes. Recent geologic mapping (see Appendix B), interpretive geologic cross-sections and lithologic logs from exploratory borings and water wells were used to develop the six model layers. The model layers consist of the following:

- Layer 1 - Upper Alluvium
- Layer 2 - Alluvium beneath the Upper Alluvium to a depth of approximately 1,200 ft[2]
- Layer 3 - Alluvium beneath a depth of 1,200 ft
- Layer 4 - Fanglomerate, carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 5 - Carbonate, lower Paleozoic sequence and weathered granitic rocks
- Layer 6 - A Detachment Fault Zone (approximately 200 ft thick) in the Fenner Gap area, and weathered granitic rocks

Groundwater flow is assumed to occur horizontally within each of the model layers while the layers maintain hydraulic connection to each other through vertical leakance. Bedrock beneath model layer 6 was considered as non-water bearing. The sources of recharge in the Cadiz groundwater model include natural recharge and artificial recharge during the pilot infiltration test conducted in 1999 (GEOSCIENCE, 1999). The discharge terms include evapotranspiration from the Bristol and Cadiz dry lakes, and Cadiz agricultural pumping.

5.2. Computer Code

The computer codes used in the Cadiz groundwater model include MODFLOW-2000 and SEAWAT-2000 Version 4. MODFLOW is a modular finite-difference flow model developed by the United States Geologic Survey (USGS) to solve the groundwater flow equation (Harbaugh, et. al., 2000). SEAWAT-2000 was developed by the USGS (Langevin, et. al., 2008) to simulate three-dimensional, variable density, groundwater flow and solute transport in porous media. The source code for SEAWAT Version

[2] 1,200 feet is the assumed base of the primary groundwater production zone based on screen intervals of existing wells (GEOSCIENCE, 1999).

4 was developed by combining MODFLOW and MT3DMS[3] into a single program that solves the coupled flow and solute transport equations. MODFLOW was used for the steady state and transient model calibration runs. SEAWAT-2000 Version 4 was used in the Cadiz groundwater model predictive model runs in order to evaluate the potential movement of saline water present beneath Bristol and Cadiz Dry Lakes due to Project pumping.

In addition, In order to simulate subsidence potential, the Cadiz groundwater model was augmented by incorporating the Subsidence and Aquifer-System Compaction (SUB) Package (Hoffmann, et. al, 2003). The SUB package is used in conjunction with SEAWAT-2000 to simulate the elastic (recoverable) compaction and expansion and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The deformation of interbeds is caused by changes in effective stress as a result of water level changes. If the stress is less than the preconsolidation[4] stress of the sediments, the deformation is elastic (i.e., recoverable). If the stress is greater than the preconsolidation stress, the deformation is inelastic (i.e., permanent).

5.3. Model Domain, Grid and Time Discretization

The Cadiz groundwater model covers approximately 3,000 square miles (see Figure 4) and consists of 674 nodes (model cells) in the north-to-south direction (i-direction) and 492 nodes in the west-to-east direction (j-direction), for a total of 1,989,648 nodes for all six model layers (see Figure 5). Each model cell represents an area of approximately 500 ft x 500 ft (5.7acres).

The transient model calibration run covers the period from 1986 through 2009. A total of 233 stress periods[5] were used including an annual stress period for the period from 1986 through 1990 and a monthly stress period for the period from January 1991 through December 2009. All the predictive model runs were simulated for a 100 year period with an annual stress period.

[3] MT3DMS is a modular three-dimensional solute transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems (Zheng and Wang, 1999).

[4] Preconsolidation stress is the maximum stress to which a deposit has been subjected, and which it can withstand without undergoing additional permanent deformation.

[5] Stress period is the time length used to change model parameters such as pumping and natural recharge.

5.4. Boundary Conditions

A boundary condition is any external influence or effect that either acts as a source or sink, adding or removing water from the groundwater flow system. The boundary conditions used in the Cadiz groundwater model are no-flow (inactive), wells, evapotranspiration, and natural recharge (see Figure 6). In general, the groundwater flow model boundary conditions can be grouped into three main types: 1) constant head (this type was not used in the Cadiz groundwater model), 2) specified flux (i.e., wells, recharge, and no-flow), and 3) head-dependant with a limiting conductance or rate term (i.e., evapotranspiration).

For the Cadiz groundwater model, the no-flow cells include bedrock in the mountainous areas (i.e., Hackberry, Clipper, Marble, Ship, and Bristol mountains) and unsaturated alluvium in the Fenner Valley. Natural recharge was distributed along the contact of model inactive and active cells as well as portion of the valley floor. Evapotranspiration was simulated at the Bristol and Cadiz dry lakes using the Evapotranspiration Package by specifying the maximum evapotranspiration rate, evapotranspiration surface and extinction depth[6].

5.5. Aquifer Parameters

5.5.1. Lithologic Model in the Fenner Gap Area

A 3-dimensional lithologic model was constructed for the Fenner Gap area by Numeric Solutions, LLC., to identify the physical extents, thickness, and continuity of the lithologic and geologic units encountered (see Figure 7 for the lithologic model boundary). The model was generated utilizing the Schlumberger Petrel 3-Dimensional Geo-Modeling software. Results from lithologic model were used to determine the extent of the model layers and the distribution of hydraulic conductivity. Construction of the 3-dimensional lithologic model included the following steps:

1. Place eight geologic cross-sections constructed by Dr. Miles Kenney (see Appendix B) within 3-dimensional space inside the geo-modeling software (see example below).
2. Digitize the base of model layer 3 for the Fenner Gap area along the nine cross-sections, separating the geology into conceptual model layers. Model layers 1 through 3 include the alluvium.

[6] The maximum rate is used when the water level is at the land surface. No evapotranspiration occurs when the water level is below the extinction depth. In between these two extremes, the evapotranspiration rate is assumed to be linear.

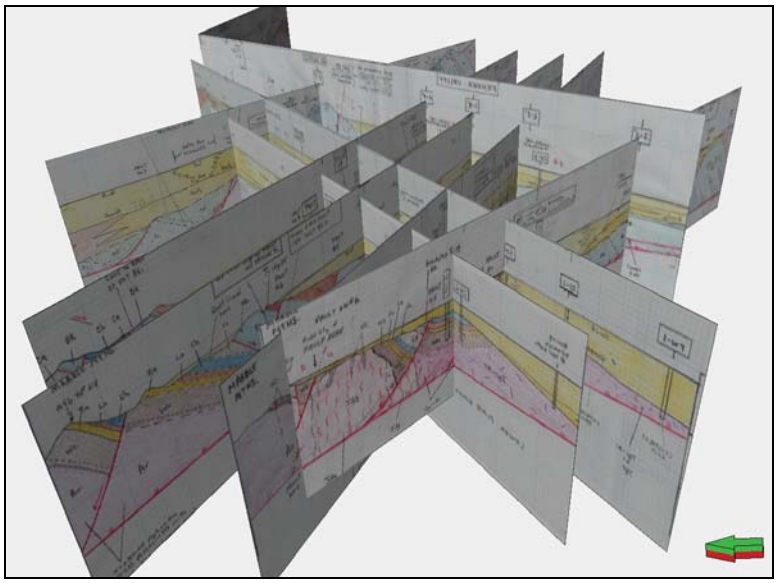
3. Digitize the base of model layer 4. The base of model layer 4 was delineated by incorporating the bottom of the fanglomerate and lower Paleozoic Sequence (see Figures 8a and 8b). Model layer 4 includes fanglomerate, carbonate, the lower Paleozoic Sequence, and weathered and fractured granitic rock.

4. Digitize the base of model layer 5. The base of model layer 5 was delineated as the top of the detachment fault separating the water bearing geology from non-water bearing geology. Model layer 5 consists of carbonate and, weathered, fractured and faulted granitic rocks (see Figures 8a and 8b).

5. Digitize the base of model layer 6 assuming a 200 ft thick layer that simulates the groundwater flow through the detachment fault zone.

6. Interpolate 3-dimensional surfaces for each of the model layers and connect the cross-section layers into 3-dimensional surfaces.

7.



Example of Geologic Cross-Sections in 3-Dimensional Space

The faults separating the geologic units were digitized into the lithologic model in order to determine the percent carbonate distribution. From these fault elements and the knowledge of their type, expected displacement and hierarchy, a 3D fault framework was developed. Once the faults and lithologic framework was constructed, a Cartesian 3D block model was developed. The lithologic model was separated (digitized) into carbonate (i.e., high hydraulic conductivity) and non-carbonate (i.e., low hydraulic conductivity) units. The digitized carbonate units honoring the lithologic model were used to distribute the carbonate, and inversely the non-carbonate, over the 3D grid cell within the 3D block

model. The percent carbonate distribution is estimated by vertically averaging the carbonate and non-carbonate of the 3D block model into groundwater model layers 4 and 5. Results are shown as zones of percent carbonate (see Figures 9 and 10 for model layers 4 and 5, respectively), and were used to assign the hydraulic conductivity values for Cadiz ground water model layers 4 and 5.

5.5.2. Layer Elevations

The Cadiz groundwater model is a six-layer groundwater model, where the land surface elevation (top of model layer 1) was determined from a 10-meter Digital Elevation Model (DEM). The base of alluvium (i.e., base of model layer 3) was delineated based on geophysical studies by Maas (1994), USGS (2006), and NORCAL (1997), drillers lithologic logs in the Fenner Gap area (GEOSCIENCE, 1999), and recent geologic mapping by Kenney (see Appendix B). The total alluvial thickness was further separated into the three uppermost model layers (i.e. model layers 1 through 3). The base of model layer 1 (upper alluvial aquifer) is separated from the model layer 2 by a discontinuous clay-rich sequence. Wells utilized to delineate the boundary of model layers 1 and 2 are shown in the following table:

Well	Elevation [ft amsl]	Elevation Base of Model Layer 1 [ft amsl]	Depth to Base of Model Layer 1
5N/14E-13	898 ft	350 ft	548 ft
22	754 ft	430 ft	324 ft
21N	789 ft	450 ft	339 ft
Chambless Trailer Park	683 ft	360 ft	323 ft
California Salt Company	756 ft	400 ft	356 ft

The base elevation of model layer 2 was arbitrarily limited to 1,200 ft, which is the assumed base of the primary groundwater production zone based on screen intervals of existing wells (GEOSCIENCE, 1999). For areas with alluvial thickness less than 1,200 ft, model layer 3 was assigned a thickness of 10 ft.

The base of model layers 4, 5 and 6 in the Fenner Gap area were delineated based on the results of the 3-dimensional lithologic model discussed in the previous section. For the area outside of Fenner Gap, a 10 ft thickness was assumed for each of the model layers. See Figure 11 for the base elevations and Figure 12 for the thickness of each model layer.

5.5.3. Effective Porosity and Storativity

The unconfined storage coefficient (i.e., effective porosity or specific yield) and confined storage coefficient were estimated initially based on the character of aquifer materials and adjusted during the transient model calibration. An unconfined storage coefficient of 0.15 and a confined storage coefficient of 0.00001 were used for the Cadiz groundwater model based on the results from transient model calibration for the natural recharge of 32,000 acre-ft/yr. The coefficients remain the same for the transient calibration runs with natural recharge of 16,000 acre-ft/yr and 5,000 acre-ft/yr.

5.5.4. Hydraulic Conductivity

Initial hydraulic conductivity values, prior to calibration, were assigned based on hydraulic conductivity values estimated from pumping test data. The initial hydraulic conductivity values for the alluvium in the area of the existing Cadiz wells were estimated to be 3 ft/day to 270 ft/day (see Table 14 in GEOSCIENCE, 1999). Based on the pumping tests conducted for wells TW-1 and TW-2, the hydraulic conductivity values in the Fenner Gap area were estimated by CH2M Hill to be 9 ft/day to 794 ft/day for the alluvium, and 1,139 ft/day to 1,168 ft/day for the carbonates (see Table 2 of Appendix A of Appendix A of this report). Using the same pumping test data, the hydraulic conductivity values in the Fenner Gap area were estimated by GEOSCIENCE to be 37 ft/day to 780 ft/day for the alluvium and 602 ft/day to 1,023 ft/day for the carbonates (see Table 1 of Appendix C). The hydraulic conductivity values for the fractured rock aquifers were estimated to range from 3.9 to 4.2 ft/day by CH2M Hill (see Table 2 of Appendix A of Appendix A) and from 5 ft/day to greater than 40 ft/day by GEOSCIENCE (see Appendix C). The hydraulic conductivity values were then modified within pre-established upper and lower bounds during model calibration in order to match the observed groundwater levels in the model area. The calibrated hydraulic conductivity values for each transient calibration run (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr and 5,000 acre-ft/yr, respectively) are shown in

Figures 13, 14 and 15. The following table summarizes the calibrated hydraulic conductivity used for the Cadiz groundwater model.

Model Layer	Lithology/Location	Hydraulic Conductivity [ft/day]		
		Natural Recharge of 32,000 acre-ft/yr	Natural Recharge of 16,000 acre-ft/yr	Natural Recharge of 5,000 acre-ft/yr
1	Alluvium	0.2 – 543	0.1 – 267	0.02 - 84
2	Alluvium	0.2 – 543	0.1 – 267	0.02 - 84
3	Alluvium	0.7 – 406	0.1 - 200	0.02 - 128
4	Carbonate	500 – 1,500	500 – 1,500	150 – 450
	Fanglomerate, Lower Paleozoic Sequence and Weathered Granitic Rocks in the Fenner Gap Area	60	25	9
	Fanglomerate, Lower Paleozoic Sequence and Weathered Granitic Rocks Outside of Fenner Gap Area	2	1	0.3
5	Carbonate	500 – 1,500	500 – 1,500	150 – 450
	Fanglomerate, Lower Paleozoic Sequence and Weathered Granitic Rocks in the Fenner Gap Area	60	25	9
	Fanglomerate, Lower Paleozoic Sequence and Weathered Granitic Rocks Outside of Fenner Gap Area	2	1	0.3
6	Weathered Granitic Rocks in the Detachment Fault Zone in the Fenner Gap Area	75	50	15
	Weathered Granitic Rocks Outside of Fenner Gap Area	2	1	0.3

As shown in the above table and Figures 13 through 15, in general, the variations of the hydraulic conductivity values used for the same lithology in the model are approximately proportional to the amount of natural recharge. For example, the hydraulic conductivity values in the Fenner Gap are 400 ft/day and 200 ft/day in model layer 1 for natural recharge of 32,000 acre-ft/yr and 16,000 acre-ft/yr, respectively (see Figures 13 and 14)—an approximate ratio of 2 to 1 for both hydraulic conductivity and the amount of natural recharge. The reduction of hydraulic conductivity values with reduced natural recharge is necessary in order to calibrate against the observed water levels. In general, the calibrated hydraulic conductivity values are considered reasonable as compared to the values from the pumping tests and published documents.

5.5.5. Vertical Leakance

Vertical leakance values between model layers were determined based on model calibration. The final calibrated vertical leakance values range from 0.00001 day^{-1} for the alluvium in the existing Cadiz agricultural well area to 1 day^{-1} for the Carbonate in the Fenner Gap area (see Figure 16)

5.5.6. Initial Groundwater Elevations

Initial groundwater level elevations for the steady state model calibration used an arbitrary elevation of 4,000 ft amsl initially and adjusted based on the results from the preliminary steady state model calibration. Groundwater elevations from each final steady state model calibration run (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr and 5,000 acre-ft/yr) were used for initial water levels of the transient model calibration runs (see Figures 17, 18, and 19).

5.5.7. Dispersivity

A longitudinal dispersivity of 200 ft was used for all the predictive model scenarios. The horizontal transverse dispersivity was assumed to be 20 ft, while the vertical transverse dispersivity was assumed to be 2 ft.

5.5.8. Elastic and Inelastic Storage Coefficients

In the Cadiz groundwater model, it was assumed that compaction occurs only in model layers 1 and 2. It was assumed there is little potential for compaction of sediments in layers 3 through 6 as they have been subjected to very large overburden stress due to their greater depth.

The elastic storage coefficient (i.e., elastic compressibility) used in the Cadiz groundwater model was assumed to be 0.00001 based on the lithology. The inelastic storage coefficient (i.e., virgin compressibility) was calculated as the product of the specific inelastic storage coefficient and thickness of the clay in model layers 1 and 2. A specific inelastic storage coefficient of 0.00012 ft^{-1} was assigned based on the value previously used for subsidence evaluation in the Cadiz area (GEOSCIENCE, 1999). Clay layers and their thickness were identified based on the geophysical borehole logs. For the model layer 1, the clay thickness ranges from 3 ft in most of the area to 150 ft beneath Bristol dry lake (see Figure 20). For the model layer 2, the clay thickness ranges from 20 ft in most of the area to 350 ft beneath Bristol dry lake (see Figure 20). The resultant inelastic storage coefficients range from 0.00036 to 0.018 for model layer 1 and 0.0024 to 0.042 for model layer 2 (see Figure 20).

5.5.9. Preconsolidation Stress

In the model, a normally consolidated condition was assumed for the preconsolidation stress. Normally consolidated materials have been only subjected to the cumulative weight of the overburden. Over-consolidated sediments have been either subjected to additional overburden weights (which may have been eroded away), subsequent wetting and drying (i.e., desiccation) of clayey materials, or extreme drawdowns in the past (increasing effective stresses and resulting compactions). By assuming normally consolidated conditions, the worst case was considered.

5.6. Recharge and Discharge

5.6.1. Natural Recharge and Artificial Recharge

Natural recharge and artificial recharge were simulated using the Recharge Package. A long-term average natural recharge of approximately 32,000 acre-ft/yr from the Fenner Watershed and Orange Blossom Wash was used for the Cadiz groundwater model based on results from the watershed model conducted by CH2M Hill using INFIL 3.0 (see Appendix A). Appendix D contains a chronology of estimated natural recharge to the Cadiz project area. Figure 21 shows the areal distribution of the recharge rates. These average long-term rates remain the same through the entire transient model calibration period from 1986 to 2009. This is justified because regional groundwater levels show a fairly steady trend outside of the Cadiz agricultural pumping area. The steady trend in water levels reflects that recharge variation effects are largely dampened as water is transmitted through the bedrock outcrop areas. A test run was made using a varying transient recharge condition. Results show that there is little to no variation in the Fenner Gap and Bristol Valley area.

In order to assess the effects of the amount of natural recharge on the model results, the model was also calibrated to a natural recharge of 16,000 acre-ft/yr and 5,000 acre-ft/yr, respectively. This was done by multiplying the recharge rates used for the 32,000 acre-ft/y by a factor of 0.5 for the natural recharge of 16,000 acre-ft/yr calibration (i.e., 16,000 divided by 32,000). A factor of 0.1563 was used for the natural recharge of 5,000 acre-ft/yr calibration run (i.e., 5,000 divided by 32,000). However, due to the reduction of natural recharge, in order to calibrate against the observed water levels, hydraulic conductivity values and maximum evapotranspiration rates were reduced.

A volume of 1,118 acre-ft was recharged during the pilot infiltration testing conducted during the period from March to September 1999 (GEOSCIENCE, 1999) was also simulated using the Recharge Package.

5.6.2. Groundwater Pumping

Groundwater pumping was simulated using the Well Package in the Cadiz groundwater mode. Cadiz, Inc., currently owns and operates seven full-scale irrigation wells in the Cadiz Valley including Wells 21 South, 21 North, 22, 27 South, 27 North, 28 and 33. Groundwater production data has been compiled for the Cadiz production wells. Where wells are screened in multiple aquifers, a proportion of the total production for the well was apportioned to each aquifer according to the screened interval of the well and the hydraulic conductivity of each aquifer within the screened interval. During the period from 1986 to 2009, the annual total amount of groundwater pumped by Cadiz, Inc. ranged from approximately 1,882 acre-ft in 2009 to 6,689 acre-ft in 1990 with an annual average of 4,602 acre-ft/yr (see Figure 22). In addition, a total of 1,118 acre-ft of groundwater was pumped from Well PW-1 to provide a source of water for the pilot infiltration test conducted during the period between March and September 1999 (GEOSCIENCE, 1999).

Table 1 summarizes the groundwater pumping for each well for each stress period of transient model calibration (i.e., annual pumping for the period 1986 to 1990 and monthly pumping for the period January 1991 through December 2009).

5.6.3. Evapotranspiration

The Evapotranspiration Package was used to simulate the effects of plant transpiration and direct evaporation in removing water from the saturated groundwater regime in the Bristol and Cadiz dry lakes. Data on maximum evapotranspiration rate, evapotranspiration surface, and extinction depth are required for the model. The evapotranspiration surface was determined based on surface elevations for the USGS 15 minute topographic quadrangles (Cadiz, Danby, Bristol Lake and Cadiz Lake). Extinction

depth was assumed to be 15 ft. The maximum evapotranspiration rates for the dry lakes were determined based on the model calibration results. The following table summarizes the evapotranspiration rates used in the model.

Location	Maximum Evapotranspiration Rate [in/year]		
	Natural Recharge of 32,000 acre-ft/yr	Natural Recharge of 16,000 acre-ft/yr	Natural Recharge of 5,000 acre-ft/yr
Bristol Dry Lake	240	120	18
Cadiz Dry Lake	613	307	44

It is important to note that the maximum evapotranspiration rates used were based on model calibration results in order to obtain a more reasonable evapotranspiration from the dry lakes and a better match between the model-calculated and observed water levels. It may exceed the pan evaporation rate of 158 in/yr at the Amboy weather station (US Ecology, 1989). For example, a maximum evapotranspiration rate of 240 in/yr was used for the Bristol dry lake for the calibration run with natural recharge of 32,000 acre-ft/yr. This is due to the fact that groundwater levels were not simulated to the accuracy required to calculate the evapotranspiration across the entire dry lake surface. Results show an average of 19 in/yr over those cells where evapotranspiration is occurring in this run, which is reasonable as an average. For the Cadiz dry lake, the maximum evapotranspiration rate was adjusted by a factor of approximately 2.5 from the maximum evapotranspiration rate of the Bristol dry lake due to the fact that most of the Cadiz Dry Lake area is outside of the model boundary.

6.0 MODEL CALIBRATION AND SENSITIVITY ANALYSIS

6.1. Model Calibration Approach

Model calibration is performed to compare model-simulated groundwater levels to field-measured values. The method of calibration used by the Cadiz groundwater model was the industry standard "history matching" technique, including steady state and a transient calibration. For the steady state calibration, the model was calibrated against water levels measured in 1964. The transient model calibration covers the period from 1986 through 1990 with an annual stress period[7] and from January 1991 through December 2009 with a monthly stress period.

To assist in the trial-and-error adjustment of parameters for "history matching", the software PEST (Parameter ESTimation) (Doherty, 2004) was used to aid in the calibration of the groundwater flow model during the steady state model calibration. PEST is an inverse modeling technique used to estimate groundwater model parameter values, such as hydraulic conductivity, where measurements of groundwater levels and stresses (such as pumping or recharge) are known (i.e., PEST calculates values of hydraulic conductivity that make the groundwater model "calibrate" to the measured values). PEST makes many (often thousands) model simulation runs to find the best set of parameter values that minimizes the residuals (differences) in simulated and observed measurements (e.g., groundwater levels).

In the steady state model calibration process, initial hydraulic conductivity values were input to PEST in the form of ranges of acceptable values for each hydraulic conductivity zone established based on estimated hydraulic conductivity values from pumping tests and aquifer lithology. Through a nonlinear estimation technique, PEST adjusted the values assigned to each of the hydraulic conductivity zones to best fit the model-calculated water levels to the observed heads (reduce residual error) at wells across the model area.

After the initial calibration, regularization, in combination with pilot points (Doherty, 2004), was used to improve the model calibration. Regularization provides smoothing of parameter estimates, so that each model cell is not considered to have a unique independent value and there is a "smooth transition" across the model cells from high to low values. In addition, prior information is used to "tell PEST" the preferred values for each parameter and a range over which PEST may vary parameter values in order to match target values (i.e., measured groundwater levels). Parameter values are estimated by

[7] Stress period is the time length used to change model parameters such as pumping and natural recharge.

PEST at pilot points; then, kriging techniques are employed to spatially interpolate parameter values to all cells in the Cadiz groundwater model. Regularization is used to estimate hydraulic conductivity values of the alluvial aquifer units in the Fenner Gap, Bristol and Cadiz valleys (model layers 1 and 2), and the Fenner valley (model layers 1, 2 and 3), and evapotranspiration rates for Bristol and Cadiz dry lakes. Hydraulic conductivity of underlying aquifer units, including carbonates, fractured bedrock, and detachment fault zone, is held constant during PEST simulations at values determined from the initial model calibration.

Figure 23 shows the distribution of pilot points. A total of 66 pilot points were used in the Cadiz groundwater model. In general, pilot points were spaced relatively uniformly, subject to aquifer geometry, approximately 15,000 to 20,000 feet apart. In the Fenner Gap area, pilot points were spaced more densely, approximately 3,000 to 5,000 feet apart.

Three versions of the model were developed, representing a range of recharge (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr and 5,000 acre-ft/yr[8]). The majority of the PEST regularization runs were carried out using the natural recharge of 16,000 acre-ft/yr. For this run, a maximum hydraulic conductivity of 10 ft/day was imposed in the Bristol dry lake area based on lithology and well pumping rates in the area. A maximum hydraulic conductivity of 25 ft/day was assigned in the vicinity of existing Cadiz agricultural wells based on transient calibration results. In the remaining model domain, the maximum hydraulic conductivity was set to 200 ft/day based on aquifer testing of alluvium. For the steady state calibration runs with natural recharge of 32,000 acre-ft/yr and 5,000 acre-ft/yr, adjustments were made manually (i.e., without PEST) to the hydraulic conductivity until the model calibrated. All the transient model calibration runs also use manual trial-and-error adjustments.

6.2. Steady State Model Calibration

Steady-state calibration was performed using groundwater level measurements collected in 1964 to generate the initial water levels for the transient model calibration. A total of 31 water level measurements from wells (i.e., target wells) were used for the steady state model (see Figure 24). Fifteen of these 31 water level targets were based on the data collected in 1964 (Shafer 1964 and Moyle 1967). Twelve water level targets located in the Fenner Gap area were carried over from the Fenner Gap model (see Appendix A); however, a water level of five feet was added to each water level

[8] Natural recharge of 32,000 acre-ft/yr is based on the results from the INFIL3.0 model (see Appendix A). Natural recharge of 16,000 acre-ft/yr is to account for a 50% variability in the estimate. Natural recharge of 5,000 acre-ft/yr is to represent the Cadiz historical production.

measurement based on transient water level data suggesting an approximately 5 ft decline in heads in the Fenner Gap from predevelopment conditions. Three water level targets in the northern Fenner Valley were developed based on historical water level data outside the model boundary. Additionally, one target located in the north of the Clipper Mountains was estimated based land surface elevation in order to avoid simulated water levels from being above the land surface. The historical water level data were evaluated and anomalous and redundant data were not used.

The model-calculated water levels match very well with observed data for all the calibration runs (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr). The following table summarizes the water level residual (i.e., measured water level minus model-calculated water levels) statistics.

Parameter	Natural Recharge of 32,000 acre-ft/yr	Natural Recharge of 16,000 acre-ft/yr	Natural Recharge of 5,000 acre-ft/yr
Mean Residual	1.4 ft	1.7 ft	0.8 ft
Standard Deviation of Residuals	3.7 ft	3.6 ft	3.6 ft
Relative Error	0.15%	0.15%	0.15%

Relative Error = standard deviation of the residuals divided by the observed head range

The relative error of the water level residuals (i.e., standard deviation of the residuals divided by the observed head range) was calculated to quantitatively evaluate the model calibration. Common modeling practice is to consider a good fit between historical and model predicted data if the relative error is below 10% (Spitz and Moreno, 1996; and Environmental Simulations, Inc., 1999). As seen in the table above, the relative error is 0.15% for each calibration run, well below the recommended relative error of 10%.

A graphical comparison between measured and model-calculated water levels for the steady state calibration is shown on Figure 25, 26 and 27 for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively. In these figures, the closer the water levels fall on the straight line,

the better the match. As shown, there is a very good match between the model-calculated and measured water levels.

Figures 28, 29, and 30 show the spatial distribution of the water level residuals in the 31 wells for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively. As shown, the water level residuals in the Fenner Gap area are very small, indicating a good calibration in the Gap area. The average water level residuals are -0.7 ft (model overestimation), 0.6 ft (model underestimation) and 0.5 ft (model underestimation) for the natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively.

6.3. Transient Model Calibration

The results of the initial steady-state calibration provided initial aquifer parameter estimates and groundwater elevations for the transient flow model calibration. A total of 1,700 groundwater elevation data points, measured in 29 wells during the period from 1986 to 2009 were utilized for the transient calibration. Figure 31 shows the location of these 29 wells (i.e., target wells). Adjustments to horizontal hydraulic conductivity, vertical leakance, and storativity / specific yield were made iteratively until an acceptable match between measured and model-generated groundwater elevations was achieved.

In order to evaluate the accuracy of the model calibration, water levels from each of the three calibration runs are shown as hydrographs at selected target wells (see Figures 32, 33, and 34 for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively). Hydrographs for all 29 target wells are shown in Appendices E, F, and G. In general, the pattern of the model-generated and measured hydrographs is similar in that the model appears to capture the long- and short-term temporal trends for groundwater levels in the model area.

Plots of measured water levels versus model-calculated water levels within orthogonal axes for the 29 target wells were also prepared to show the performance of the match and the ranges of variations (see Figures 35, 36, and 37 for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively). As shown, all of the water levels are clustered around the diagonal line indicating a good match between the observed and model-calculated water levels.

Residual water levels for the 29 target wells during the period from 1986 to 2009 were also plotted as histograms for each calibration run (see Figures 38, 39, and 40 for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively). Water level residuals are calculated by subtracting the model-calculated water levels from the measured water levels. Consequently, a

negative residual represents an overestimation by the model and a positive residual indicates an underestimation by the model. The histograms show a bell shape with most of the water level residuals in the range of +/- 10 ft, indicating a good model calibration. As shown, water level residuals between an overestimated 10 ft and an underestimated 10 ft account for 70%, 77% and 79% of the 1,700 water level measurements for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively.

In order to examine the spatial distribution of water level residuals over time, water level residuals for the target wells in selected years 1994, 1999, 2004, and 2009 were plotted (see Figures 41, 42, and 43 for calibration run with natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively). In general, water level residual distribution is random with most of residuals in the range of +/- 10 ft. These figures show that there are slightly higher residuals in the vicinity of the existing Cadiz agricultural wells. The reason for the higher residuals is likely due to a combination of model resolution (i.e., cell size) and quality of water level data. It is most likely that many of the larger residuals are due to the reported groundwater levels not being true static levels (i.e., not fully recovered from pumping). Additionally, the model-predicted value is averaged over the 500 ft x 500 ft area, whereas the actual water level measurement taken at the well is for a small point within the model cell

In addition, water level residuals over the time period from 1986 to 2009 for all 29 target wells were plotted in Figures 44, 45, and 46 for each calibration run with natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr, respectively. The cumulative departure from mean annual precipitation at Mitchell Caverns was also included on these figures to show climatic cycles during the same period of time. As shown in these figures, the water level residual is randomly distributed over the calibration period and is not particularly correlated with wet or dry periods.

Overall, the model-calculated water levels match very well with observed data for all the transient calibration runs (i.e., natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr, and 5,000 acre-ft/yr). The relative error of the water level residuals is 1.7% for each transient calibration run, which is well below the recommended error of 10%. The following table summarizes the water level residual (i.e., measured water levels minus model-calculated water levels) statistics.

Parameter	Natural Recharge of 32,000 acre-ft/yr	Natural Recharge of 16,000 acre-ft/yr	Natural Recharge of 5,000 acre-ft/yr
Mean Residual	-3.6 ft	-1.5 ft	-0.7 ft
Standard Deviation of Residuals	9.2 ft	9.0 ft	8.9 ft
Relative Error	1.7%	1.7%	1.7%

6.4. Sensitivity Analysis

Model sensitivity to hydraulic conductivity and maximum evapotranspiration rate was partly accomplished by reducing the estimated natural recharge of 32,000 acre-ft/yr to 16,000 acre-ft/yr and 5,000 acre-ft/yr. Each calibration run produces a set of best-estimated hydraulic conductivity values and maximum evapotranspiration rates. In general, a greater amount of natural recharge requires a higher hydraulic conductivity value and maximum evapotranspiration rate.

Additional sensitivity analysis was performed on the transient calibration run with natural recharge of 32,000 acre-ft/yr to assess the parameters that affect the model results. The parameters of specific yield/storativity and vertical leakance were varied by the amounts of plus or minus 50% to assess the relative change in model error. The sensitivity analysis indicates that the model is not sensitive to changes in specific yield/storativity or vertical leakance. A plot of the normalized sensitivities for the selected parameters is summarized on Figure 47.

7.0 MODEL PREDICTIVE SCENARIOS

7.1. Description of Model Scenarios

After the model was calibrated, three model runs were simulated for a period of 100 years with an annual stress period. The predictive model runs include one Project scenario and two sensitivity scenarios. The purpose of the sensitivity scenarios was to evaluate the potential ranges of worst case impacts by: (1) reducing the amount of available natural recharge, and (2) increasing the distances between the wells within the proposed Project wellfield. Two wellfield configurations were used for the sensitivity analysis. Wellfield Configuration A consists of wells clustered around Fenner Gap as shown on Figure 48. Wellfield Configuration B consists of wells spread out southwest from Fenner Gap as shown on Figure 49. Wellfield Configuration B, coupled with lower natural recharge volumes (i.e., natural recharge of 16,000 and 5,000 acre-ft/yr), presents a worst-case scenario in terms of the potential impact to Bristol Dry Lake from Project pumping. Situating the wellfield closer to the Bristol and Cadiz Dry Lakes will result in greater groundwater level drawdown and, as such, will present the greatest risk for potential land subsidence. Additionally, Wellfield Configuration B presents a worst-case scenario for impacts related to migration of saline water from Bristol Dry Lake as the wells are located closer to the saline water/freshwater interface. The model scenarios and the assumptions used for each are provided in the following table. Detailed discussions of each assumption are provided in the following sections.

Model Scenario	Assumptions			
	Natural Recharge	Wellfield Configuration	Average Annual Groundwater Pumping from Years 1 to 50	Average Annual Groundwater Pumping from Years 51 to 100
	[acre-ft/yr]		[acre-ft/yr]	[acre-ft/yr]
Project Scenario	32,000	Clustered around Fenner Gap (Configuration A)	50,000	0
Sensitivity Scenario 1	16,000	Spread Out from Fenner Gap	50,000	0

		(Configuration B)		
Sensitivity Scenario 2	5,000	Spread Out from Fenner Gap (Configuration B)	50,000	0

7.2. Project Pumping

The Project pumping was assumed to be 50,000 acre-ft/yr for a period of 50 years. The projected annual pumping for the 50-year period was determined based on projected annual State Water Project deliveries (referred to as Table A deliveries) water for hydrologic years from 1954 to 2003 (MWD, 2009). This period was considered as a representative hydrologic base period because it covers dry, average and wet year cycles and the average Table A delivery is approximately the long-term average delivery. Hydrologic years 1988 to 1992 represents a dry year cycle. During this period, four of five years have a 75% exceedance probability of Table A deliveries. On the other hand, hydrologic years 1980 to 1984 represent a wet year cycle, when four of five years have a 25% exceedance probability of Table A deliveries.

For years with 75% exceedance probability of Table A deliveries (i.e., dry year cycles), the annual pumping is assumed to be 75,000 acre-ft. For years with 25% exceedance probability of Table A deliveries, the annual pumping is assumed to be 25,000 acre-ft. The annual pumping for the remaining years is 50,000 acre-ft. Figure 50 shows the annual pumping for the Project Scenario. The same annual pumping was used for Sensitivity Scenarios 1 and 2. Project pumping in excess of the natural annual recharge of 32,000 acre-ft is for the purpose of creating and maintaining a groundwater trough in the Project area to ensure that groundwater flowing from Fenner Valley is captured by the wellfield, thus maximizing long-term sustainable yield. Additionally, supplemental storage space is created within the basin allowing for optimization of the conservation and conjunctive use of water.

7.3. Natural Recharge

A natural recharge value of approximately 32,000 acre-ft/yr was generated by CH2M Hill using INFIL 3.0 as the estimated annual recoverable water quantity for the model period 1958-2007 (see Appendix A). In order to assess the effects of natural recharge on the model results, two sensitivity model runs were performed with reduced natural recharge. In the model run for Sensitivity Scenario 1, the natural recharge was reduced to 16,000 acre-ft/yr to account for a 50% variability in the estimate. For

Sensitivity Scenario 2, the natural recharge was reduced to 5,000 acre-ft/yr. This is the approximate historical production by Cadiz.

7.4. Project Extraction Wells

7.4.1. Wellfield Configuration

Two wellfield configurations were used for the model scenarios. Wellfield Configuration A (see Figure 48) includes two new high capacity wells (15,000 acre-ft/yr [13,250 gpm] and 70% operational), 15 new wells (2,250 acre-ft/yr [2,000 gpm] and 70% operational) and five existing Cadiz agricultural wells (also pumping 2,250 acre-ft/yr [2,000 gpm] and 70 % operational). The 15 new wells are clustered closely with the two new high capacity wells in the Fenner Gap area. Wellfield Configuration B (see Figure 49) includes 29 new wells (2,206 acre-ft/yr [2,000 gpm], 68% operational) and five existing Cadiz agricultural wells (also pumping 2,206 acre-ft/yr [2,000 gpm], 68% operational). The 29 new wells are spread out from the Fenner Gap area towards the existing Cadiz agricultural wells. Wellfield Configuration B, located closer to Bristol and Cadiz Dry Lakes, represents a worst case scenario regarding Project impacts on land subsidence in the Bristol Dry Lake and saline water intrusion from the Bristol Dry Lake.

The following table summarizes the assumptions used for the two wellfield configurations:

Wellfield		Wellfield Configuration A	Wellfield Configuration B
Number of Wells	Existing Cadiz Wells	5	5
	Proposed New High Capacity Wells	2	0
	Proposed New Wells	15	29
	Total	22	34
Depth of Production	Existing Cadiz and Proposed New Wells	350 ft – 1,200 ft	200 ft – 1,200 ft
	Proposed New High Capacity Wells	450 ft – 2,100 ft	NA
Total Depth of Well	Existing Cadiz and	700 ft – 1,200 ft	680 ft – 1,200 ft
	Proposed New High Capacity Wells	1,800 ft - 2,100 ft	NA
Wells Penetrate Carbonate Rock		Yes	Yes
Well Capacity	Existing Cadiz and Proposed New Wells	2,000 gpm	2,000 gpm
	Proposed New High Capacity Wells	13,250 gpm	NA
Operation Time to Yield 75,000 acre-ft/yr		8.4 months (70% annually)	8.2 months (68% annually)

7.4.2. Conceptual Drill Site Layout and Wellfield Manifold System

The conceptual drill site layout is shown on Figure 51. The footprint required for drilling operations is an area measuring 15,000 to 20,000 square feet. Several pieces of equipment, taking up approximately 6,000 square feet of space, would be required for drilling a new Project well. Figure 51 also shows the approximate equipment dimensions. However, actual equipment sizes and arrangement may vary depending on the site location and contractor's equipment within the overall footprint shown on Figure 51.

The wells in the Project wellfield will be connected through a wellfield manifold system. A schematic of the wellfield manifold system shown on Figure 52 assumes that all wells will be connected together to a single pumping station positioned to pump water to the Colorado River Aqueduct (CRA). The schematic of the wellfield manifold system shown on Figure 52 will likely be refined based on productivity of the extractions wells as they are installed.

7.4.3. Well Cross-Section

Figure 53 shows a proposed conceptual well cross-section for new Project wells, including the following technical details:

- **Borehole:** 32 in. borehole (50-150 ft) and 28 in. borehole (150-940 ft)
- **Casing:** 36 in. OD x 3/8 in. wall, mild steel conductor casing (+0.5-50 ft), 18 in. ID x 5/16 in. wall copper-bearing steel well casing (+1-400, 900-920 ft)
- **Screen:** 18 in. ID x 5/16 in. wall copper-bearing steel Ful-Flo louvered well screen with 3/32 in. (0.094 in.) openings (400-900 ft)
- **Gravel feed tubes:** two (2), 3 in. sch. 40 mild steel gravel feed tubes (+1-140 ft)
- **Sounding tube:** 2 in. sch. 40 mild steel sounding tube (+1-398 ft)
- **Seal and filter pack:** sand-cement seal (0-130 ft), fine sand layer (130-133 ft), and ¼ in. x 16 custom blend filter pack (133-940 ft)

The actual depths and dimensions of the well casing and screen, and the well materials and filter pack gradation will be identified during the design phase based on the results of borehole lithology, geophysical logs, and anticipated production rate.

7.5. Initial conditions

The model-calculated water levels at the end of transient model calibration (i.e., December 2009, see Figure 54) with natural recharge of 32,000 acre-ft/yr were used as the initial water levels of the Project Scenario. Similarly, model-calculated water levels at the end of transient model calibration runs (i.e., December 2009, see Figures 55 and 56) with natural recharge of 16,000 acre-ft/yr and 5,000 acre-ft/yr were used as the initial water levels of the Sensitivity Scenario 1 and Sensitivity Scenario 2, respectively. The initial TDS concentrations developed based on the historical data (Shafer, 1964; Table 3 of GEOSCIENCE, 1999; and Table 3 of Appendix A of Appendix A of this report) were used as the initial TDS concentrations for all the predictive model scenarios (see Figure 57).

8.0 IMPACT ANALYSIS

8.1. Groundwater Elevations

The model-calculated groundwater elevations at the end of 50 years (i.e., end of Project pumping) and 100 years (i.e., end of model simulation) for each model layer under Project Scenario conditions are shown on Figures 58 and 59, respectively. The model-calculated groundwater levels for Sensitivity Scenario 1 are shown on Figures 60 and 61, and on Figures 62 and 63 for Sensitivity Scenario 2. In general, the lowest water levels (i.e., greatest impact) would occur at the center of the wellfield in the vicinity of Fenner Gap at the end of 50 years as a result of the Project pumping (see Figures 58, 60 and 62). Under Project pumping conditions, groundwater would flow toward the proposed wellfield from Fenner, Bristol and Cadiz valleys. At the end of 100 years, water levels in the wellfield recover and groundwater flow directions would be similar to current conditions (see Figures 59, 61 and 63). Groundwater flow within the Bristol watershed flows toward, and terminates in, Bristol Dry Lake. Groundwater flow within the Cadiz watershed flows toward, and terminates in, Cadiz Dry Lake. Groundwater flow within the Fenner watershed flows from Fenner Valley through Fenner Gap and terminates at Bristol and Cadiz Dry Lakes.

8.2. Drawdown Analysis

8.2.1. Regional Drawdown

When Project pumping begins, water levels within the wells begin to decline and water levels fall below the level in the surrounding aquifer. As a result, groundwater is induced to move from the aquifer to the wells. The movement of water from an aquifer into the wellfield results in the formation of a local cone of depression. The cone of depression would expand outward from the wellfield and can affect areas in the regional scale. The affected areas can be evaluated using the areal decline in water levels (i.e., regional drawdowns). The predicted regional drawdowns at the end of 50 years (i.e., end of Project pumping) and 100 years (i.e., end of model simulation) for each model layer under Project Scenario conditions are shown on Figures 64 and 65, respectively. The regional drawdowns for Sensitivity Scenario 1 are shown on Figures 66 and 67, and on Figures 68 and 69 for Sensitivity Scenario 2. In general, the maximum drawdown would occur at the center of the wellfield in the vicinity of Fenner Gap. As anticipated, the water level in the Bristol and Cadiz Dry Lakes would decline as a result of interception of natural recharge by the Project, consequently reducing or eliminating

groundwater currently lost to evaporation from the surface of the dry lakes. The table on the following page summarizes the predicted drawdown at the wellfield and at Bristol Dry Lake.

Model Scenario	End of 50 Years (End of Project Pumping)		End of 100 Years (End of Model Simulation)	
	Drawdown at Wellfield [ft]	Drawdown at Bristol Dry Lake [ft]	Drawdown at Wellfield [ft]	Drawdown at Bristol Dry Lake [ft]
Project Scenario	70 – 80	10 – 30	0 – 10	10 - 20
Sensitivity Scenario 1	120 – 130	10 – 60	10 – 20	30 – 40
Sensitivity Scenario 2	260 – 270	0 – 80	50 – 60	10 – 70

8.2.2. Drawdown during Dry Year, Wet Year and Average Year Conditions

Drawdowns during a single (1) and multiple (5) dry, wet and average years were analyzed at selected locations. Figure 70 shows the predicted drawdown during the 100 year model simulation period at selected locations, including the center of the wellfield, the existing Cadiz wells, the edge of Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake. Average annual drawdown in a single dry year (i.e., pumping 75,000 acre-ft/yr), wet year (i.e., pumping 25,000 acre-ft/yr) and average year (i.e., pumping 50,000 acre-ft/yr) was calculated at these locations. The following table summarizes the results:

Location	Hydrology	Annual Drawdown [ft]		
		Project	Sensitivity	Sensitivity
Center of Wellfield	Single Dry Year	11.1	13.9	22.1
	Single Wet Year	-9.4	-9.1	-13.1
	Single Average Year	2.5	2.9	6.2
Existing Cadiz Wells	Single Dry Year	4.2	4.3	9.4
	Single Wet Year	-2.1	-0.9	-3.4
	Single Average Year	0.7	1.7	3.2
Edge of Bristol Dry Lake	Single Dry Year	0.8	1.2	1.6
	Single Wet Year	0.4	1.0	1.7
	Single Average Year	0.8	1.3	1.8
Center of Bristol Dry Lake	Single Dry Year	0.6	0.8	0.7
	Single Wet Year	0.6	0.9	0.8
	Single Average Year	0.6	0.9	0.7
Edge of Cadiz Dry Lake	Single Dry Year	0.4	1.0	1.2
	Single Wet Year	0.0	0.8	1.3
	Single Average Year	0.3	1.1	1.5

Note: A negative sign represents a rise of water level.

As shown in the above table, drawdowns in the wellfield, including the center of the wellfield and the area of the existing Cadiz wells, correspond to the hydrologic conditions and amount of natural recharge. The maximum single year drawdown would be 22.1 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2) and dry year conditions (i.e., pumping of 75,000 acre-ft/yr). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), there is very little change in drawdown during the dry, wet and average years.

Drawdown in multiple dry years (hydrologic years 1988 to 1992), multiple wet years (hydrologic years 1980 to 1984) and multiple average years (hydrologic years 1964 to 1968) was also calculated at these locations. The following table summarizes the results:

Location	Hydrology	Drawdown [ft]		
		Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	Multiple Dry Years	24.5	38.0	65.9
	Multiple Wet Years	-17.2	-20.0	-39.4
	Multiple Average	3.8	8.1	25.1
Existing Cadiz Wells	Multiple Dry Years	13.7	17.1	32.4
	Multiple Wet Years	-6.2	-3.2	-7.0
	Multiple Average	4.0	8.2	15.6
Edge of Bristol Dry Lake	Multiple Dry Years	4.3	6.6	8.3
	Multiple Wet Years	0.6	4.3	8.9
	Multiple Average	4.4	6.8	8.8
Center of Bristol Dry Lake	Multiple Dry Years	2.3	4.1	4.8
	Multiple Wet Years	2.6	4.7	4.5
	Multiple Average	4.0	4.7	2.3
Edge of Cadiz Dry Lake	Multiple Dry Years	3.7	7.5	7.7
	Multiple Wet Years	-1.0	3.4	7.5
	Multiple Average	0.6	4.8	5.3

Note: A negative sign represents a rise of water level.

8.3. Depth to Groundwater

Figure 71 shows the predicted depth to groundwater during the 100 year model simulation period at selected locations, including the center of the wellfield, the existing Cadiz wells, at the edge of Bristol Dry Lake, at the center of Bristol Dry Lake, and at the edge of Cadiz Dry Lake. Depth to groundwater at

the end of 50 years (end of Project pumping) and at the end of 100 years (end of model simulation) was calculated at these locations. The following table summarizes the results:

Location	Time	Depth to Groundwater [ft]			
		Existing	Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	End of 50 Years	354	435	486	627
	End of 100 Years		351	371	412
Existing Cadiz Wells	End of 50 Years	156	197	241	315
	End of 100 Years		154	181	219
Edge of Bristol Dry Lake	End of 50 Years	33	68	95	118
	End of 100 Years		42	74	108
Center of Bristol Dry	End of 50 Years	18	50	63	54
	End of 100 Years		33	62	79
Edge of Cadiz Dry Lake	End of 50 Years	7	21	59	72
	End of 100 Years		10	17	68

8.4. Saline Water/Freshwater Interface

The SEAWAT-2000 variable density groundwater flow and solute transport model was used to predict the movement of the saline water/freshwater interface in the vicinity of Bristol and Cadiz Dry Lakes resulting from Project pumping. The location of the current saline water/freshwater interface for this Project is defined by the location of the 1,000 mg/L total dissolved solids (TDS)[9] concentration contour based on recent groundwater quality data from the Cadiz agricultural wells, monitoring wells, and from historical data from other wells in the area (see Figure 72). The locations of the model-predicted saline water/freshwater interface at the end of 50 years and 100 years is shown on Figures 72, 73, and 74 for the Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2, respectively. Results of the modeling indicate the saline water/freshwater interface in the Bristol Dry Lake area would move a maximum distance of approximately 10,400 ft northeast during Project pumping (years 1 to 50) under Project Scenario conditions. The saline water and freshwater interface would move a maximum of approximately 9,700 ft and 6,300 ft during the same period of time under Sensitivity Scenarios 1 and 2, respectively. After Project pumping for all scenarios, the saline water/freshwater interface in the Bristol Dry Lake area continues to move towards the northeast to reach a distance of 11,500 ft, 11,100 ft, and

[9] Saline groundwater is a general term referring to any groundwater containing more than 1,000 mg/L TDS (Todd, 1980).

9,200 ft for the Project Scenario, Sensitivity Scenario 1, and Sensitivity Scenario 2, respectively. The following table summarizes the maximum migration distance of the saline water/freshwater interface:

Model Scenario	Maximum Migration of Saline Water/Freshwater Interface at the End of 50 Years	Maximum Migration of Saline Water/Freshwater Interface at the End of 100 Years
Project Scenario	10,400 ft Northeast	11,500 ft Northeast
Sensitivity Scenario 1	9,700 ft Northeast	11,100 ft Northeast
Sensitivity Scenario 2	6,300 ft Northeast	9,200 ft Northeast

Model-predicted TDS concentrations over time at three selected locations (Locations A, B, and C) along the southern and southwestern boundaries of Cadiz owned land are shown on Figure 75.

8.5. Groundwater in Storage

The overall water budgets for each of the model runs were compiled (see Tables 2, 3 and 4 for the Project Scenario, Sensitivity Scenario 1, and Sensitivity Scenario 2, respectively). The inflow term for the model includes natural recharge and release of water from storage within the interbeds[10], while the outflow terms consist of groundwater pumping, uptake of water into storage within the interbeds, and evapotranspiration. The difference between the total inflow and total outflow is the change in groundwater storage. Figure 76 shows cumulative annual changes in groundwater storage during the 100 year model simulation period for each model scenario. As shown, the cumulative annual change in groundwater storage would reach a maximum of -1,090,000 acre-ft (a negative sign represents a decline in groundwater storage) in year 50 under the Project Scenario conditions. This decline in groundwater storage is approximately 3% to 6% of the total groundwater in storage. The total groundwater in storage was estimated to be 17 to 34 million acre-ft (see Appendix A). The groundwater in storage would begin to recover after the Project pumping stops in year 50. The cumulative annual change in groundwater storage would be approximately -220,000 acre-ft in year 100 under the Project Scenario. According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 117 (i.e., 67 years after Project pumping stopped).

[10] Interbeds represent a poorly permeable bed within a relatively permeable aquifer and consist of highly compressible clay and silt deposits.

The following table summarizes the cumulative annual changes in groundwater storage at the end of 50 years (end of Project pumping) and 100 years (end of model simulation) for each model scenario as volume in units of acre-ft and percent of the total groundwater in storage. The amount of time it will take groundwater storage to recover is also included.

Model Scenario	Cumulative Annual Changes in Groundwater Storage at the End of 50 Years		Cumulative Annual Changes in Groundwater Storage at the End of 100 Years		Time for Groundwater Storage to Recover after Project Pumping Stopped in Year 50
	Volume	% of Total Groundwater Storage	Volume	% of Total Groundwater Storage	
	[acre-ft]	[%]	[acre-ft]	[%]	Years
Project Scenario	-1,090,000	3 to 6	-220,000	1	67 (in Year 117)
Sensitivity Scenario 1	-1,680,000	5 to 10	-870,000	3 to 5	103 (in Year 153)
Sensitivity Scenario 2	-2,160,000	6 to 13	-1,870,000	6 to 11	390 (in Year 440)

Note: A negative sign represents a decline in groundwater storage.

8.6. Potential Land Subsidence

Model-predicted potential land subsidence at the end of 50 years and 100 years is shown on Figures 77, 78, and 79 for the Project Scenario, Sensitivity Scenario 1, and Sensitivity Scenario 2, respectively. In general, the amount of land subsidence corresponds to the magnitude of water level decline and the thickness of the clay layers. A sharp increase in land subsidence from zone "0.75 to 1.0 ft" to zone "2.5 to 3.13 ft" in the Bristol Dry Lake area (see Figure 79 year 100) reflects changes in zone clay thickness from 120 ft to 350 ft (see Figure 20). Model-predicted land subsidence over time at selected locations (including the center of the wellfield, the existing Cadiz wells, at the edge of Bristol Dry Lake, at the center of Bristol Dry Lake, and at the edge of Cadiz Dry Lake) for each model run is shown on Figure 80. As shown, any predicted subsidence would occur gradually over time and be dispersed laterally over a large area from the Fenner Gap to the Bristol and Cadiz Dry Lakes.

The following table summarizes the maximum potential land subsidence at these locations for each model scenario.

Location	Time	Maximum Potential Land Subsidence [ft]		
		Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	End of 50 Years	0.2	0.4	0.7
	End of 100 Years	0.2	0.4	0.7
Existing Cadiz Wells	End of 50 Years	0.6	1.0	1.5
	End of 100 Years	0.6	1.0	1.5
Edge of Bristol Dry Lake	End of 50 Years	0.5	1.0	1.4
	End of 100 Years	0.5	1.0	1.7
Center of Bristol Dry Lake	End of 50 Years	0.9	1.7	1.2
	End of 100 Years	0.9	2.1	2.7
Edge of Cadiz Dry Lake	End of 50 Years	0.1	0.4	0.5
	End of 100 Years	0.1	0.4	0.6

9.0 FINDINGS

The following findings and recommendations are based on the results of the groundwater model and impact analyses:

Groundwater Elevations

- Model-calculated groundwater elevations at the end of 50 years (i.e., end of Project pumping) under Project Scenario and Sensitivity Scenario conditions indicate that the lowest water levels (i.e., greatest potential impact) would occur at the center of the wellfield in the vicinity of Fenner Gap.
- Under Project pumping conditions, groundwater would flow toward the proposed wellfield from Fenner, Bristol and Cadiz valleys.
- At the end of 100 years (i.e., 50 years following cessation of Project pumping), water levels in the wellfield recover and groundwater flow directions would be similar to current conditions (i.e., groundwater flow within the Bristol watershed flows toward, and terminates in, Bristol Dry Lake; groundwater flow within the Cadiz watershed flows toward, and terminates in, Cadiz Dry Lake; groundwater flow within the Fenner watershed flows from Fenner Valley through Fenner Gap and terminates at Bristol and Cadiz Dry Lakes).

Groundwater Level Drawdown

- Predicted regional drawdown at the end of 50 years (i.e., end of Project pumping) under Project Scenario and Sensitivity Scenario conditions indicate that a maximum groundwater level drawdown (i.e., greatest potential impact) of 260 to 270 ft (under natural recharge conditions of 5,000 acre-ft/yr) would occur at the center of the wellfield in the vicinity of Fenner Gap.
- Groundwater levels in the Bristol and Cadiz Dry Lakes would decline as a result of interception of natural recharge by the Project, consequently reducing or eliminating groundwater currently lost to evaporation from the surface of the dry lakes.
- Drawdown within the wellfield, including the center of the wellfield and the area of the existing Cadiz wells, corresponds to hydrologic conditions and amount of natural recharge.

- The maximum single year drawdown would be 22.1 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2) and dry year conditions (i.e., pumping of 75,000 acre-ft/yr). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), there would be very little change in drawdown during single dry, wet and average years.
- Maximum drawdown within the wellfield during multiple dry year conditions (i.e., pumping of 75,000 acre-ft/yr; hydrologic years 1988 to 1992) would be 65.9 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.3 ft.
- Maximum drawdown within the wellfield during multiple wet year conditions (i.e., pumping of 25,000 acre-ft/yr; hydrologic years 1980 to 1984) would be -39.4 ft (groundwater level rise) under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.9 ft.
- Maximum drawdown within the wellfield during multiple average year conditions (i.e., pumping of 50,000 acre-ft/yr; hydrologic years 1964 to 1968) would be 25.1 ft under a natural recharge of 5,000 acre-ft/yr (i.e., Sensitivity Scenario 2). Away from the wellfield (i.e., the Bristol and Cadiz Dry Lakes), the maximum drawdown would be 8.8 ft.

Depth to Groundwater

- Depth to groundwater at the end of 50 years (end of Project pumping under Project Scenario conditions) would range from 197 to 435 ft bgs in the vicinity of the wellfield, 50 to 68 ft bgs at Bristol Dry Lake, and 21 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 50 years (end of Project pumping under Sensitivity Scenario 1 conditions) would range from 241 to 486 ft bgs in the vicinity of the wellfield, 63 to 95 ft bgs at Bristol Dry Lake, and 59 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 50 years (end of Project pumping under Sensitivity Scenario 2 conditions) would range from 315 to 627 ft bgs in the vicinity of the wellfield, 54 to 118 ft bgs at Bristol Dry Lake, and 72 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Project Scenario conditions) would range from 154 to 351 ft bgs in the vicinity of the wellfield, 33 to 42 ft bgs at Bristol Dry Lake, and 10 ft bgs at Cadiz Dry Lake.

- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Sensitivity Scenario 1 conditions) would range from 181 to 371 ft bgs in the vicinity of the wellfield, 62 to 74 ft bgs at Bristol Dry Lake, and 17 ft bgs at Cadiz Dry Lake.
- Depth to groundwater at the end of 100 years (50 years following cessation of Project pumping under Sensitivity Scenario 2 conditions) would range from 219 to 412 ft bgs in the vicinity of the wellfield, 79 to 108 ft bgs at Bristol Dry Lake, and 68 ft bgs at Cadiz Dry Lake.

Saline Water/Freshwater Interface

- The location of the current saline water/freshwater interface for this Project is defined by the location of the 1,000 mg/L TDS concentration contour.
- Results of the modeling indicate the saline water/freshwater interface in the Bristol Dry Lake area would move a maximum distance of approximately 10,400 ft northeast during Project pumping (years 1 to 50) under Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). The saline water/freshwater interface would move a maximum of approximately 9,700 ft and 6,300 ft to the northeast during the same period of time under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr) and Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr), respectively.
- Following Project pumping for all scenarios, the saline water/freshwater interface in the Bristol Dry Lake area continues to move towards the northeast to reach a distance of 11,500 ft, 11,100 ft, and 9,200 ft for the Project Scenario conditions (under natural recharge conditions of 32,000 acre-ft/yr), Sensitivity Scenario 1 (under natural recharge conditions of 16,000 acre-ft/yr), and Sensitivity Scenario 2 (under natural recharge conditions of 5,000 acre-ft/yr), respectively.

Groundwater in Storage

- The cumulative annual change in groundwater storage would reach a maximum of -1,090,000 acre-ft (a negative sign represents a decline in groundwater storage) in year 50 under the Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). This decline in groundwater storage is approximately 3% to 6% of the total groundwater in storage.
- The groundwater in storage would begin to recover following the cessation of Project pumping in year 50. The cumulative annual change in groundwater storage would be

approximately -220,000 acre-ft in year 100 under Project Scenario conditions (i.e., natural recharge of 32,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 117 (i.e., 67 years after Project pumping stopped).

- The cumulative annual change in groundwater storage would reach a maximum of -1,680,000 acre-ft in year 50 under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr). This decline in groundwater storage is approximately 5 to 10% of the total groundwater in storage.
- The cumulative annual change in groundwater storage would be approximately -870,000 acre-ft in year 100 under Sensitivity Scenario 1 conditions (i.e., natural recharge of 16,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 153 (i.e., 103 years after Project pumping stopped).
- The cumulative annual change in groundwater storage would reach a maximum of -2,160,000 acre-ft in year 50 under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr). This decline in groundwater storage is approximately 6 to 13% of the total groundwater in storage.
- The cumulative annual change in groundwater storage would be approximately -1,870,000 acre-ft in year 100 under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr). According to the rate of recovery from years 51 to 100, the groundwater storage would fully recover in year 440 (i.e., 390 years after Project pumping stopped).

Potential Land Subsidence

- In general, the amount of land subsidence corresponds to the magnitude of water level decline and the thickness of the clay layers.
- The maximum model-predicted land subsidence is 2.7 ft at the center of Bristol Dry Lake at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).
- The maximum model-predicted land subsidence ranges from 0.7 to 1.5 ft in the vicinity of the Cadiz wellfield at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).

- The maximum model-predicted land subsidence is 0.6 ft at the edge of Cadiz Dry Lake at the end of 100 years (i.e., 50 years following cessation of Project pumping) under Sensitivity Scenario 2 conditions (i.e., natural recharge of 5,000 acre-ft/yr).
- Predicted subsidence would occur gradually over time and be dispersed laterally over a large area from Fenner Gap to the Bristol and Cadiz Dry Lakes.

Consideration of the Cadiz Groundwater Modeling and Impact Analysis report will be incorporated into the Groundwater Management Plan.

10.0 MODEL LIMITATIONS AND UNCERTAINTY

The Cadiz groundwater model is a useful tool for evaluating water levels, water quality and potential land subsidence of the aquifer systems, as the model calibration exceeds industry standards. In addition, the confidence in using the predictive model runs is increased through the reasonable results from the Project Scenario and Sensitivity Scenarios. However, it should be noted that the model is a simplified approximation of a complex geohydrologic system. The accuracy of model predictions is dependent on the simplifying assumptions used due to limited hydrogeologic data. As an example, the potential land subsidence was based on an assumed specific inelastic storage coefficient from another groundwater basin due to there being no available site-specific data. Installation of extensometers to monitor the aquifer systems responding to the water level changes can significantly enhance the capability to predict land subsidence. It is anticipated that the Cadiz groundwater model will be updated when additional hydrogeologic data become available.

11.0 REFERENCES

Bassett, A.M. and Kupfer, D.H., 1964. *A Geologic Reconnaissance in the Southeastern Mojave Desert, California*. California Division of Mines and Geology Special Report, 83.

Bassett, A.M., Kupfer, D.H. and Barstow, F.C., 1959. *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*. US Geological Survey Bulletin 1045-D. pp. 97-138.

California Division of Mines and Geology (CDMG), 1964. *Geologic Map of California: Needles Sheet*.

CH2M Hill, 2010. *Cadiz Groundwater Conservation and Storage Project*. Prepared for Cadiz, Inc., July, 2010.

Dibblee, T.W., 1980b. *Cenozoic Rock Units of the Mojave Desert*: in D.L. Fife and A.R. Brown (eds.) *Geology and Mineral Wealth of the California Desert*. South Coast Geological Society, Santa Ana, CA.

Doherty, J., 2004. *PEST Model-Independent Parameter Estimation User Manual*. 5th Edition. Watermark Numerical Computing. P336.

Environmental Simulations, Inc., 1999. *Groundwater Vistas*, version 2.1.

Freiwald, D.A., 1984. *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*: US Geological Survey Water Resources Investigation Report 83-4082.

GEOSCIENCE Support Services, Inc., 2009. *Draft Detailed Technical Specifications for Drilling, Construction, Development, and Testing of Carbonate Test Well, Cadiz, California*, Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) September 21, 2009.

GEOSCIENCE Support Services, Inc., 1999. *Cadiz Groundwater Storage and Dry-Year Supply Program*, Report 1163. Prepared for Metropolitan Water District of Southern California, November 1999.

Handford, C.R., 1982. *Sedimentology and Evaporite Genesis in a Holocene Continental Sabkha Playa Basin - Bristol Dry Lake, California*. Sedimentology, Volume 29.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000. *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process.* U.S. Geological Survey. Open-File Report 00-92.

Hoffman, J., Leake, S.A, Galloway, D.L. and Wilson, A.M., 2003. *MODFLOW-2000 Ground-Water Model – User Guide to the Subsidence and Aquifer-System Compaction (SUB) Package*.

Jachens, R.C., and Howard, K.A., 1992. *Bristol Lake Basin – A Deep Sedimentary Basin Along the Bristol-Danby Trough, Mojave Desert. Old Routes to the Colorado*. San Bernardino County Museums Special Publication 92-2. Redlands, CA. pp 57·59.

Kenney, M., 2011. *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California.* Draft report in preparation.

Koehler, J.H., 1983. *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base Baghdag Area*. USGS Water Resources Investigations Report 83·4053. California.

Langevin, C.D., Thorne, D.T., Dausman, A.M., Sukop and M.C., Guo, W., 2008. *SEAWAT Version 4: A Computer Program for Simulation Multi-Species Solute and Heat Transport*.

Maas, J., 1994. *Depth to Basement Calculated from Gravity Data*: Prepared for Cadiz Land Company, Inc.

Metropolitan Water District of Southern California (MWD), 2009. *Table of State Project Deliveries for the Period 1922 to 2003*.

Moyle, W.R., 1967. *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity; San Bernardino and Riverside Counties, California*: Bulletin 91-14. California Department of Water Resources (DWR), prepared for the United States Geological Survey.

NORCAL Geophysical Consultants, Inc., 1997. *Seismic Reflection Survey Cadiz Valley, Cadiz, California*. Proprietary report to Cadiz Inc.

Rosen, M.R., 1989. *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*. Ph.D. Dissertation, University of Texas, Austin, Texas. pp 266.

Shafer, R.A., 1964. *Report on Investigations of Conditions which Determines the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, California*: Unpublished Report, Engineering Department, Southern California Edison Company, 172 p., 12 plates.

Silver, L.T., McKinney, 1963, *U-Pb Isotopic Age Studies of a Precambrian Granite, Marble Mountains, San Bernardino County, California*; (abs): Geological Society of America Special Paper 73, p.65.

Spitz, K., and Moreno, J., 1996. *A Practical Guide to Groundwater and Solute Transport Modeling*. Wiley-Interscience. April 1996.

Thompson, D.G., 1929. *The Mojave Desert Region, California*: U.S. Geological Survey Water Supply Paper, 578, 795p.

Todd, David K., 1980. *Groundwater Hydrology, Second Edition*. New York: John Wiley & Sons, 1980.

US Ecology, Inc., 1989. *California Low-Level Radioactive Waste Disposal Facility License Application, Section 2200 - Meteorology and Climatology*.

U.S. Geological Survey (USGS), 2006. *Geology and Mineral Resources of the East Mojave National Scenic Area, San Bernardino County, California*. U.S. Geological Survey Bulletin 2160.

Wernicke, Brian, 1992. *Cenozoic extensional tectonics of the U.S. Cordillera: in Burchfiel, B.C.*, P.W. Lipman, and M.L. Zoback, eds., The Cordilleran Orogen: Conterminous U.S., The Geology of North America, G-3: Geological Society of America, Boulder, Colorado, p. 553-582.

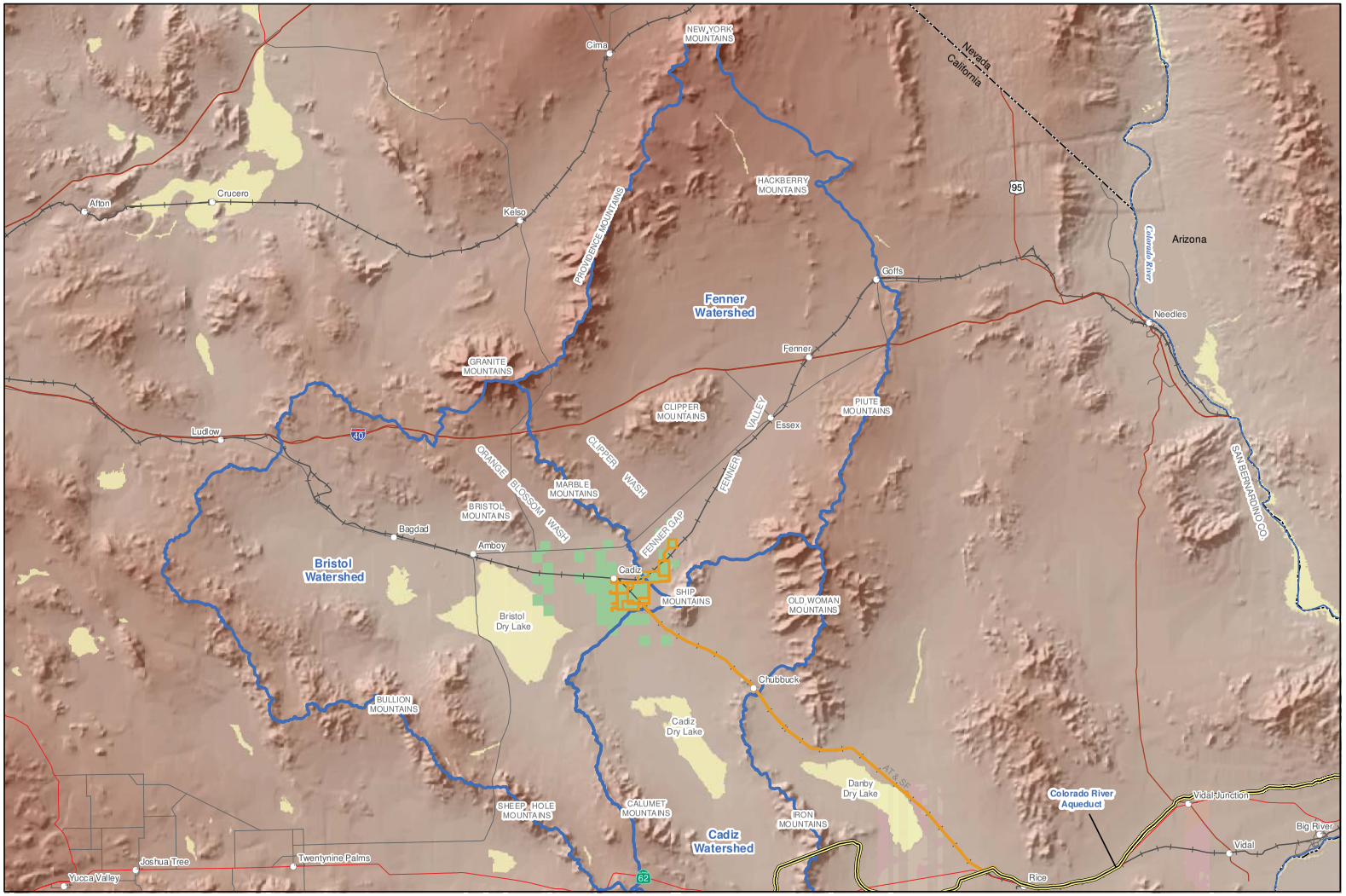
Zheng, Chunmiao, and Wang, P. Patrick, 1999. *"MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide.* Prepared for U.S. Army Engineer Research and Development Center, Vicksburg, MS.

FIGURES

BROWNSTEIN HYATT FARBER SCHRECK, LLP

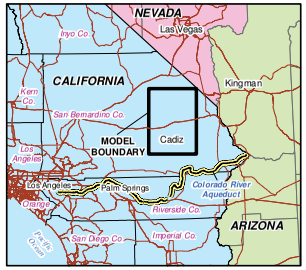
CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS

GENERAL PROJECT LOCATION



EXPLANATION

- Selected Watershed Boundaries
- Wellfield Development Areas and Pipelines
- Cadiz Owned Land
- Railroad
- State Boundary
- Colorado River Aqueduct



1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

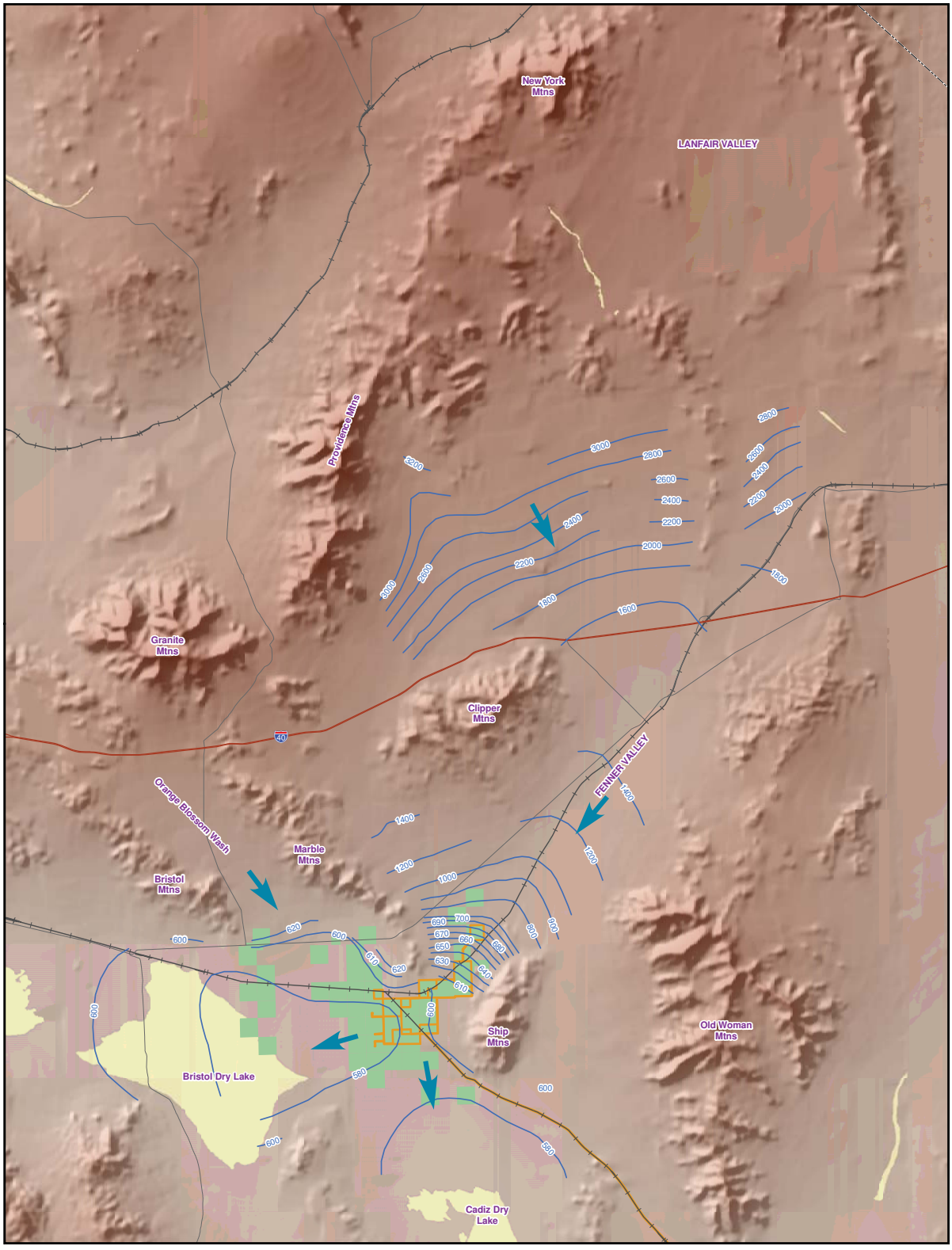
0 10 20 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 1

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_1_proj_loc_9-11.mxd



Wellfield Development Areas and Pipelines

Cadiz Owned Land

580 2009 Groundwater Elevations (ft amsl) (Source: CH2M-Hill, 2010)

Groundwater Flow Direction

2009 GROUNDWATER ELEVATIONS

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

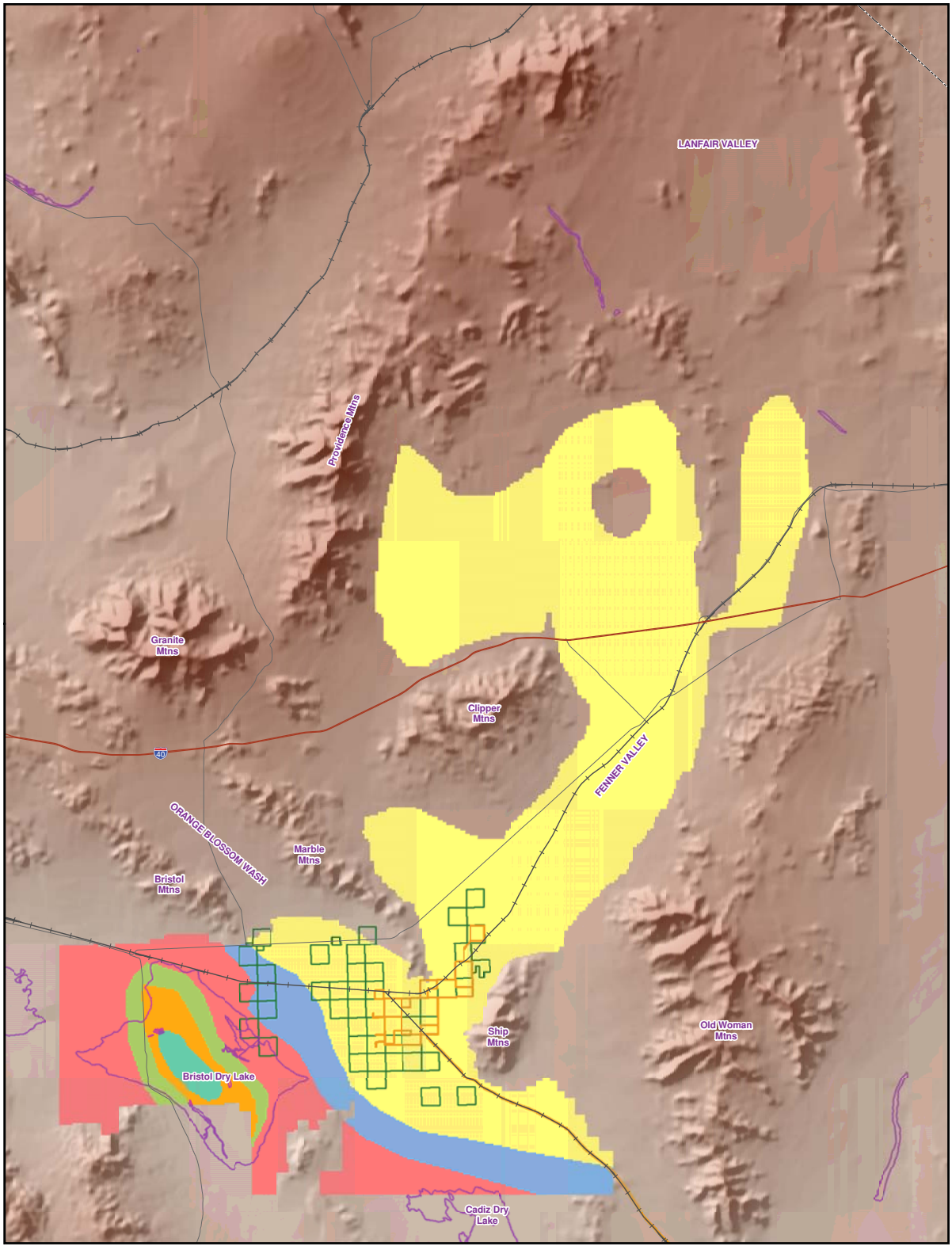
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 2

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_2_GW_elevs_2009_9-11.mxd



Wellfield Development Areas and Pipelines

Cadiz Owned Land

TDS Concentration (mg/L)

- <500
- 500 to 10,000
- 10,000 to 50,000
- 50,000 to 100,000
- 100,000 to 150,000
- 150,000 to 200,000

TOTAL DISSOLVED SOLIDS CONCENTRATIONS

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

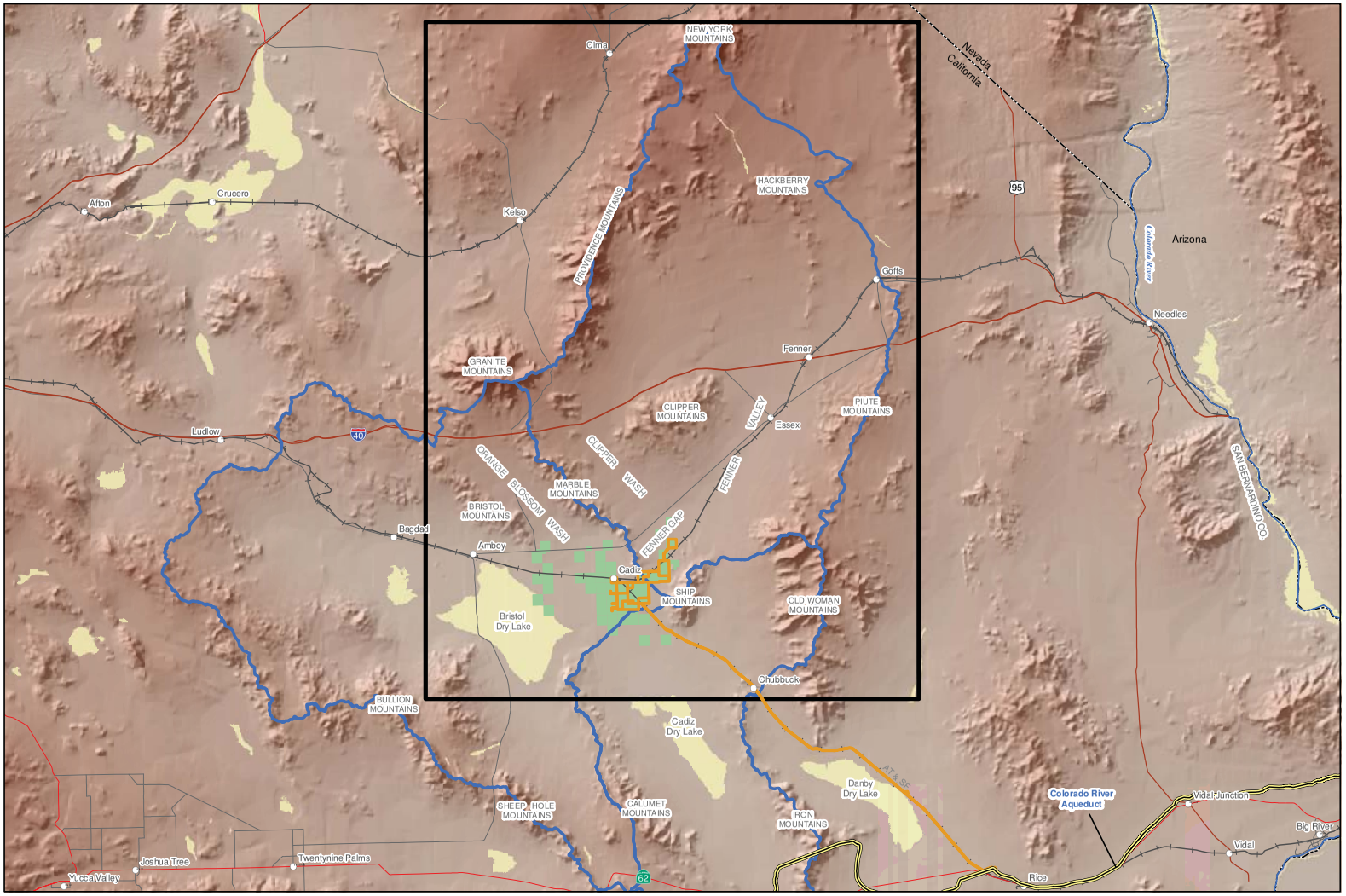
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 3

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_3_TDS_9-11.mxd



CADIZ GROUNDWATER MODEL BOUNDARY

EXPLANATION

- Groundwater Model Boundary Cell Size is 500ft x 500ft
- Selected Watershed Boundaries
- Wellfield Development Areas and Pipelines
- Cadiz Owned Land
- Railroad
- State Boundary

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

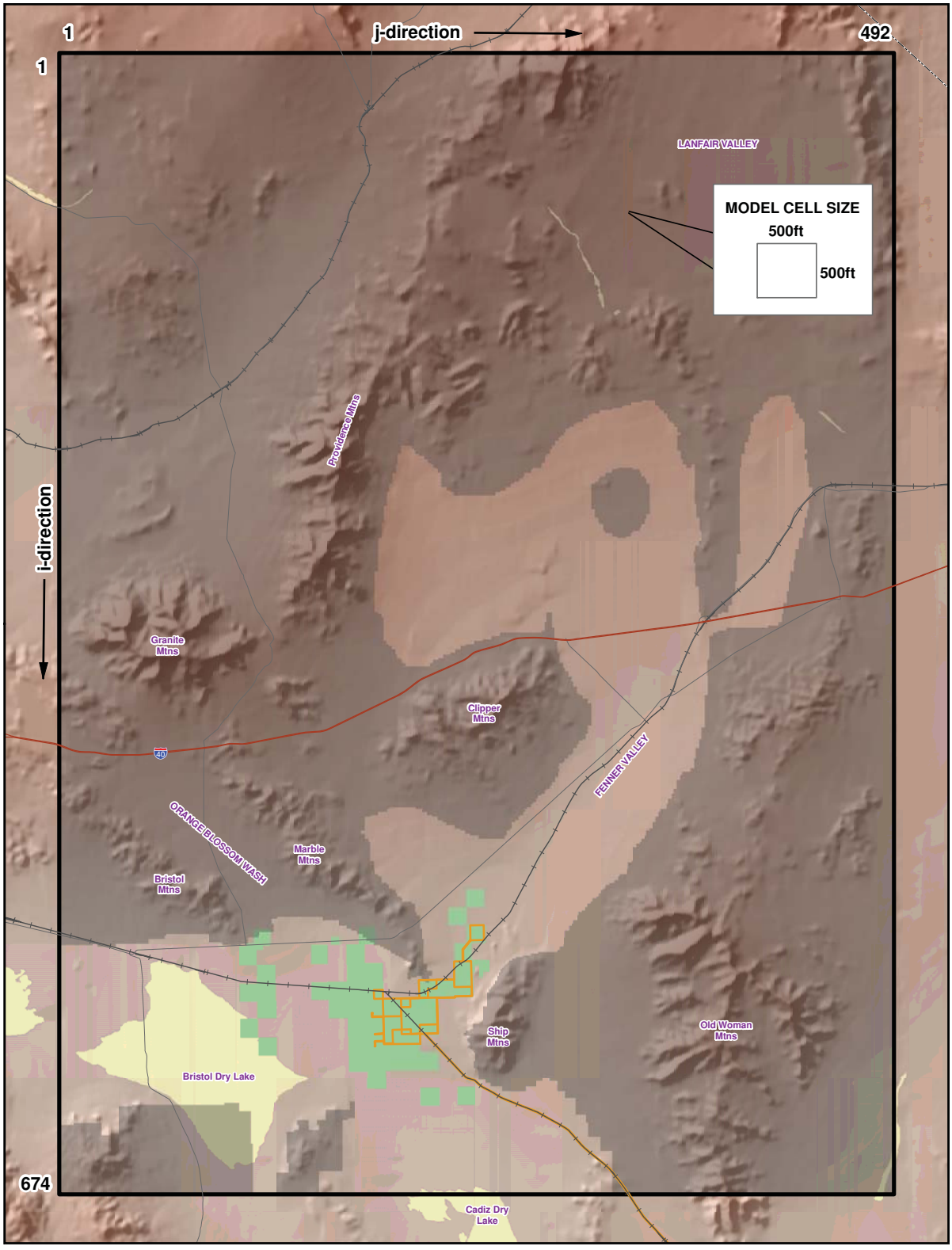
0 10 20 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 4

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_4_model_bndy_9-11.mxd



Groundwater Model Boundary
Cell Size = 500 ft x 500 ft

Wellfield Development Areas and Pipelines

No Flow Model Cell

Cadiz Owned Land

CADIZ GROUNDWATER MODEL GRID

NORTH

0 2.5 5 Miles

1-Sep-11

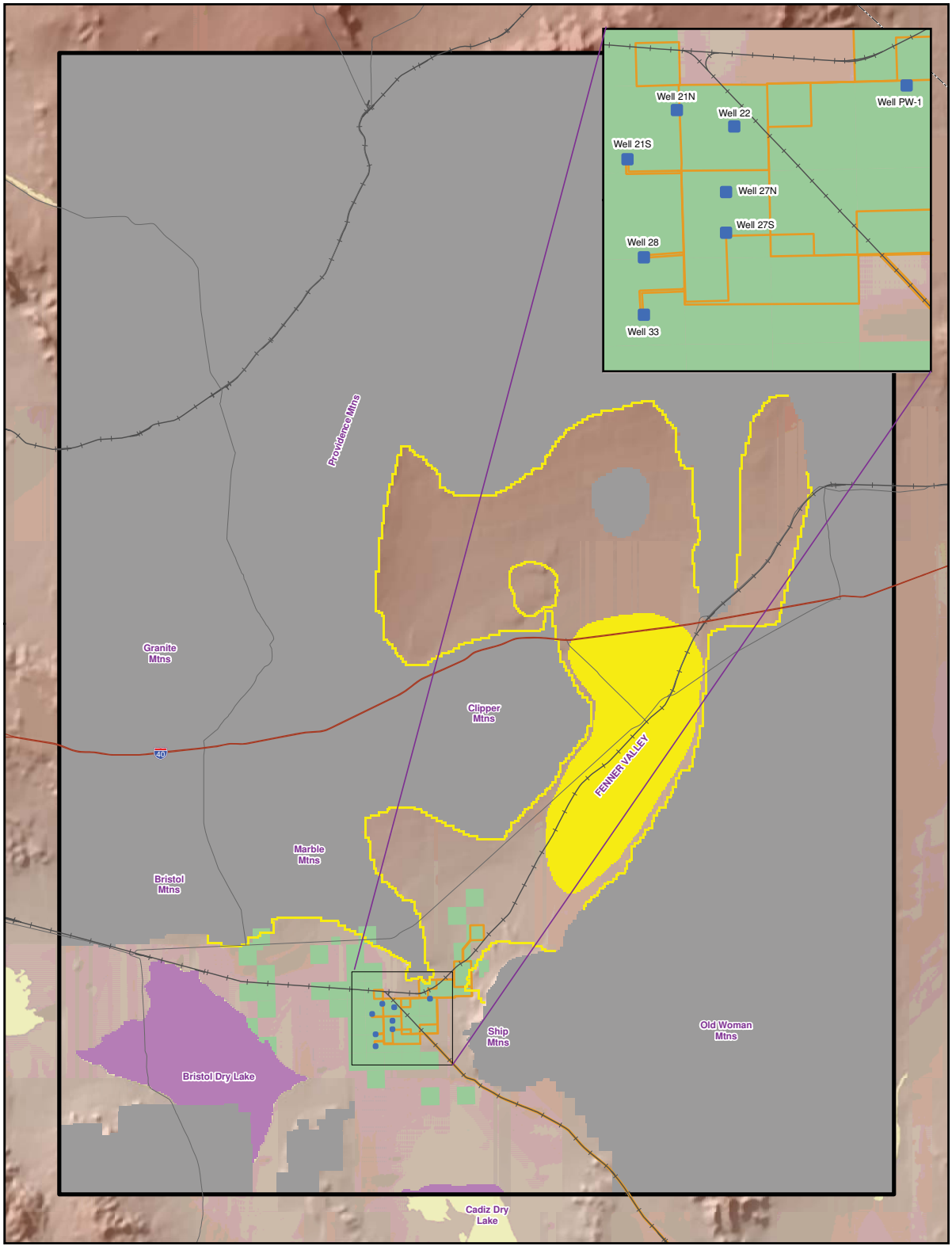
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 5

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_5_model_grid_9-11.mxd



Groundwater Model Boundary

Wellfield Development Areas and Pipelines

Cadiz Owned Land

Model Boundary Conditions

No Flow Model Cell

Well Package (See inset above for detailed view)

Evapotranspiration Package

Recharge Package

BOUNDARY CONDITIONS OF THE CADIZ GROUNDWATER MODEL

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

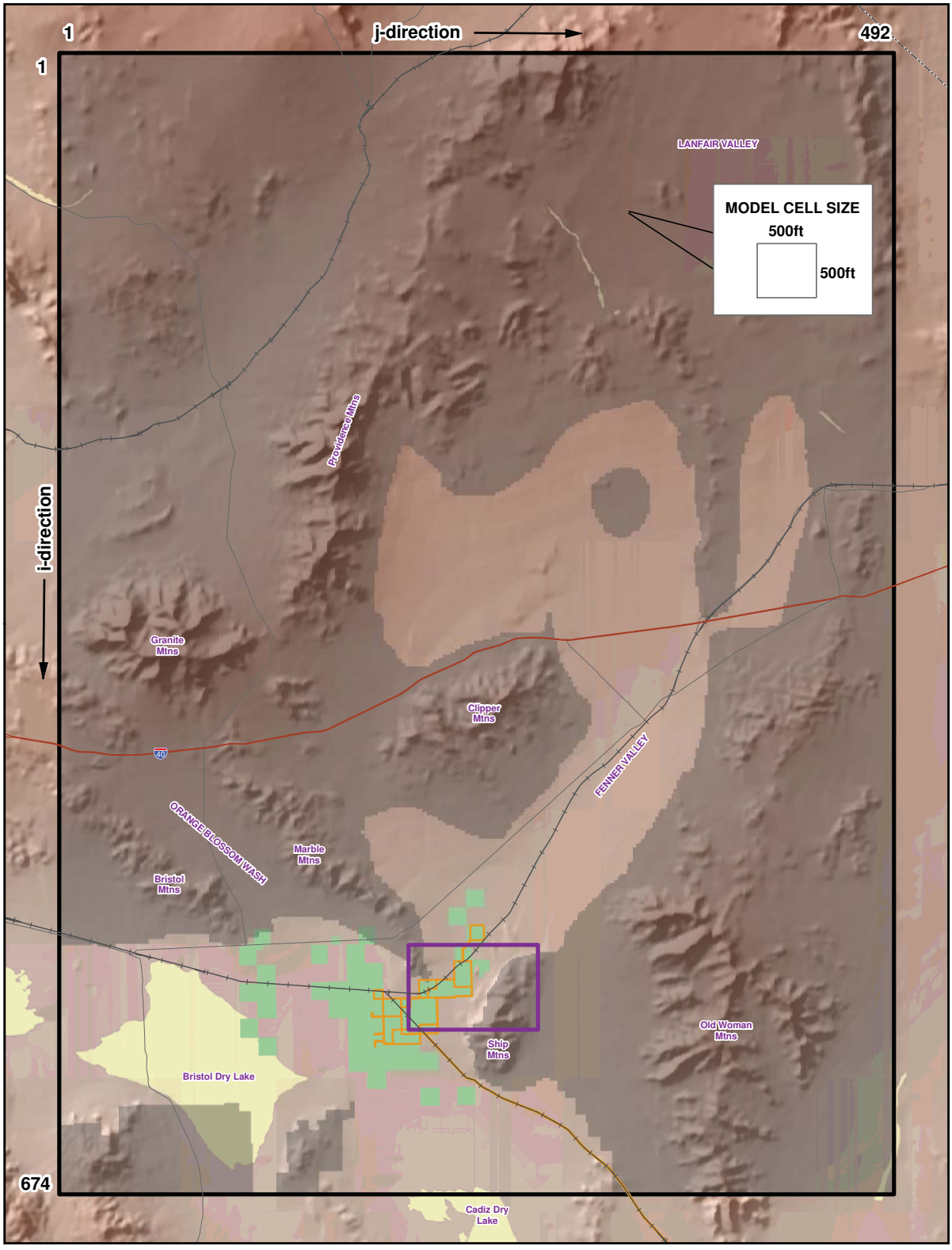
0 2.5 5 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 6

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_6_bndy_cond_9-11.mxd



Groundwater Model Boundary
Cell Size = 500 ft x 500 ft

Wellfield Development Areas and Pipelines

Lithologic Model Boundary

No Flow Model Cell

Cadiz Owned Land

FENNER GAP LITHOLOGIC MODEL BOUNDARY

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

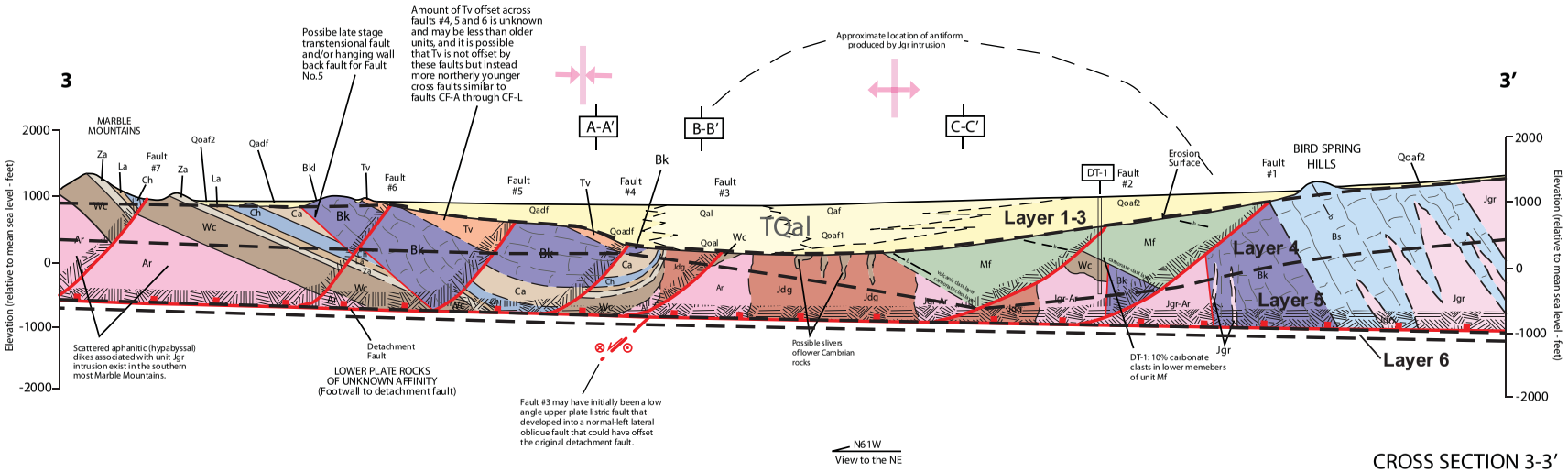
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

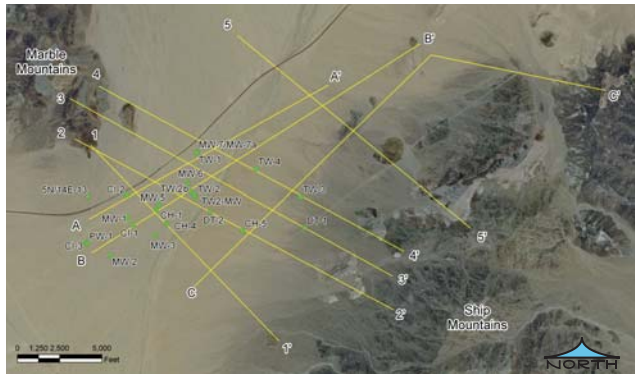
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 7

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_7_lith_model_bndy_9-11.mxd



CROSS SECTION 3-3'
FENNER GAP



See Figure 8b for Stratigraphic Legend

GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.geoswater.com

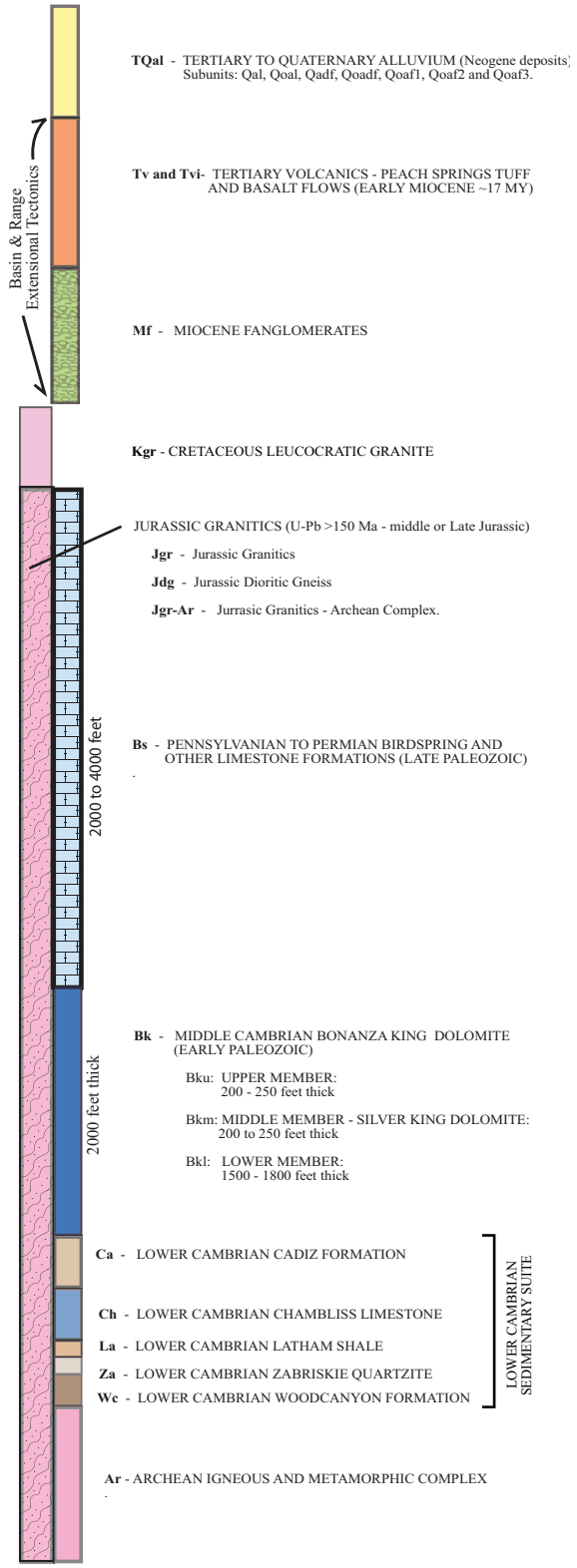
BROWNSTEIN HYATT FARBER SCHRECK, LLP

LITHOLOGIC MODEL RESULTS
CROSS SECTION 3-3'

Drawn: LB
Checked:
Approved:
Date: 1-SEP-2011

Figure 8a

STRATIGRAPHIC SECTION



TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits)
Subunits: Qal, Qoal, Qadf, Qoadf, Qoaf1, Qoaf2 and Qoaf3.

Tv and Tvi- TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)

Mf - MIOCENE FANGLOMERATES

Kgr - CRETACEOUS LEUCOCRATIC GRANITE

JURASSIC GRANITICS (U-Pb >150 Ma - middle or Late Jurassic)

Jgr - Jurassic Granitics

Jdg - Jurassic Dioritic Gneiss

Jgr-Ar - Jurrasic Granitics - Archean Complex.

Bs - PENNSYLVANIAN TO PERMIAN BIRDSPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)

Bk - MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)

Bku: UPPER MEMBER:
200 - 250 feet thick

Bkm: MIDDLE MEMBER - SILVER KING DOLOMITE:
200 to 250 feet thick

Bkl: LOWER MEMBER:
1500 - 1800 feet thick

Ca - LOWER CAMBRIAN CADIZ FORMATION

Ch - LOWER CAMBRIAN CHAMBLISS LIMESTONE

La - LOWER CAMBRIAN LATHAM SHALE

Za - LOWER CAMBRIAN ZABRISKIE QUARTZITE

Wc - LOWER CAMBRIAN WOODCANYON FORMATION

Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX

See Figure 8a for Lithologic Cross Section

GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909)451-6650 Fax: (909)451-6638
www.gssiwater.com

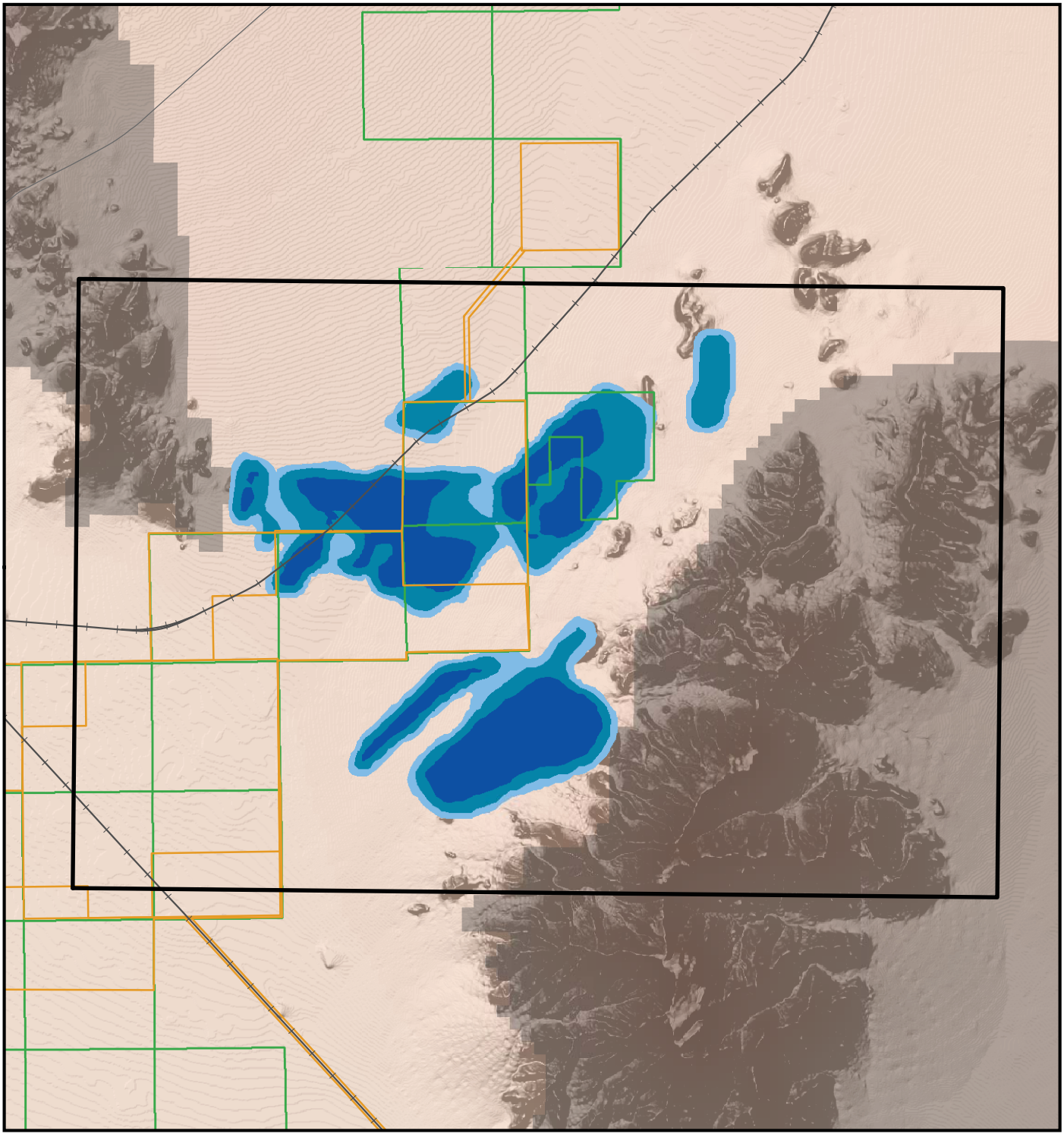
Drawn:
Checked:
Approved:
Date: 1-SEP-11

BROWNSTEIN HYATT FARBER SCHRECK, LLP

LITHOLOGIC MODEL RESULTS
CROSS SECTION 3-3' LEGEND

Figure
8b

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\79) 1_Sep_11_Modeling_Report\Figures\Lith_model_figures\Fig_8b_lith_xsec_legend_3-3_9-11.ai



GIS_proj\brownstein_cadiz_model_analysis_9-11\0_Fig_9_8x11_L4_carbonate_9-11.mxd

Lithologic Model Boundary

No Flow Groundwater Model Cell

Cadiz Owned Land

Wellfield Development Areas and Pipelines

Percent Carbonate Distribution

- <10%
- 10 to 30%
- 30 to 70%
- 70 to 100%

NORTH

0 1,500 3,000 6,000

Feet

ZONES OF PERCENT CARBONATE DISTRIBUTION FOR CADIZ GROUNDWATER MODEL LAYER 4

1-Sep-11

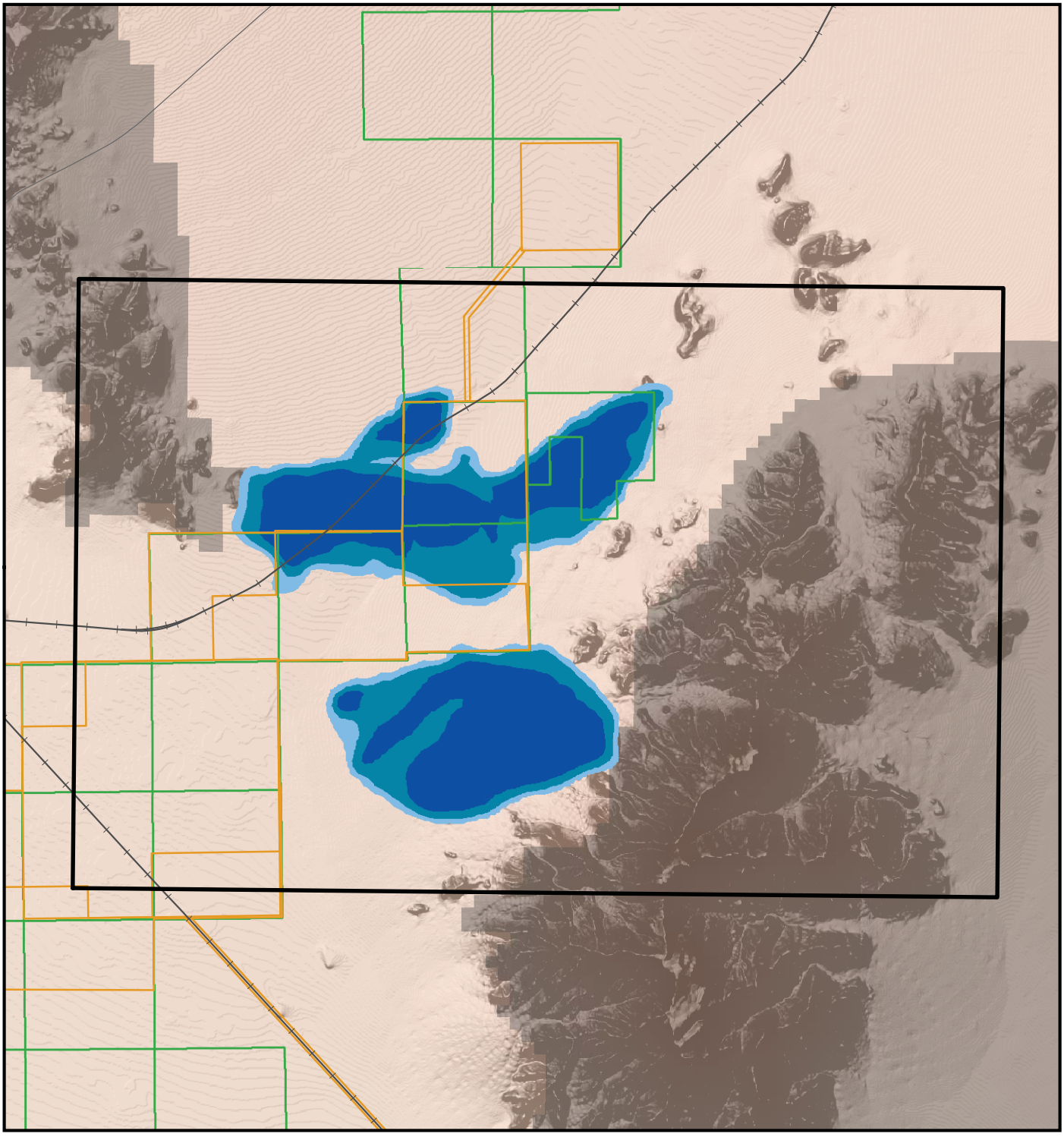
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

©2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 9



GIS_proj\brownstein_cadiz_model_analysis_9-11\0_Fig_10_8x11_L4_carbonate_FINAL_9-11.mxd

Lithologic Model Boundary

No Flow Groundwater Model Cell

Cadiz Owned Land

Wellfield Development Areas and Pipelines

Percent Carbonate Distribution

- <10%
- 10 to 30%
- 30 to 70%
- 70 to 100%

NORTH

0 1,500 3,000 6,000

Feet

ZONES OF PERCENT CARBONATE DISTRIBUTION FOR CADIZ GROUNDWATER MODEL LAYER 5

1-Sep-11

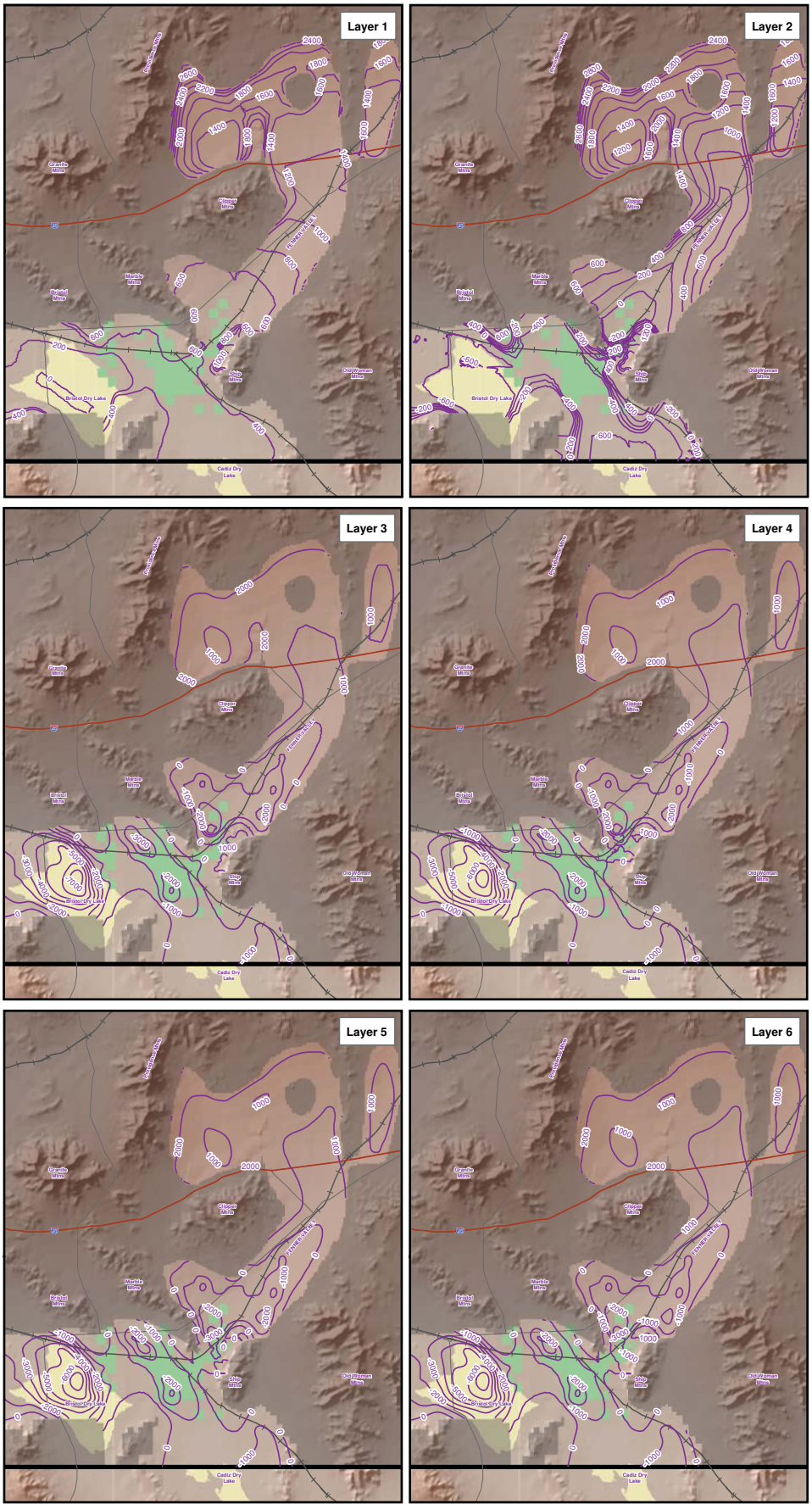
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

©2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 10



EXPLANATION

800 — Bottom Layer Elevation (ft amsl)

Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

BOTTOM LAYER ELEVATIONS OF THE CADIZ GROUNDWATER MODEL

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

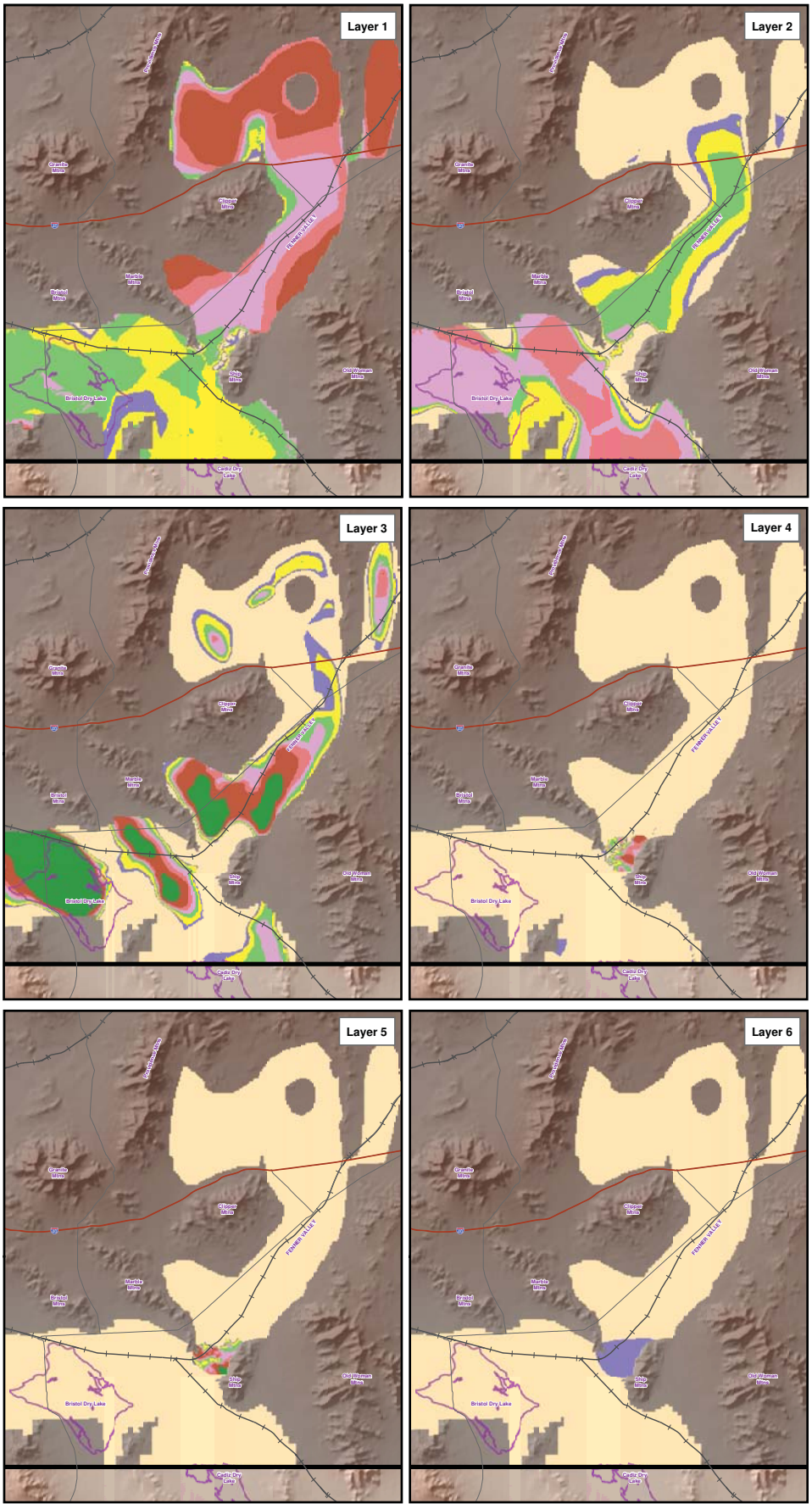
0 5.5 11 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 11

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_11_6panel_bot_layer_elev_9-11.mxd



LAYER THICKNESS OF THE CADIZ GROUNDWATER MODEL

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

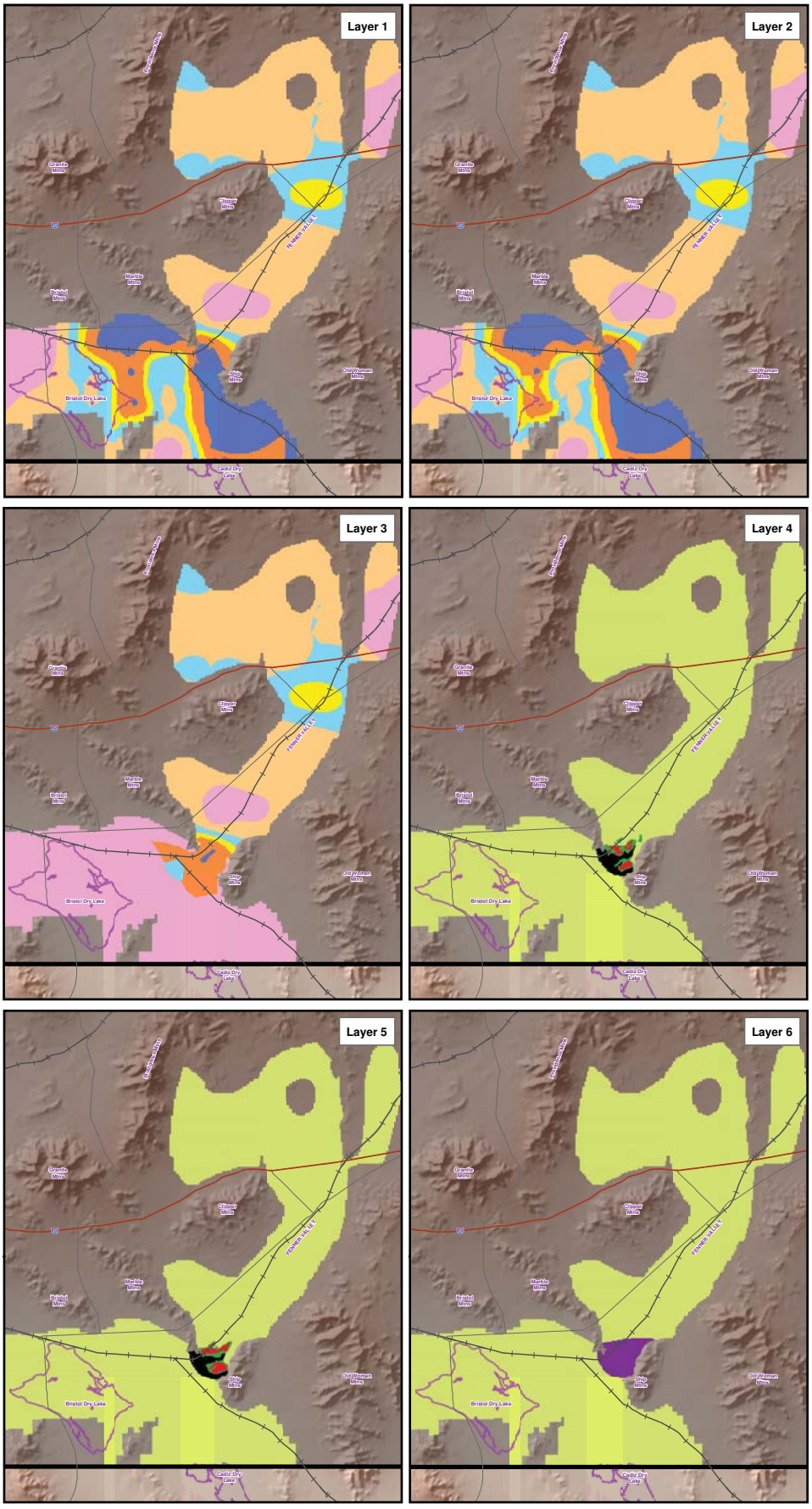
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 12

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_12_6panel_layer_thickness_9-11.mxd



EXPLANATION

Hydraulic Conductivity (ft/day)

LAYERS 1-3

- <5
- 5 - 20
- 20 - 50
- 50 - 100
- 100 - 300
- 300 - 543

LAYERS 4-6

- 2
- 60
- 75
- 500
- 1500

- Groundwater Model Boundary
- No Flow Model Cell

HYDRAULIC CONDUCTIVITY OF THE CADIZ GROUNDWATER MODEL NATURAL RECHARGE OF 32,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 13

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_13_6panel_hy_cond_32k_9-11.mxd

HYDRAULIC CONDUCTIVITY OF THE CADIZ GROUNDWATER MODEL NATURAL RECHARGE OF 16,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

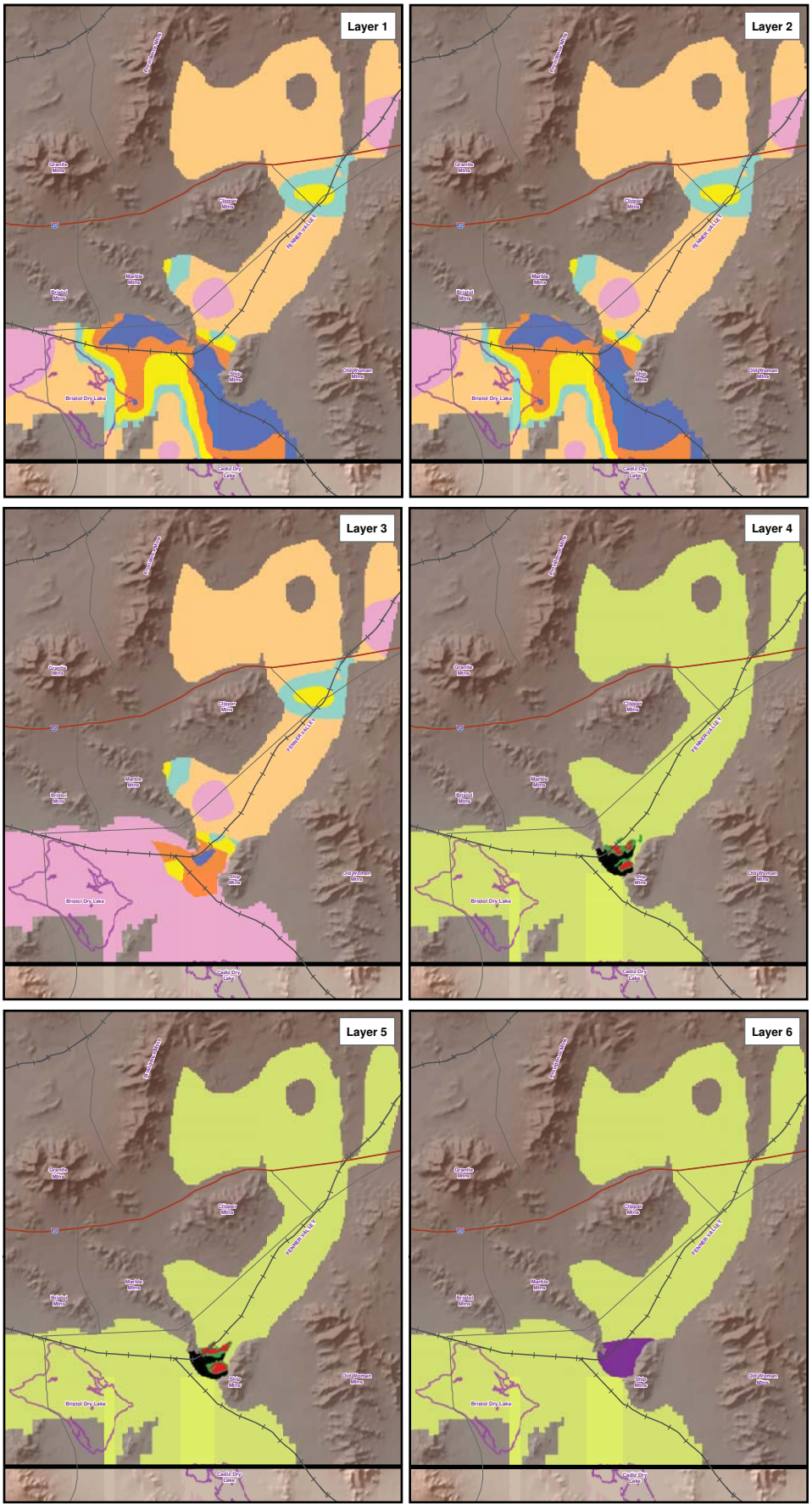
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 14

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_14_6panel_hy_cond_16k_9-11.mxd



HYDRAULIC CONDUCTIVITY OF THE CADIZ GROUNDWATER MODEL NATURAL RECHARGE OF 5,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

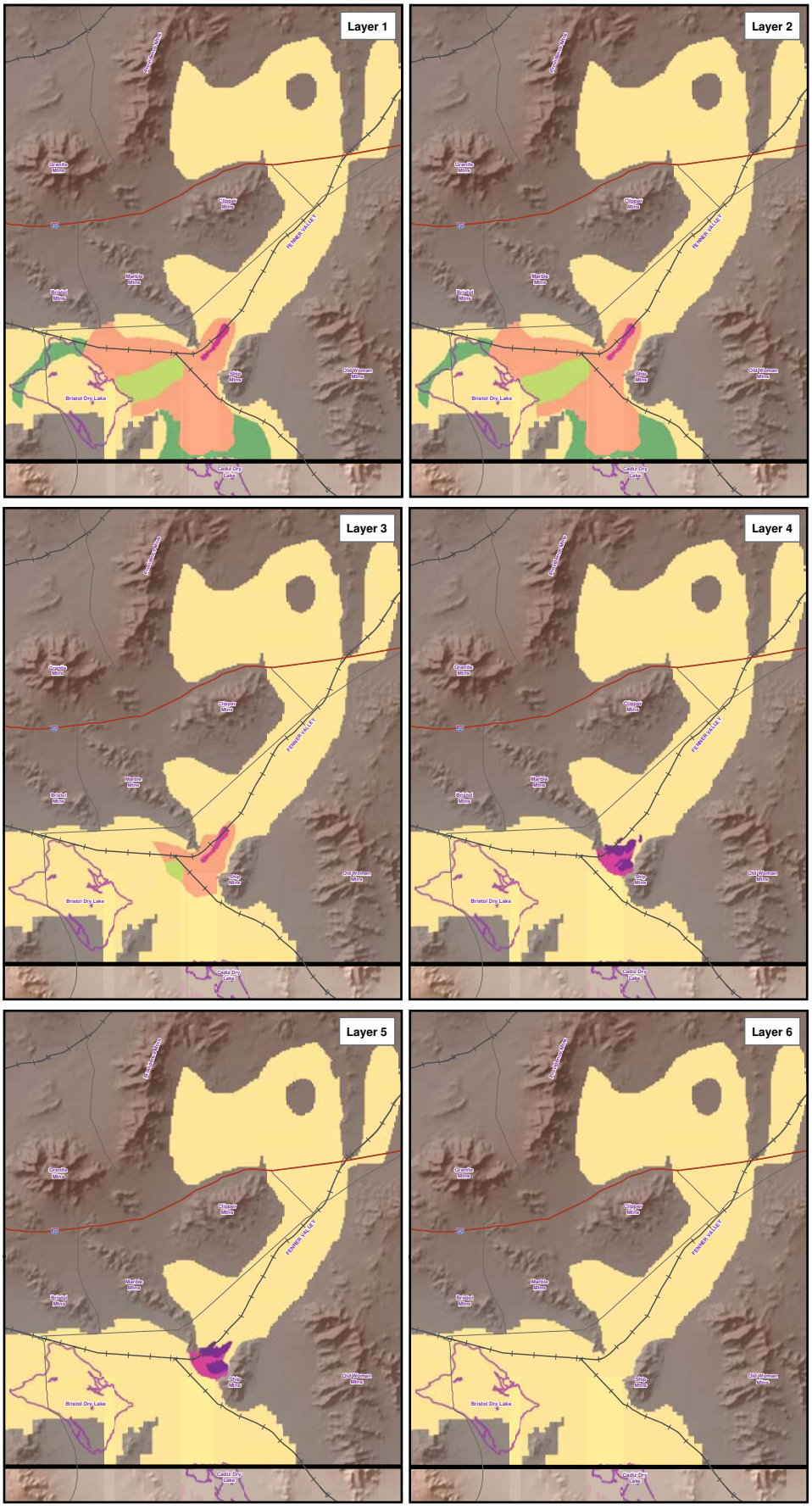
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 15

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_15_6panel_hy_cond_5k_9-11.mxd



EXPLANATION

Vertical Leakance (day $^{-1}$)

- 0.00001
- 0.001
- 0.01
- 0.1
- 0.5
- 1

Groundwater Model Boundary

No Flow Model Cell

VERTICAL LEAKANCE OF THE CADIZ GROUNDWATER MODEL

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

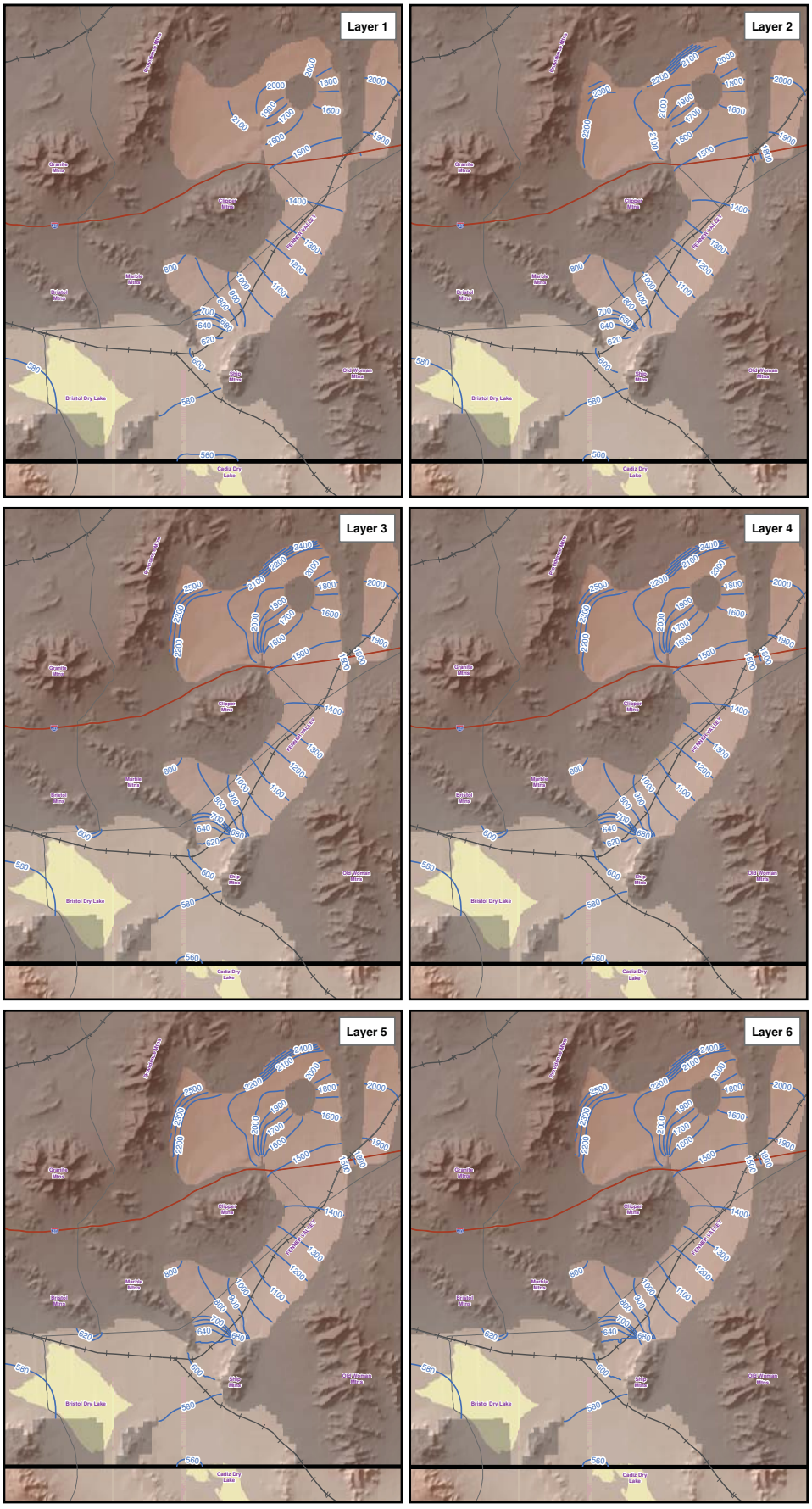
0 5.5 11 Miles

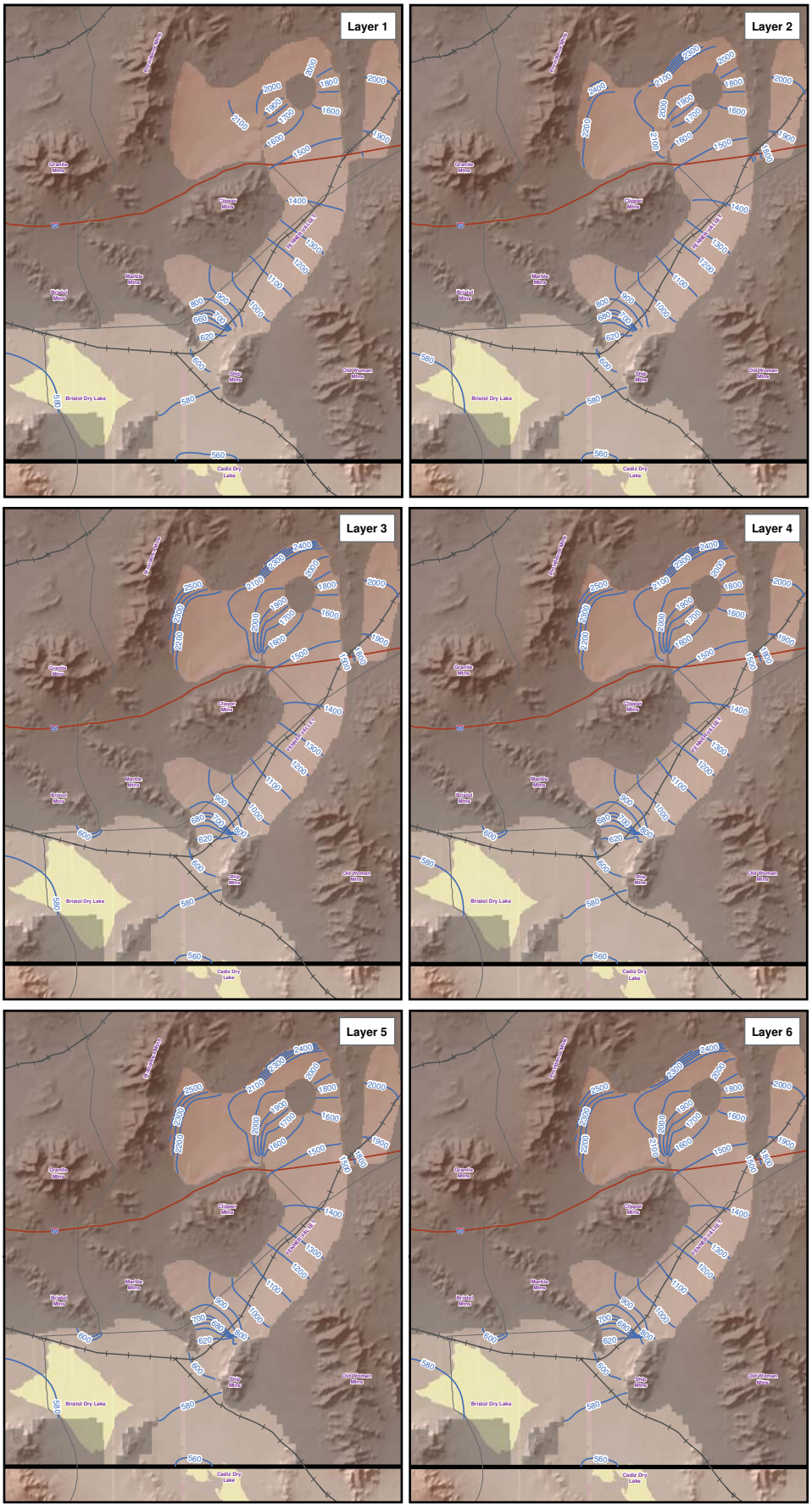
GEOSCIENCE

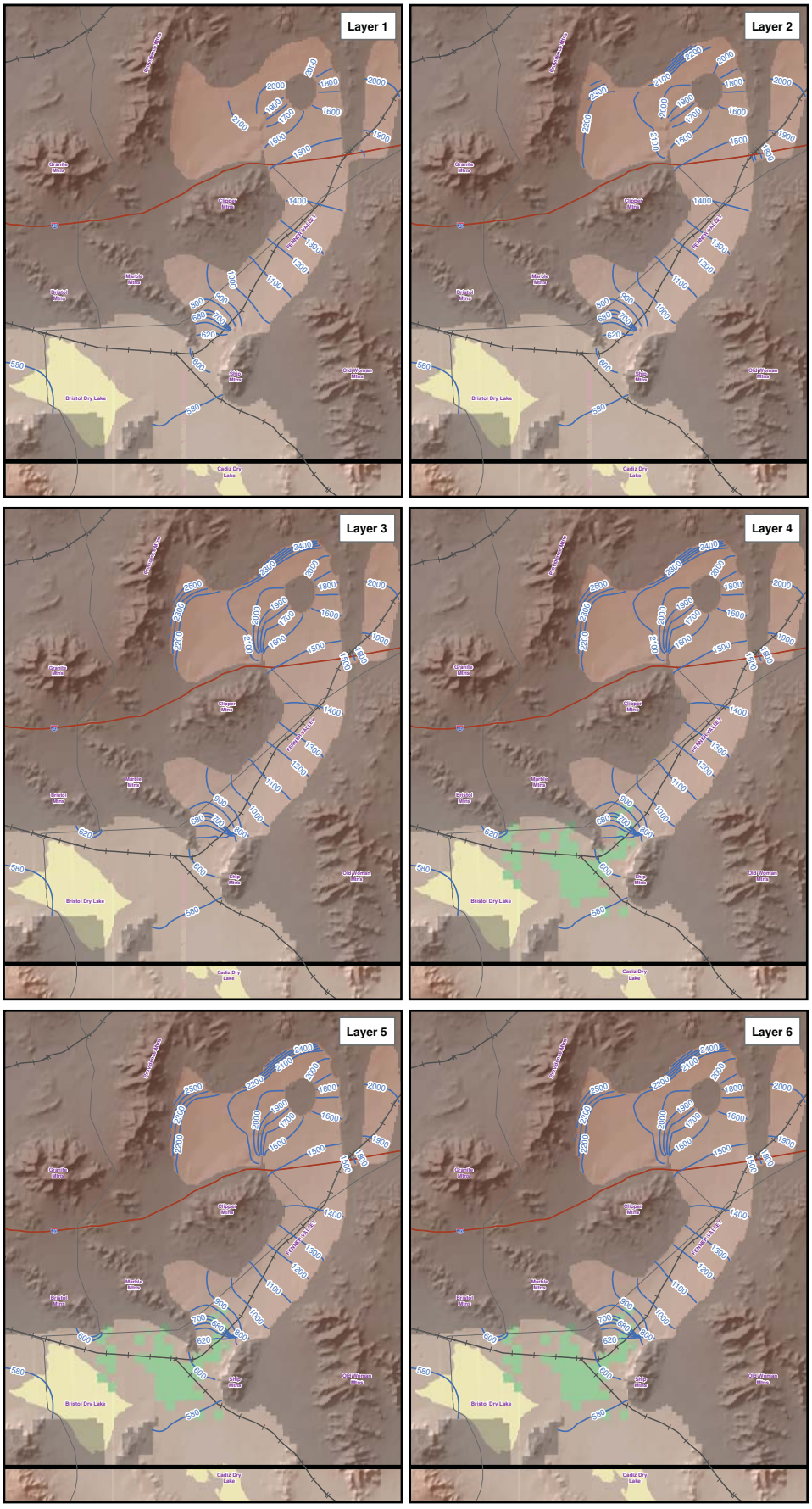
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 16

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_16_6panel_vert_leakance_9-11.mxd


Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
Bristol Dry Lake
Cadiz Dry Lake
Granite Mtns
Chiriaco Mtns
Marble Mtns
Rabbit Mtns
Old Woman Mtns
Iron Mtns
Ship Mtns
Turtle Mtns
Danby Lake
Piute Valley
Fenner Valley
Cadiz Valley
Ward Valley
Chemehuevi Valley
Lanfair Valley
Twentynine Palms
Joshua Tree
Yucca Valley
Landers
Amboy
Essex
Needles
Parker
Blythe
Desert Center
Chiriaco Summit
Vidal
Rice
Earp
Ehrenberg
Wenden
Quartzsite
Salton Sea
Lake Havasu
Colorado River
Mojave River
Twentynine Palms Highway
Amboy Road
Kelbaker Road
Cadiz Road
Rice Road
Vidal Junction
Parker Dam Road
Interstate 10
Interstate 40
Interstate 15
Interstate 95
Interstate 5
Interstate 8
Interstate 210
Interstate 215
Interstate 405
Interstate 605
Interstate 710
Interstate 105
Interstate 110
Interstate 710
Interstate 405
Interstate 605


Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
Bristol Dry Lake
Cadiz Dry Lake
Granite Mtns
Old Woman Mtns
Marble Mtns
Rabbit Mtns
Sheep Mtns
Ship Mtns
Ft Piute-Cadiz
Ft Piute-Essex
Cadiz-Amboy
Cadiz-Danby
Cadiz-Fenner
Cadiz-Valley Wells
Cadiz-Vontrigger
Cadiz-Water Supply
Cadiz-Water Supply
Cadiz-Water Supply



EXPLANATION

700 — Initial Groundwater Elevation (ft amsl)

Groundwater Model Boundary

No Flow Model Cell

INITIAL GROUNDWATER ELEVATIONS FOR TRANSIENT MODEL CALIBRATION NATURAL RECHARGE OF 5,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

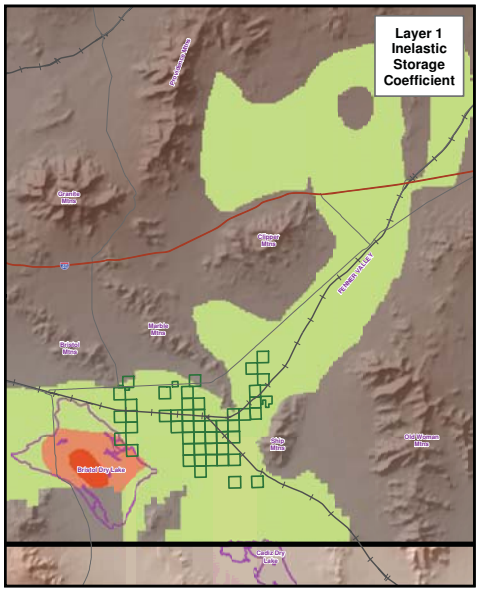
0 5.5 11 Miles

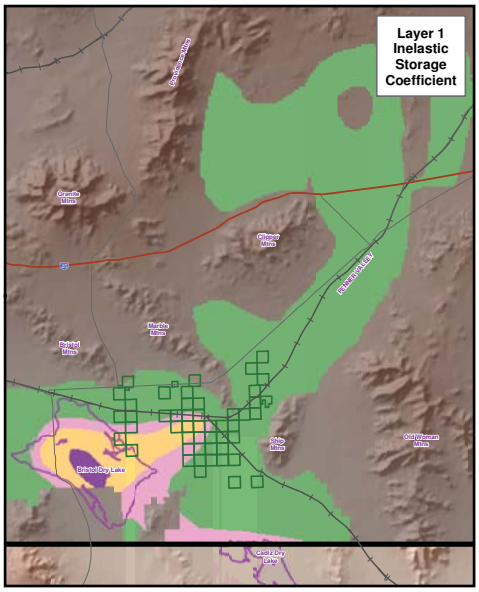
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 19

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_19_6panel_init_gw_elev_5k_9-11.mxd





EXPLANATION

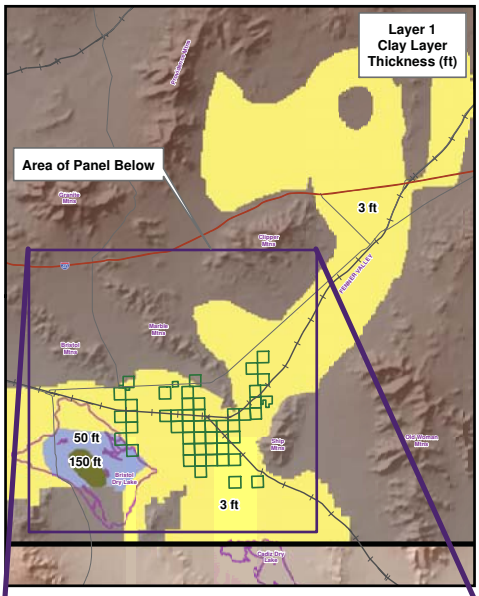
Inelastic Storage Coefficient

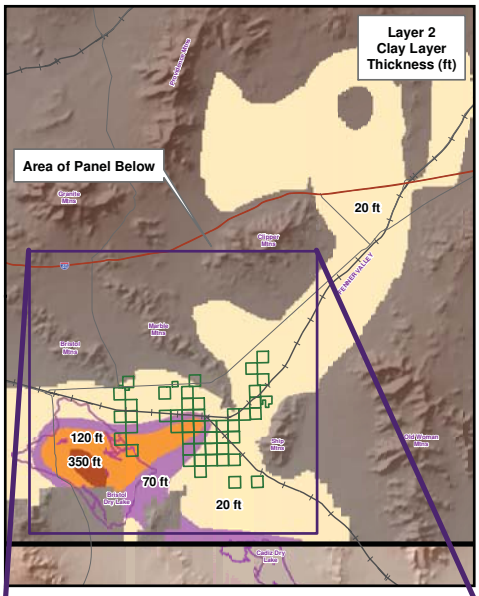
- 0.00036
- 0.00144
- 0.0024
- 0.006
- 0.0084
- 0.018
- 0.042

Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land





EXPLANATION

Clay Layer Thickness (ft)

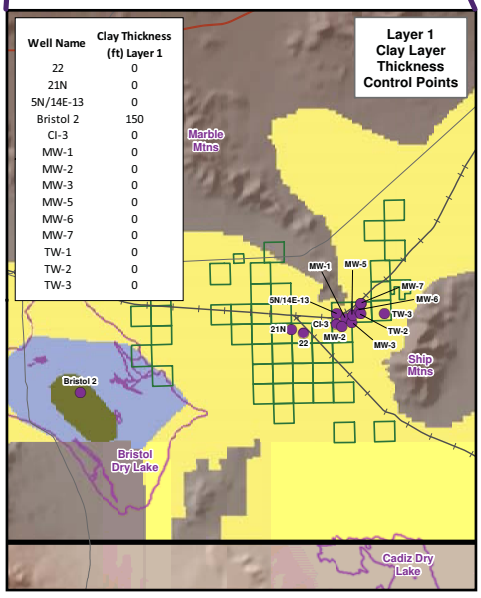
- 3 ft
- 20 ft
- 50 ft
- 70 ft
- 120 ft
- 150 ft
- 350 ft

Groundwater Model Boundary

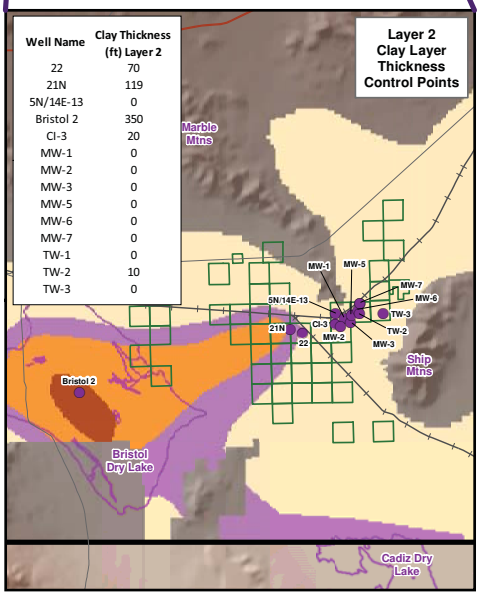
No Flow Model Cell

Cadiz Owned Land

Well Name	Clay Thickness (ft) Layer 1
22	0
21N	0
5N/14E-13	0
Bristol 2	150
CI-3	0
MW-1	0
MW-2	0
MW-3	0
MW-5	0
MW-6	0
MW-7	0
TW-1	0
TW-2	0
TW-3	0



Well Name	Clay Thickness (ft) Layer 2
22	70
21N	119
5N/14E-13	0
Bristol 2	350
CI-3	20
MW-1	0
MW-2	0
MW-3	0
MW-5	0
MW-6	0
MW-7	0
TW-1	0
TW-2	10
TW-3	0



EXPLANATION

Control Point Location with Clay Thickness (ft)

Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

INELASTIC STORAGE COEFFICIENT AND CLAY LAYER THICKNESS (FT) OF THE CADIZ GROUNDWATER MODEL

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

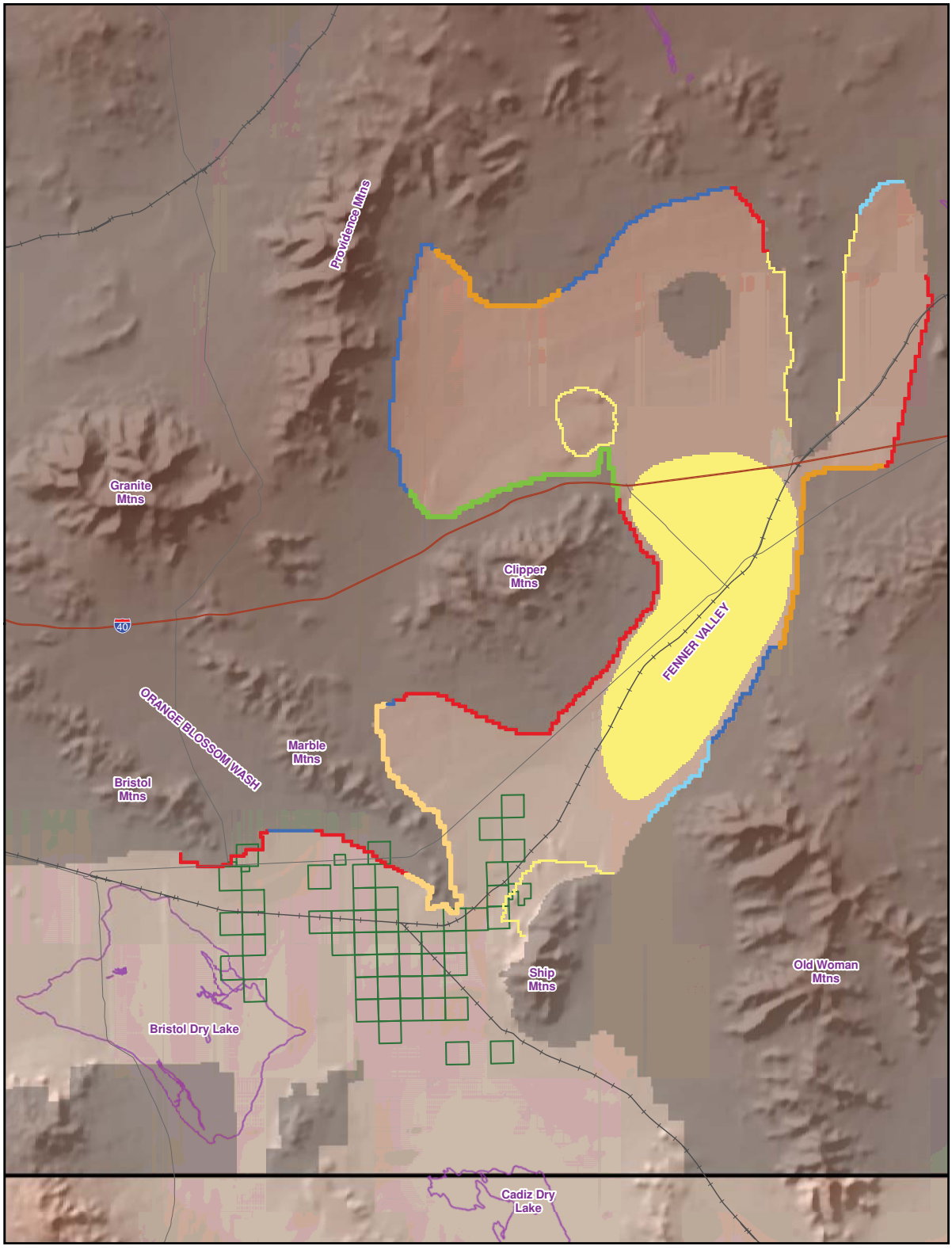
0 5.5 11 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 20

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_20_6panel_inelastic_storage_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Recharge Rate (ft/day) for Total Natural Recharge of 32,000 ac-ft/yr

0.000003 - 0.00025	0.004 - 0.006
0.00025 - 0.001	0.006 - 0.008
0.001 - 0.002	0.008 - 0.01
0.002 - 0.004	0.01 - 0.119616

AEREAL DISTRIBUTION OF NATURAL RECHARGE RATE 32,000 AC-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 2.5 5 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 21

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_21_natural_recharge_9-11.mxd

Annual Groundwater Pumping of Cadiz Agricultural Wells

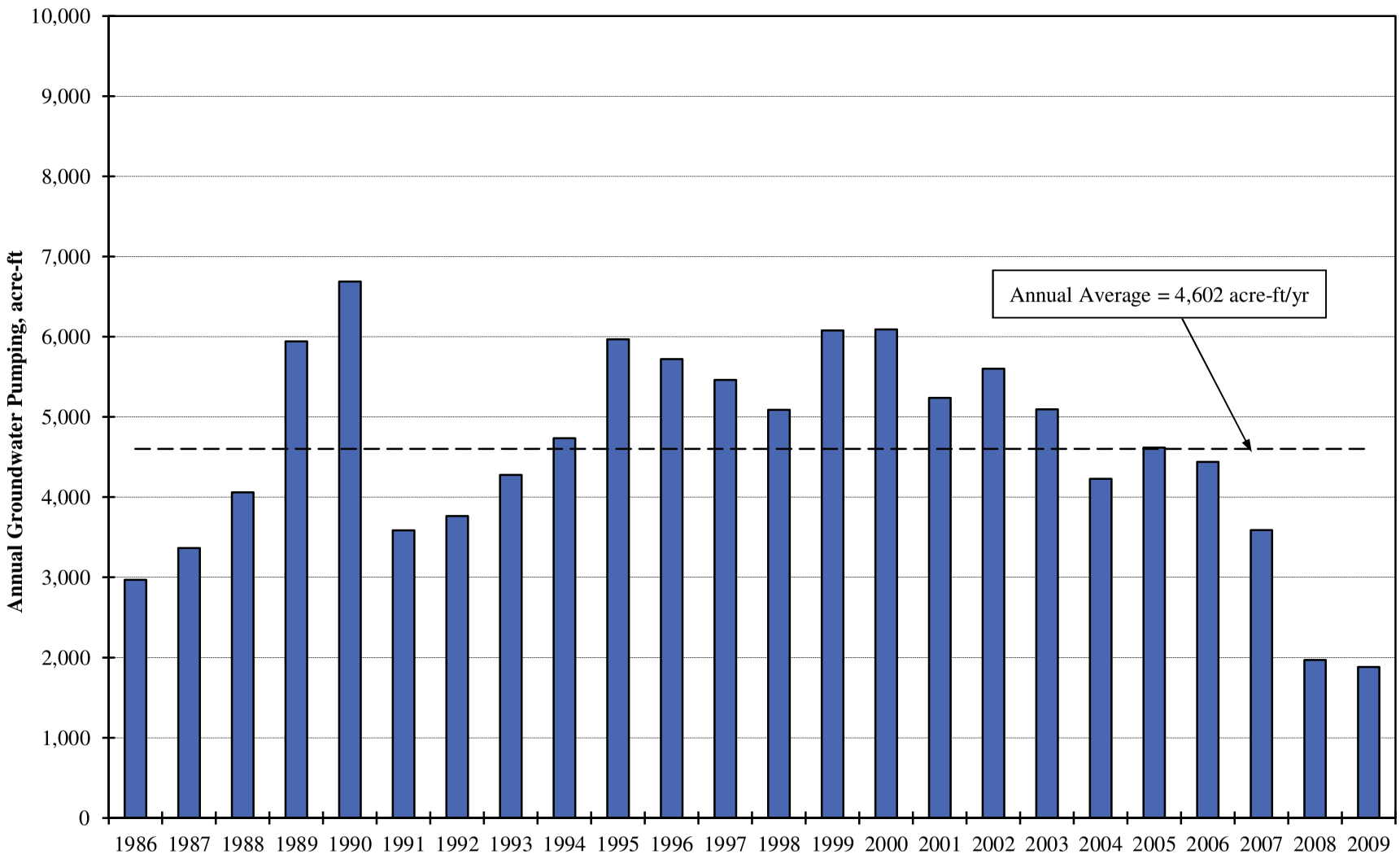
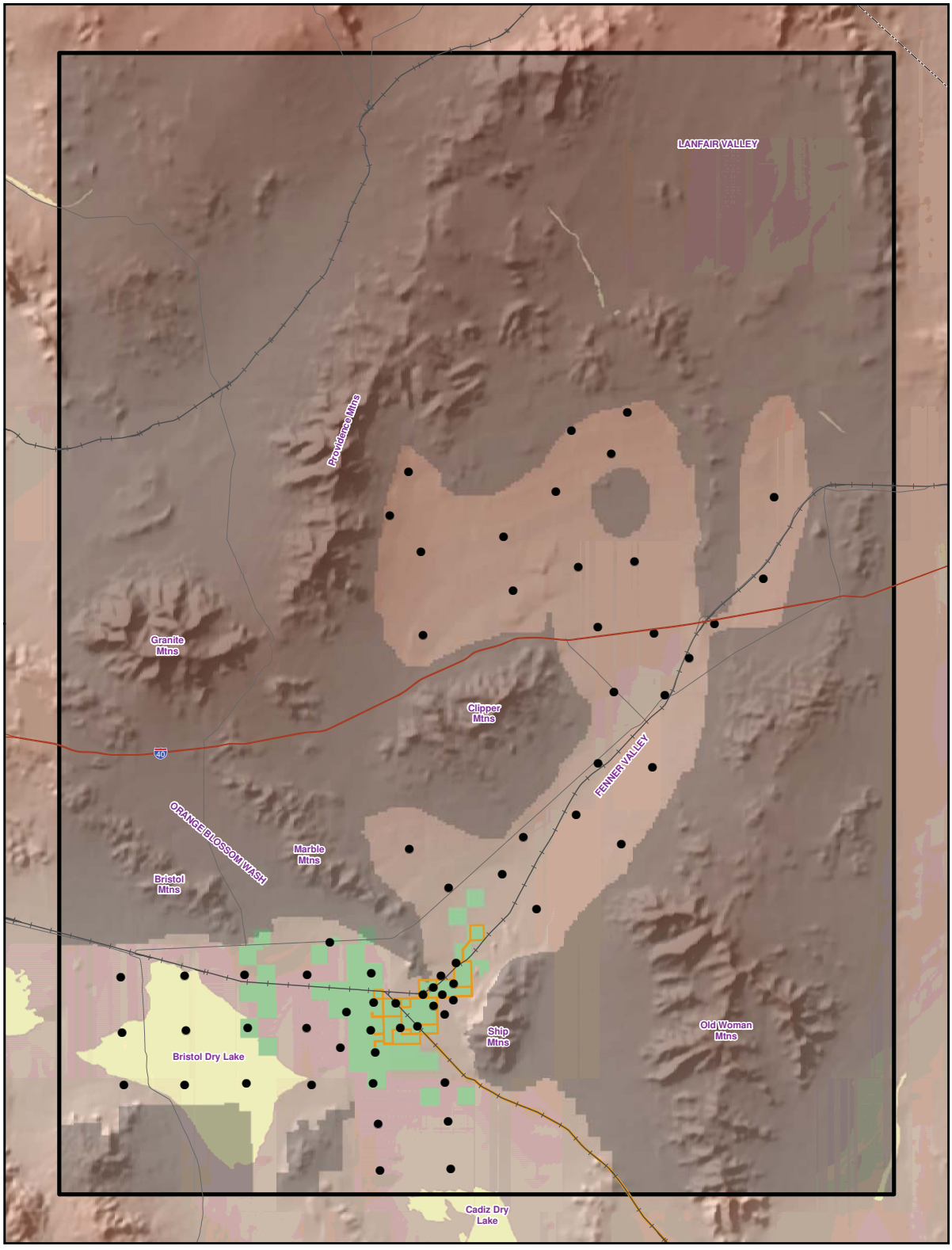


Figure 22



Groundwater Model Boundary

Wellfield Development Areas and Pipelines

PEST Hydraulic Conductivity Pilot Point

No Flow Model Cell

Cadiz Owned Land

PEST HYDRAULIC CONDUCTIVITY PILOT POINTS

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

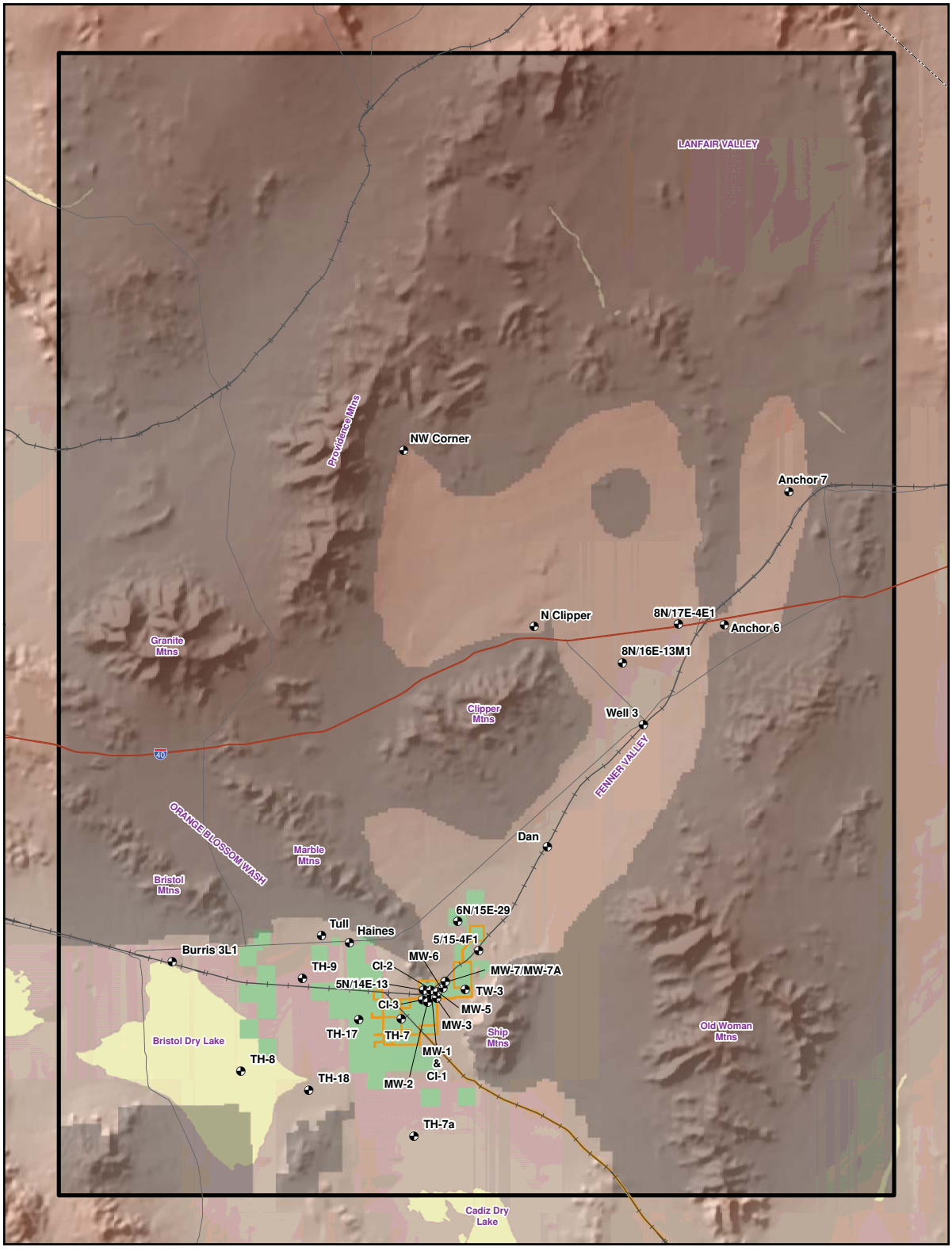
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 23

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_23_PEST_pilot_pts_9-11.mxd



Groundwater Model Boundary

Wellfield Development Areas and Pipelines

Cadiz Owned Land

No Flow Model Cell

Steady State Calibration Point

Notes:
(1) NW Corner - Based on nearby observed water levels in adjacent valleys.
(2) N Clipper - Estimated value is approximately 50 ft below ground surface, and is used to prevent simulated water levels from being above ground surface.
(3) Anchor 6 - Based on three wells to the north that are outside of the model domain.
(4) Anchor 7 - Based on five wells to the east that are outside of the model domain.

LOCATION OF WELLS WITH WATER LEVEL DATA USED FOR STEADY STATE MODEL CALIBRATION

NORTH
0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 24

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_24_ss_cali_wells_9-11.mxd

Measured versus Model-Calculated Water Levels
Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr

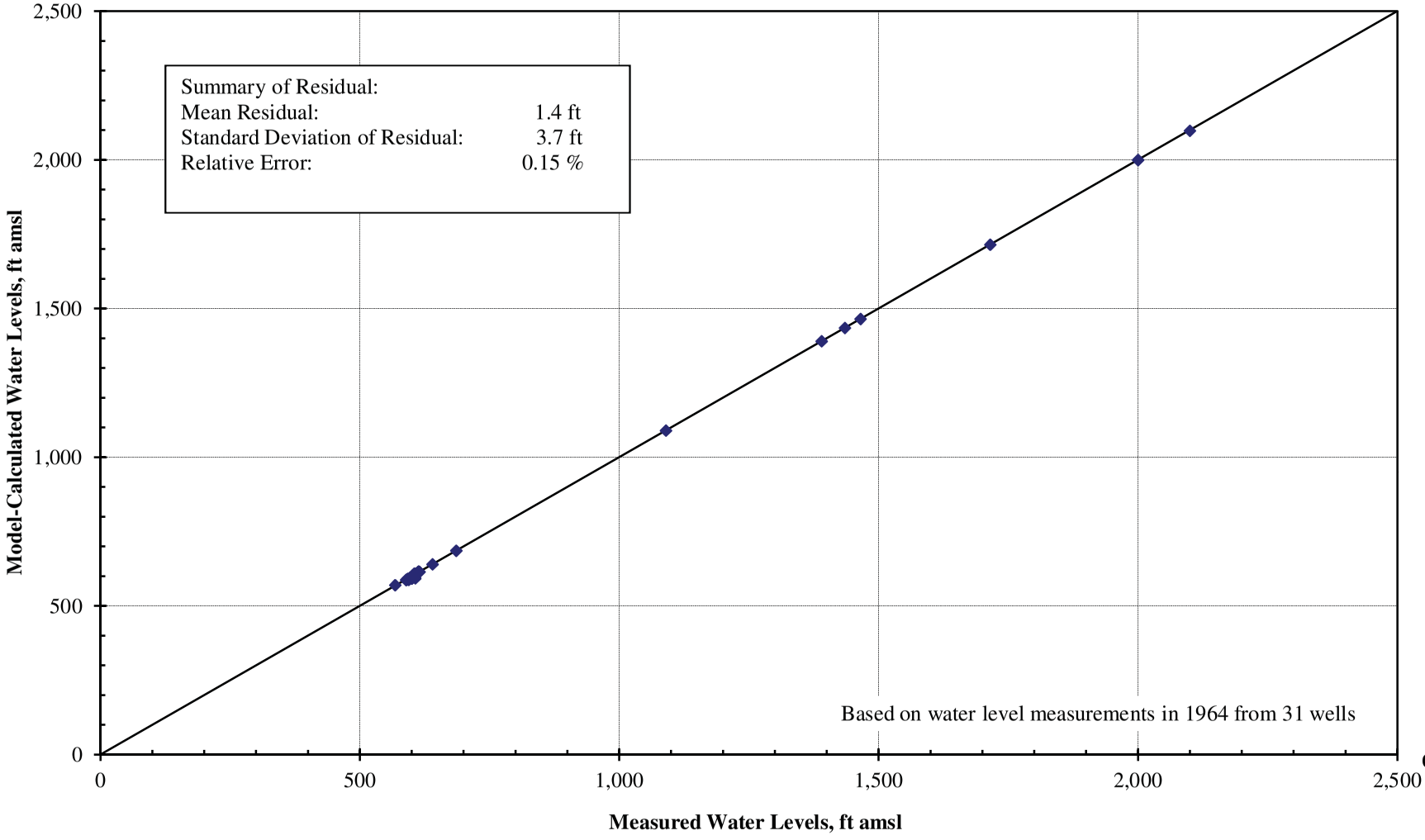


Figure 25

Measured versus Model-Calculated Water Levels
Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr

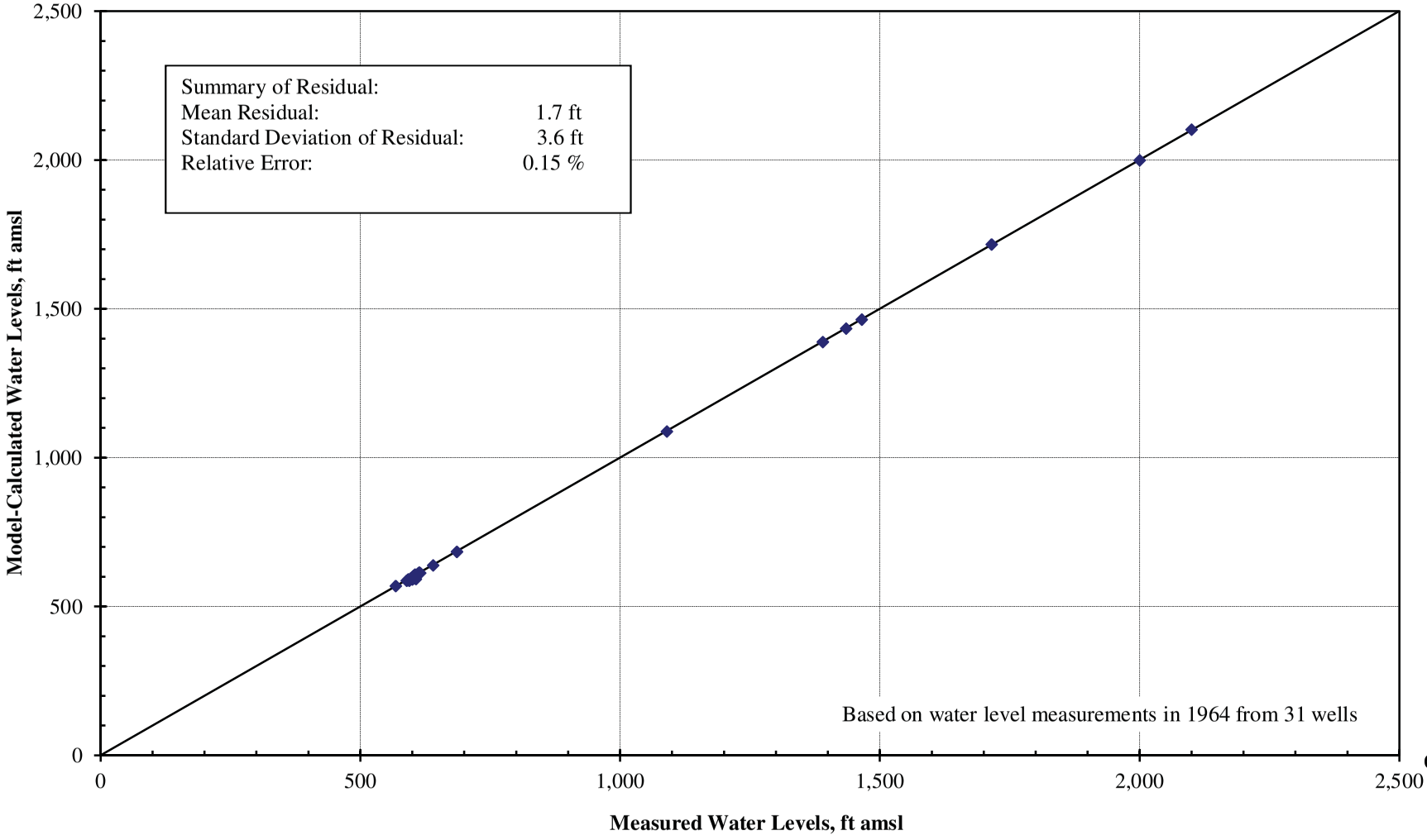


Figure 26

Measured versus Model-Calculated Water Levels
Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr

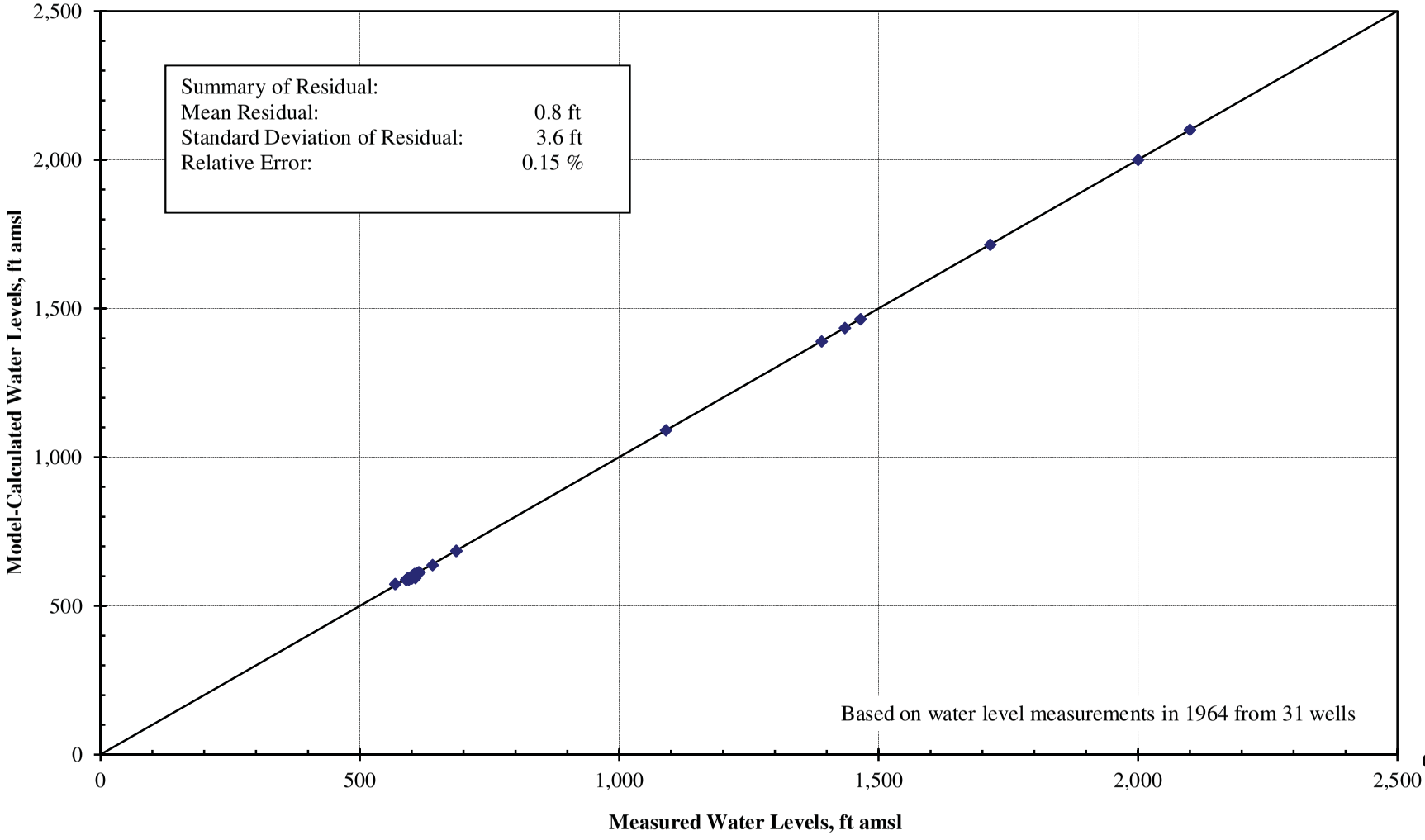
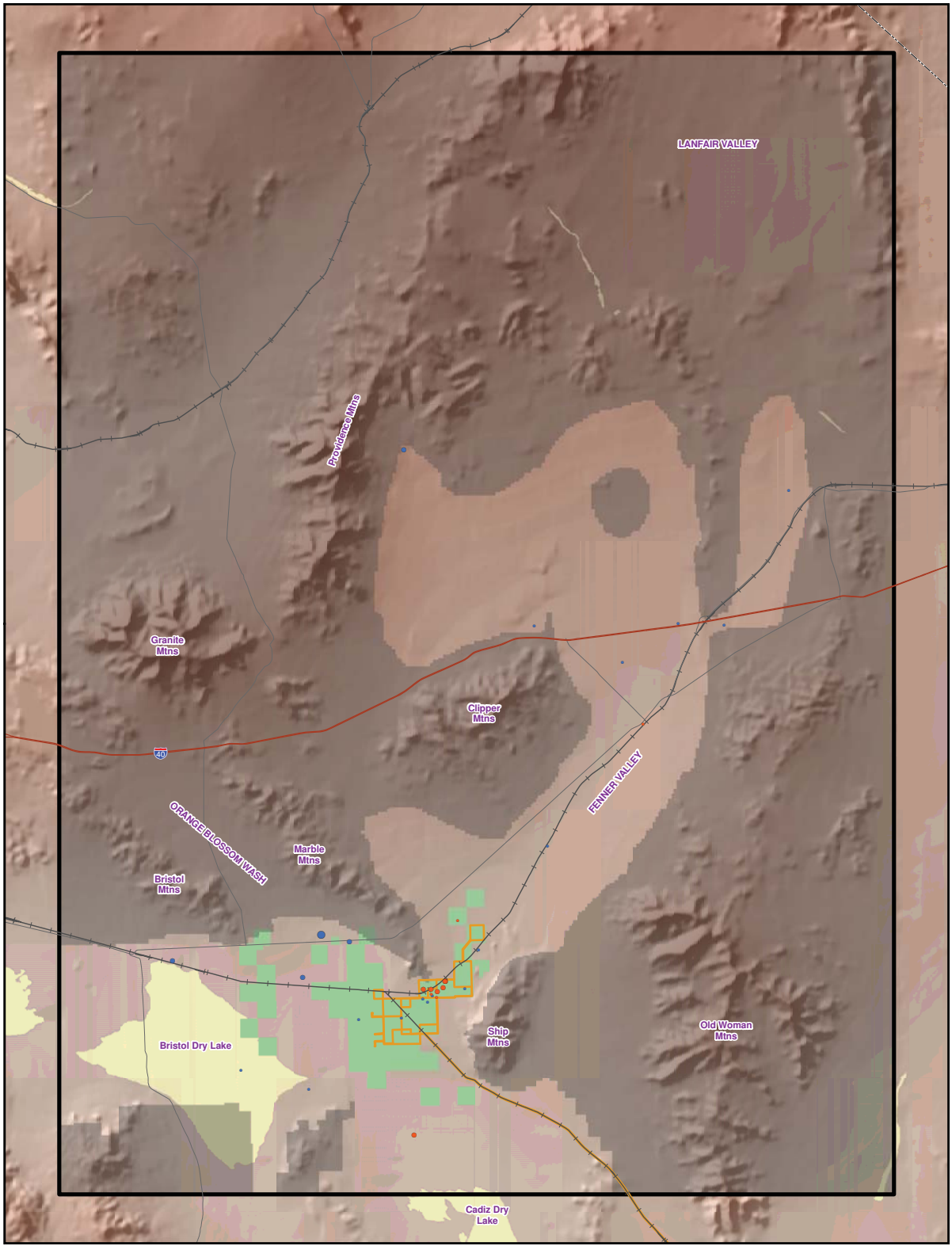


Figure 27



Groundwater Model Boundary
Cell Size = 500 ft x 500 ft

No Flow Model Cell

Proposed Wellfield Development Areas and Pipeline

Cadiz Owned Land

Groundwater Level Residuals (ft)
(measured water levels minus model-generated water levels)

- <-10
- -10 to -5
- -5 to 0
- 0 to 5
- 5 to 10
- >-10

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

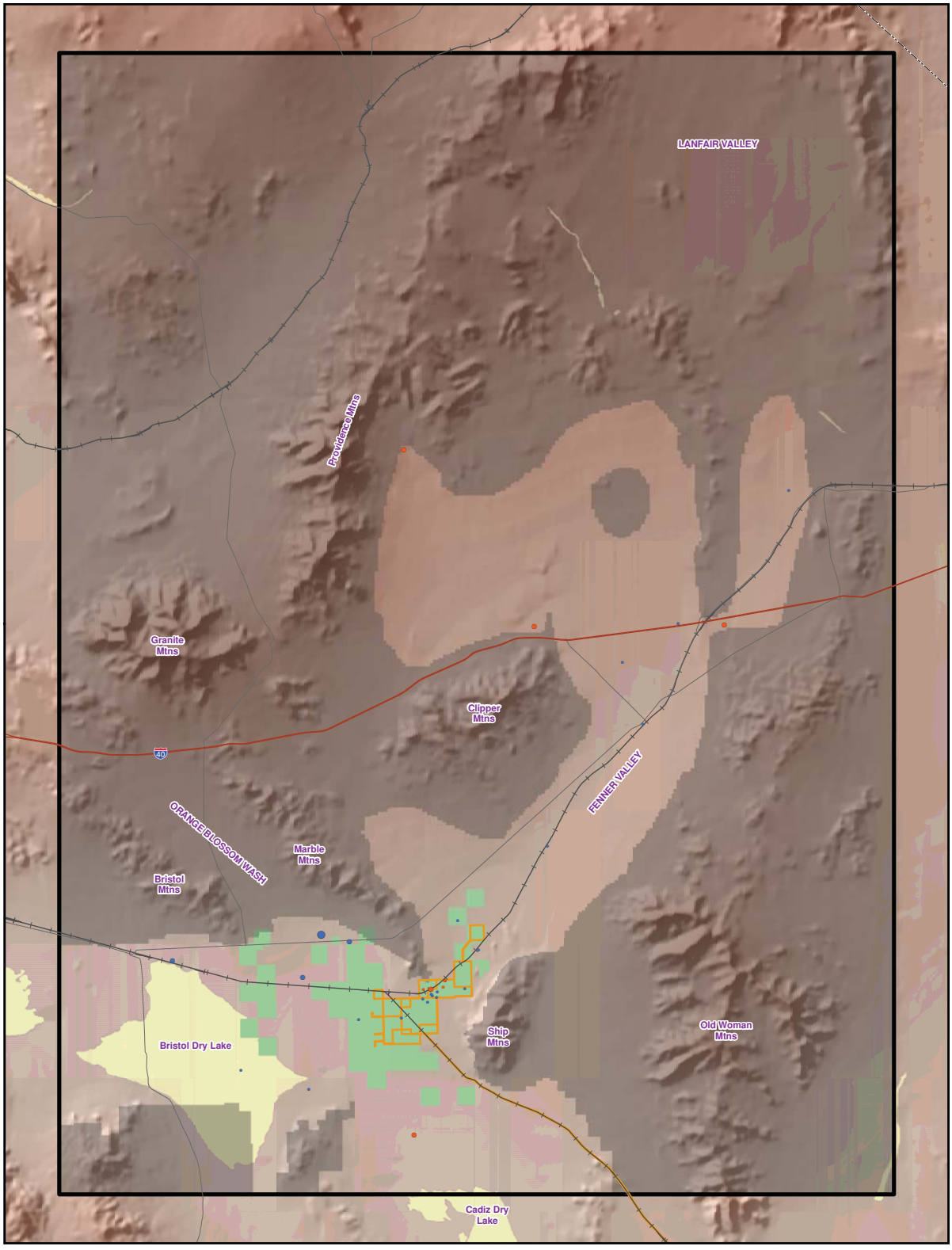
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - STEADY STATE MODEL CALIBRATION FOR NATURAL RECHARGE OF 32,000 ACRE-FT/YR

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 28

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_28_residuals_steadystate_32k_9-11.mxd



Groundwater Model Boundary
Cell Size = 500 ft x 500 ft

No Flow Model Cell

Proposed Wellfield Development Areas and Pipeline

Cadiz Owned Land

Groundwater Level Residuals (ft)
(measured water levels minus model-generated water levels)

- <-10
- -10 to -5
- -5 to 0
- 0 to 5
- 5 to 10
- >-10

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

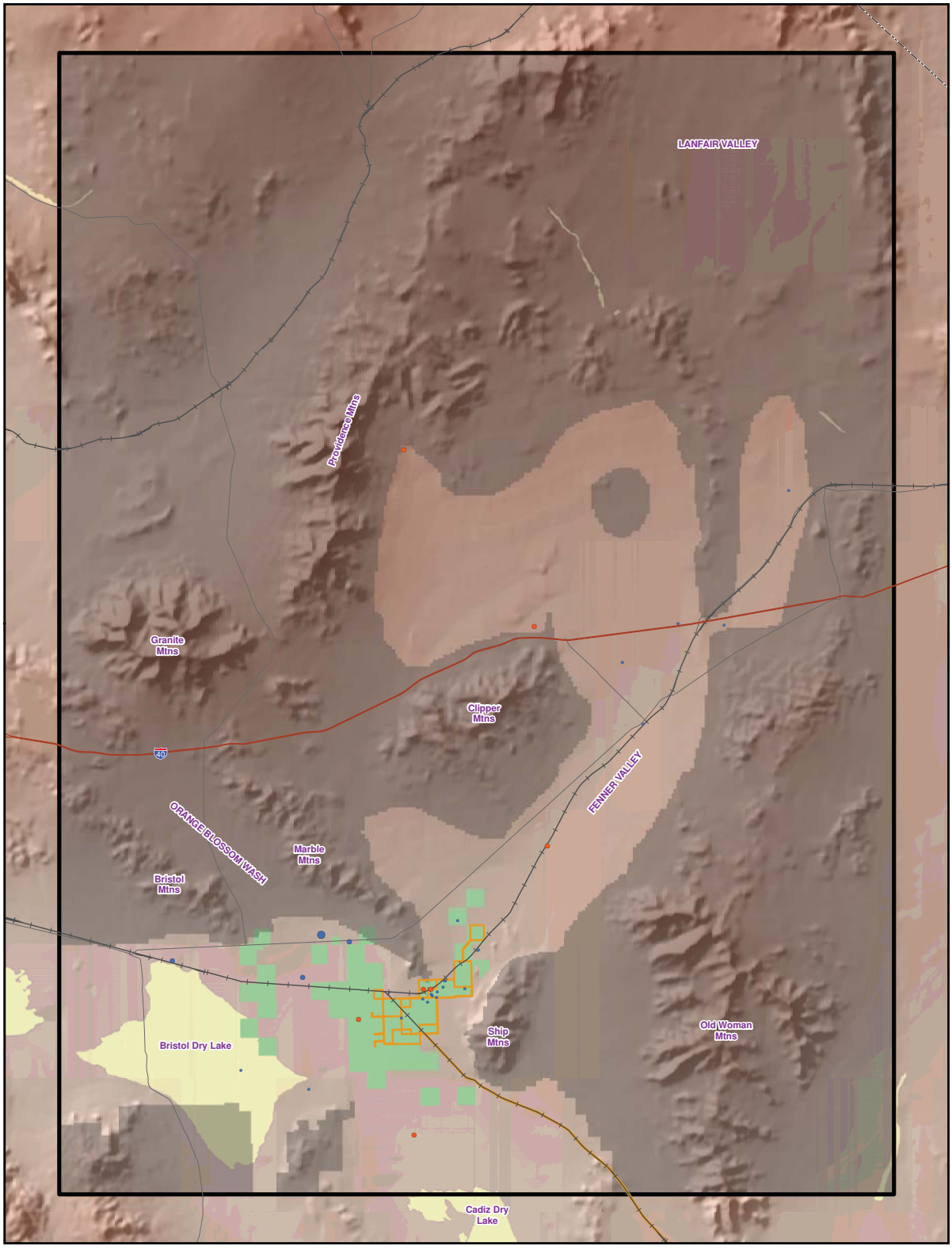
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - STEADY STATE MODEL CALIBRATION FOR NATURAL RECHARGE OF 16,000 ACRE-FT/YR

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 29

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_29_residuals_steadystate_16k_9-11.mxd



Groundwater Model Boundary
Cell Size = 500 ft x 500 ft

No Flow Model Cell

Proposed Wellfield Development Areas and Pipeline

Cadiz Owned Land

Groundwater Level Residuals (ft)
(measured water levels minus model-generated water levels)

- <-10
- -10 to -5
- -5 to 0
- 0 to 5
- 5 to 10
- >-10

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

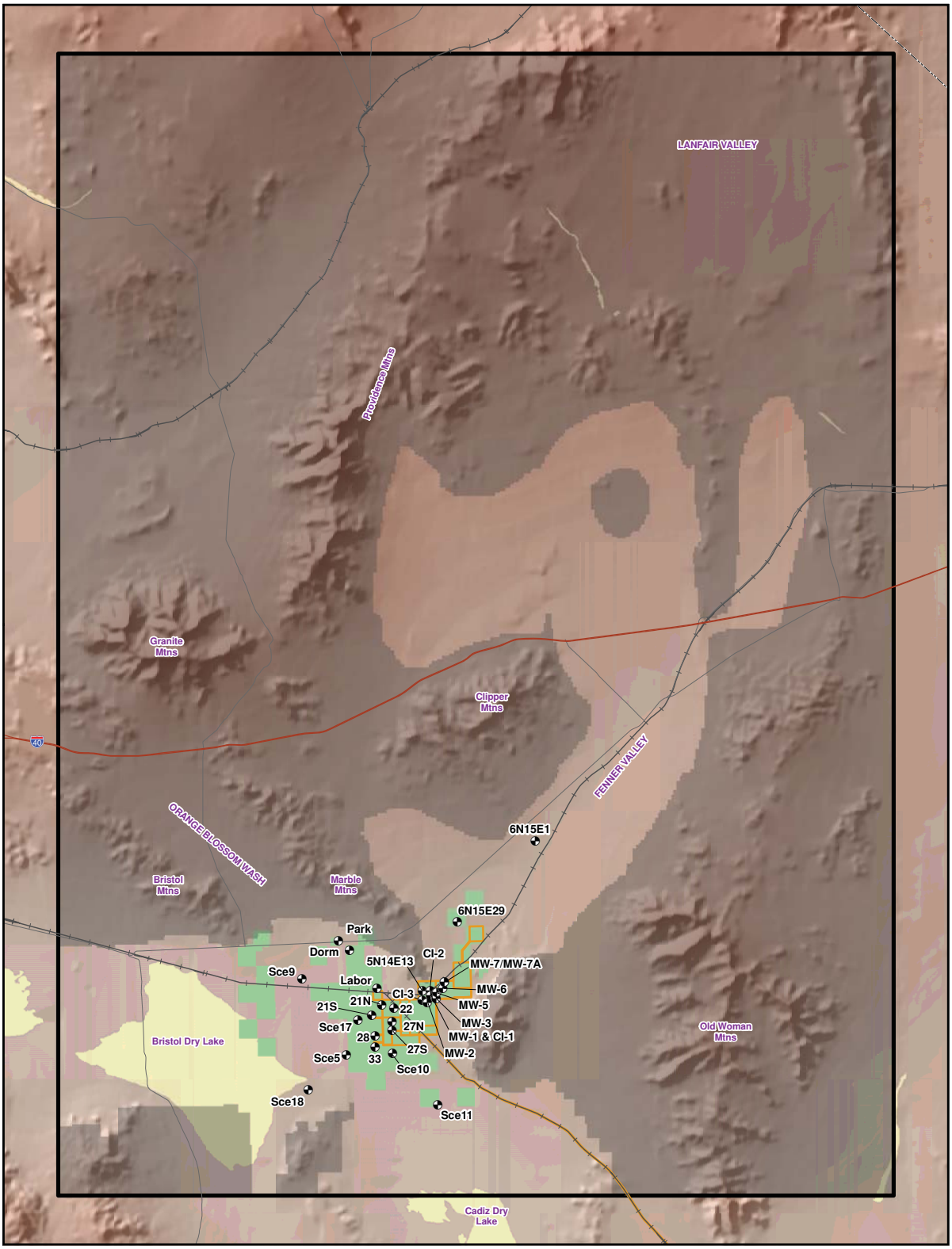
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - STEADY STATE MODEL CALIBRATION FOR NATURAL RECHARGE OF 5,000 ACRE-FT/YR

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 30

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_30_residuals_steadystate_5k_9-11.mxd



Groundwater Model Boundary

Proposed Wellfield Development Areas and Pipeline

Transient Calibration Point

No Flow Model Cell

Cadiz Owned Land

LOCATION OF WELLS WITH WATER LEVEL DATA USED FOR TRANSIENT MODEL CALIBRATION

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

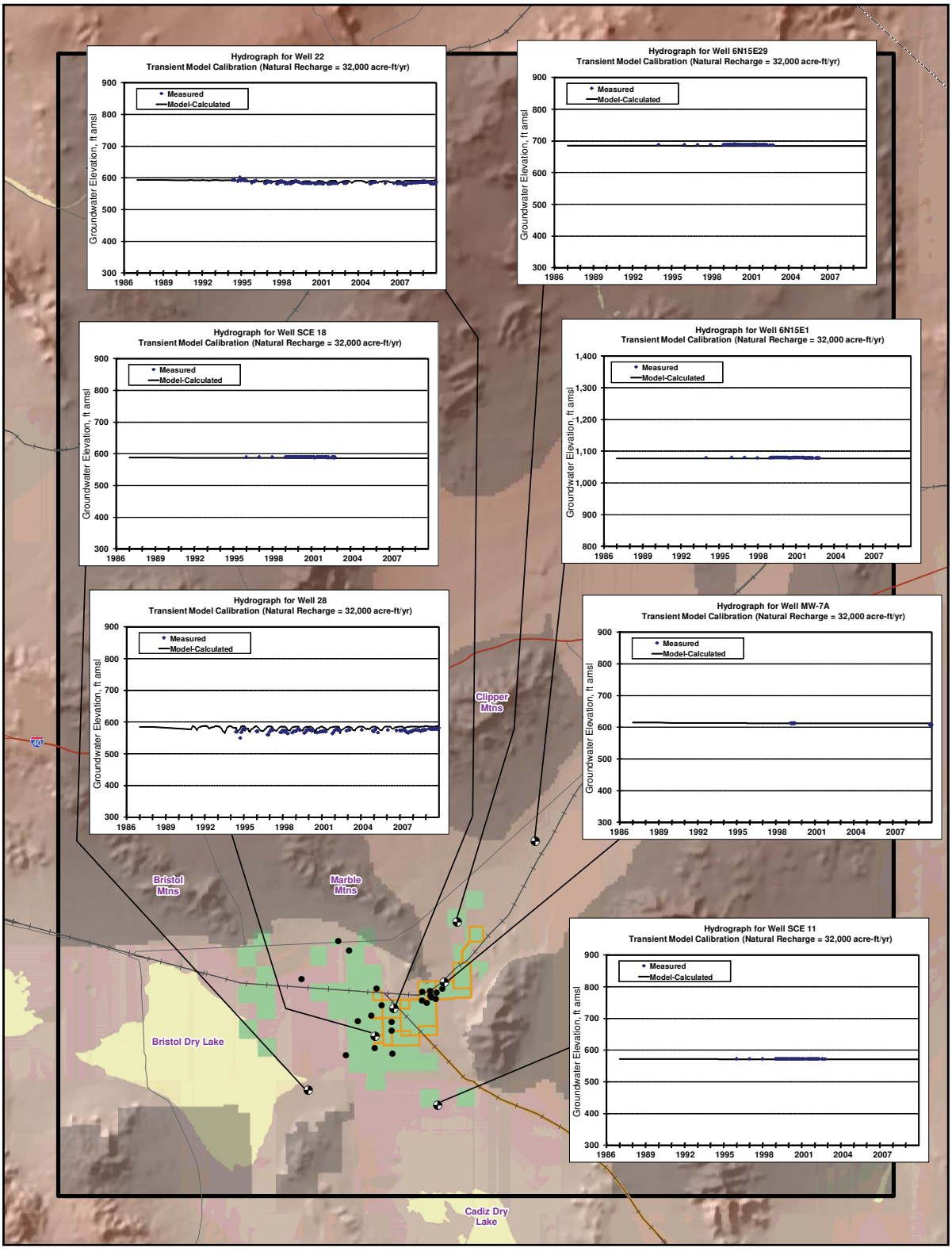
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 31

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_31_trans_cali_wells_9-11.mxd



Groundwater Model Boundary

Wellfield Development Areas and Pipelines

Transient Calibration Point with Hydrograph

No Flow Model Cell

Cadiz Owned Land

Transient Calibration Point

SELECTED HYDROGRAPHS OF TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 32,000 ACRE-FT/YR

NORTH

0 2.5 5 Miles

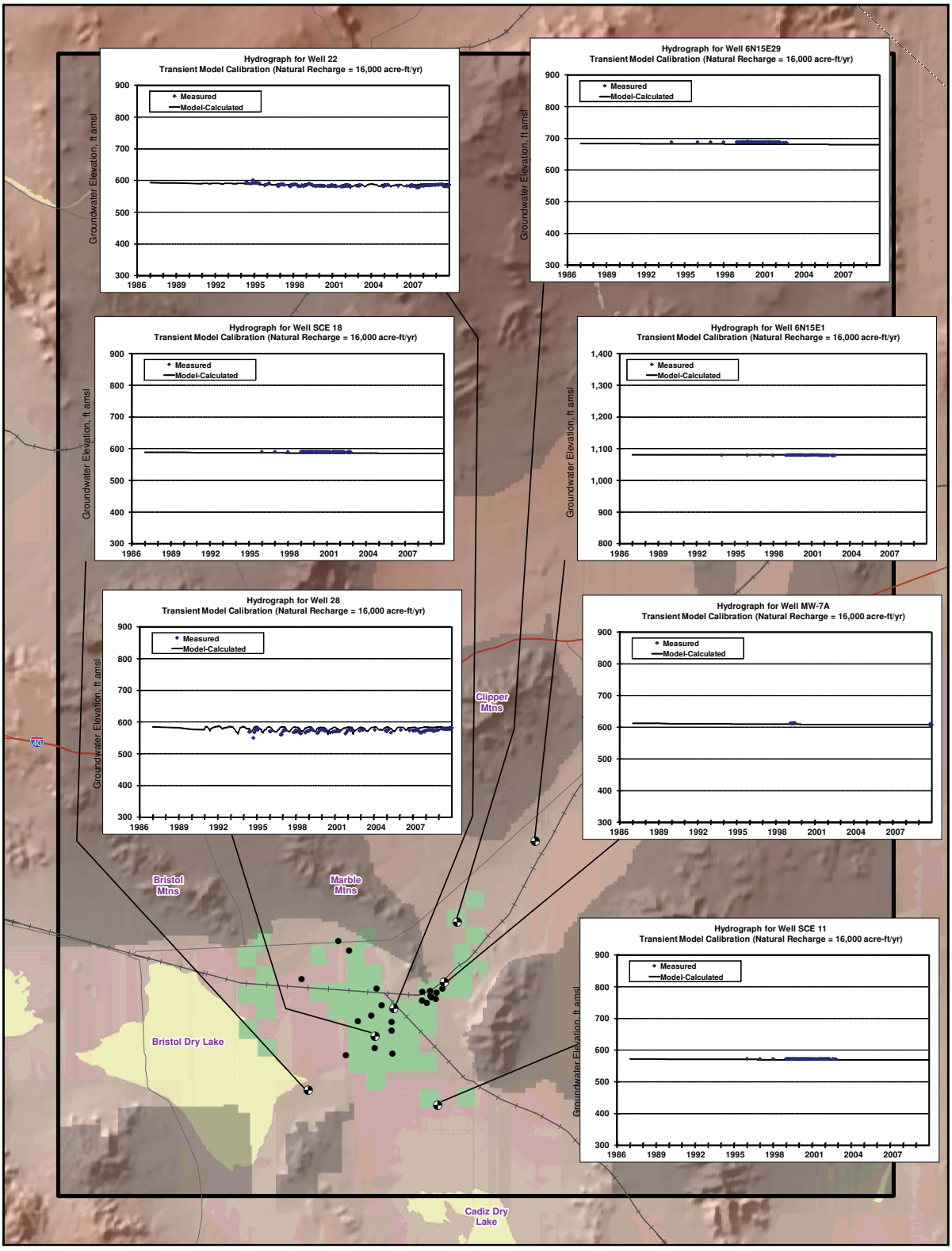
1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

Figure 32

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_32_32k_hydrographs_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Transient Calibration Point with Hydrograph

Transient Calibration Point

SELECTED HYDROGRAPHS OF TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 16,000 ACRE-FT/YR

NORTH

0 2.5 5 Miles

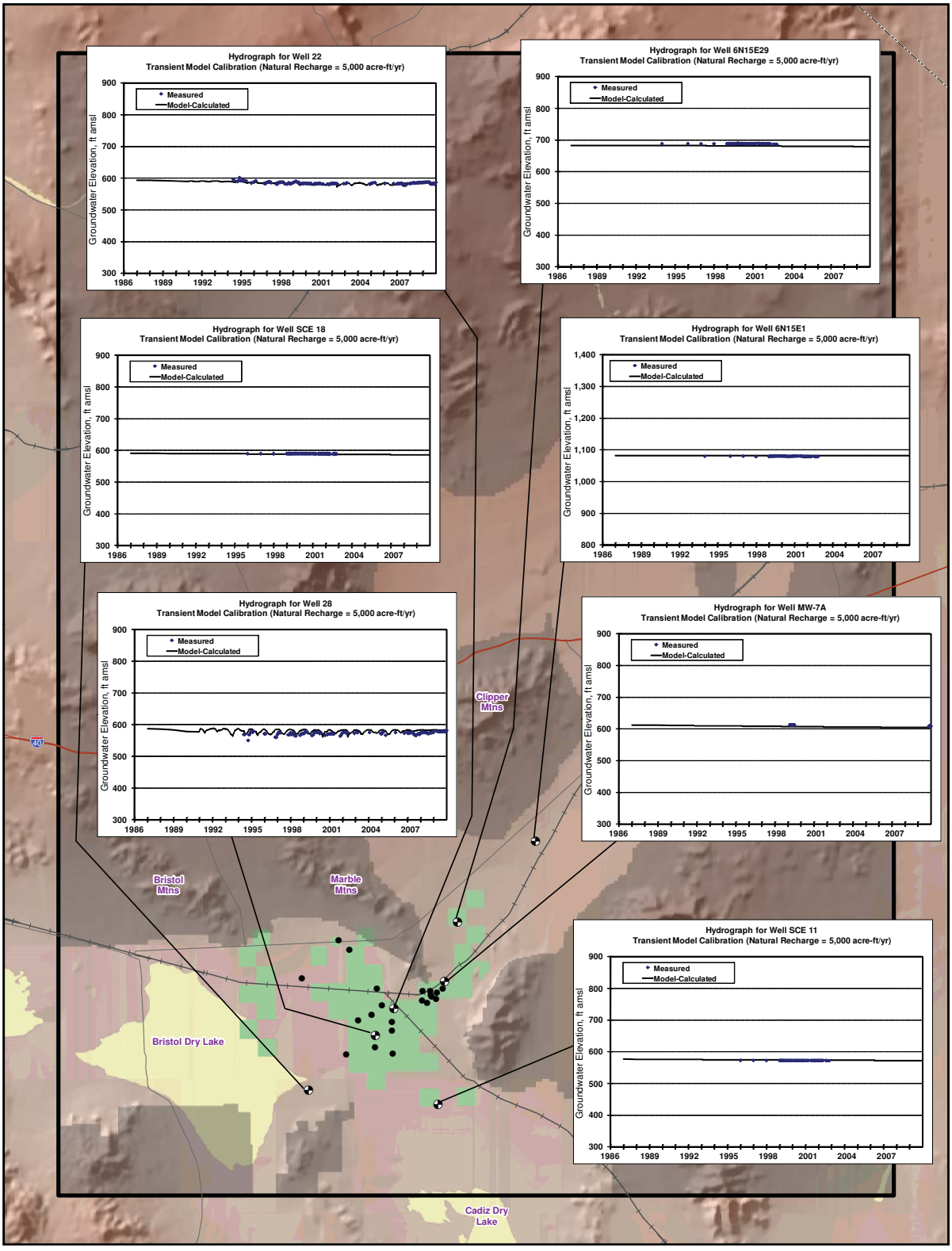
1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

Figure 33

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_33_16k_hydrographs_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Transient Calibration Point with Hydrograph

Transient Calibration Point

SELECTED HYDROGRAPHS OF TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 5,000 ACRE-FT/YR

NORTH

0 2.5 5 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

Figure 34

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_34_5k_hydrographs_9-11.mxd

Measured versus Model-Calculated Water Levels
Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

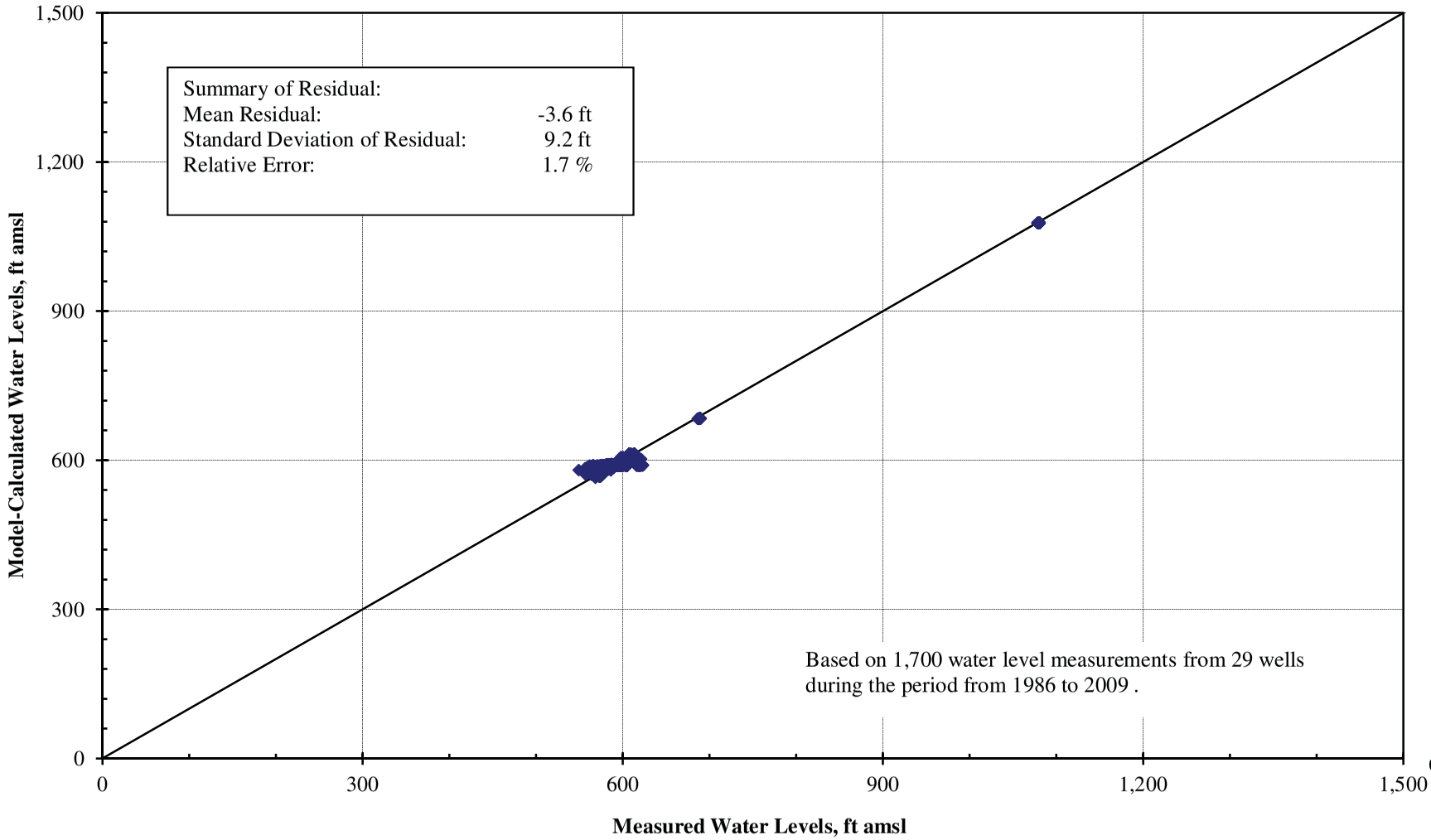


Figure 35

Measured versus Model-Calculated Water Levels
Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr

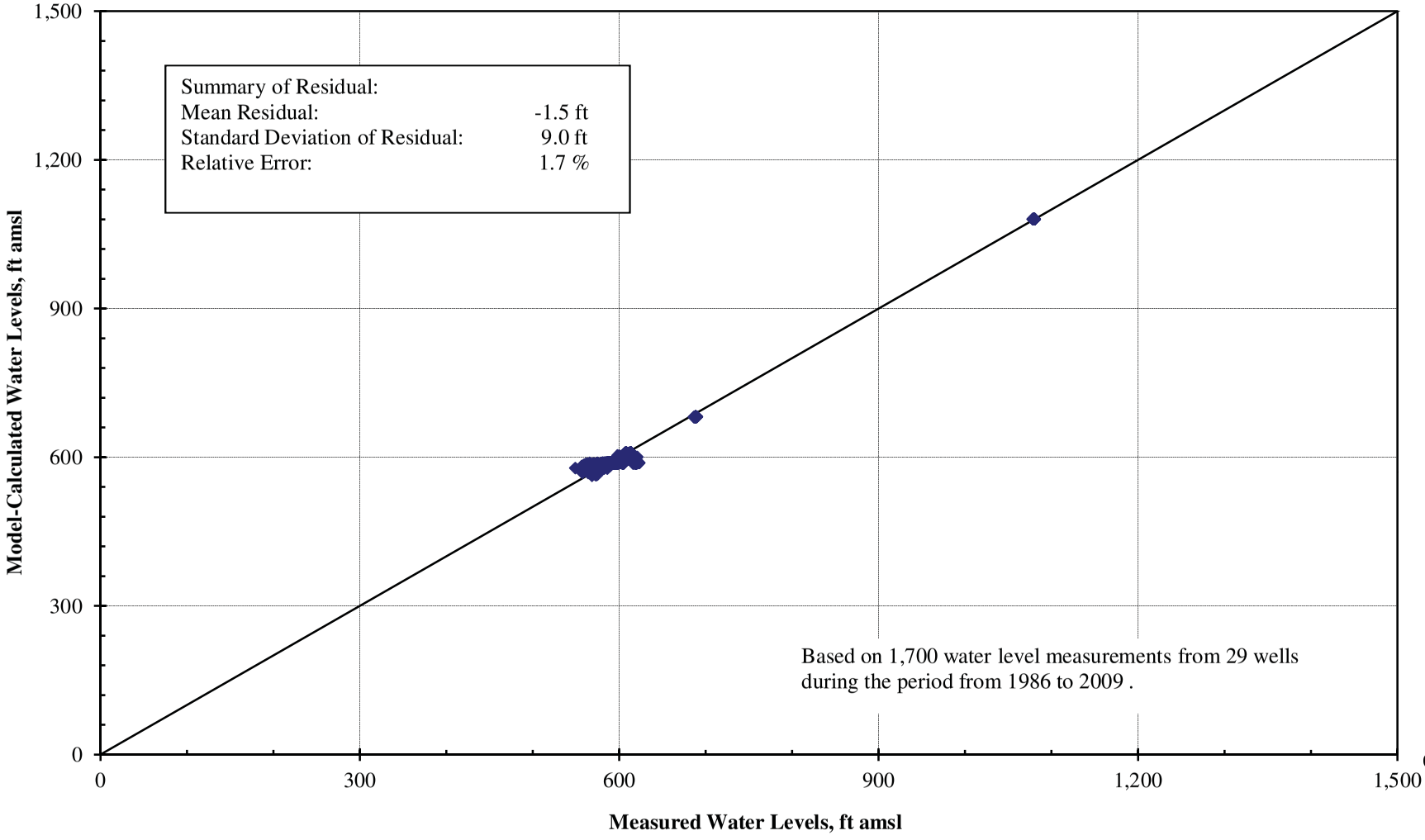


Figure 36

Measured versus Model-Calculated Water Levels
Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr

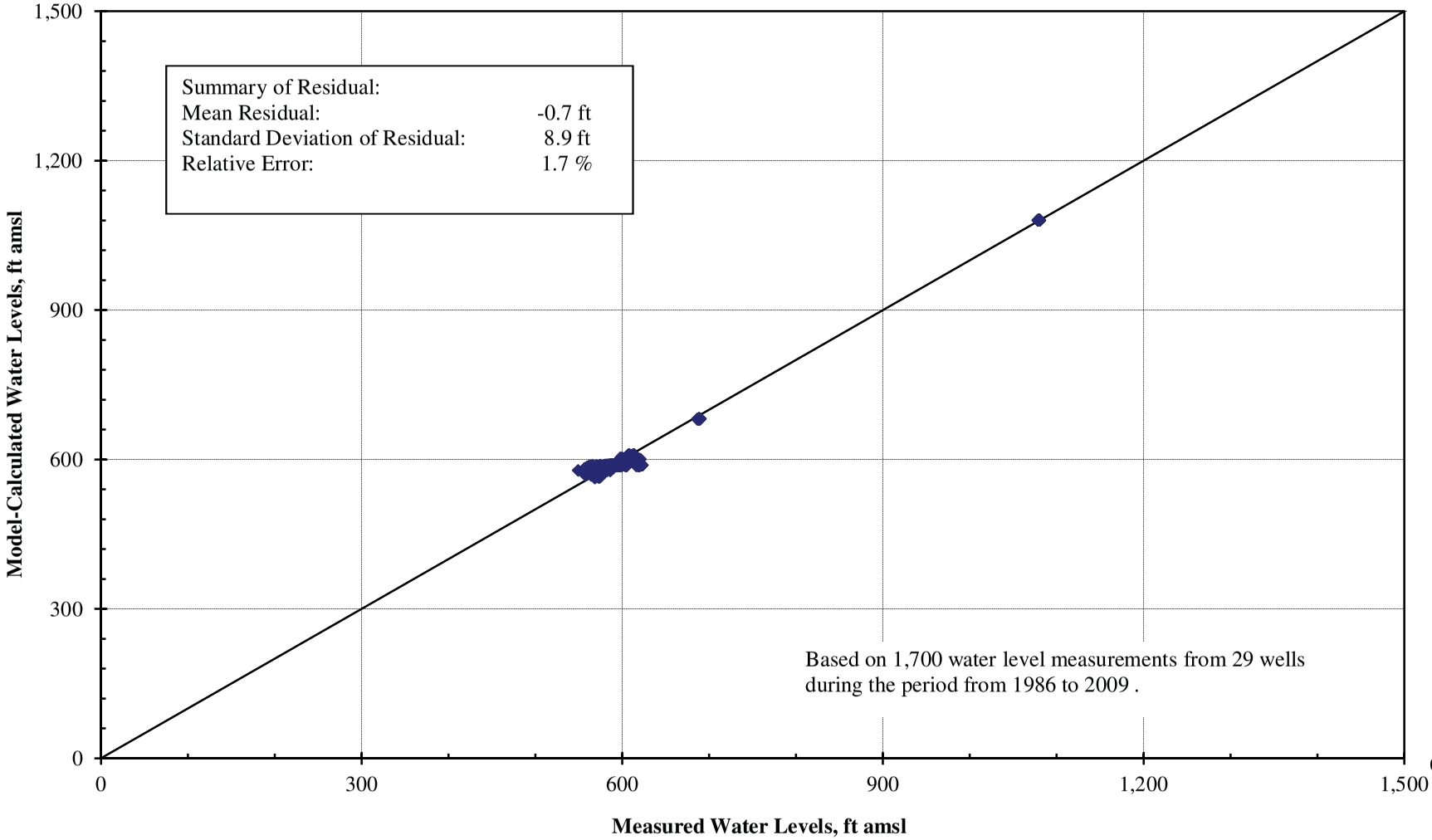


Figure 37

Histogram of Water Level Residuals
Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

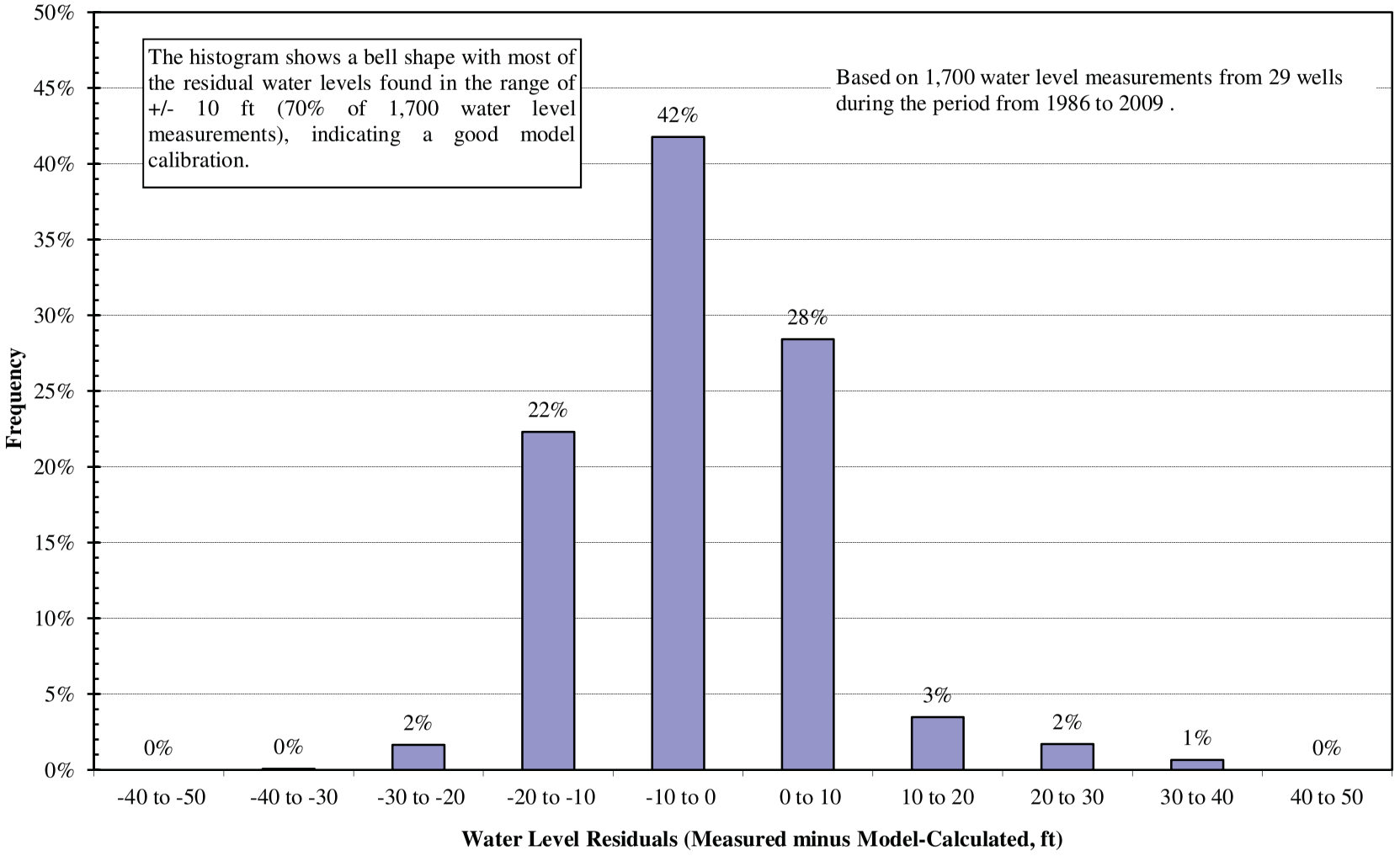


Figure 38

Histogram of Water Level Residuals
Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr

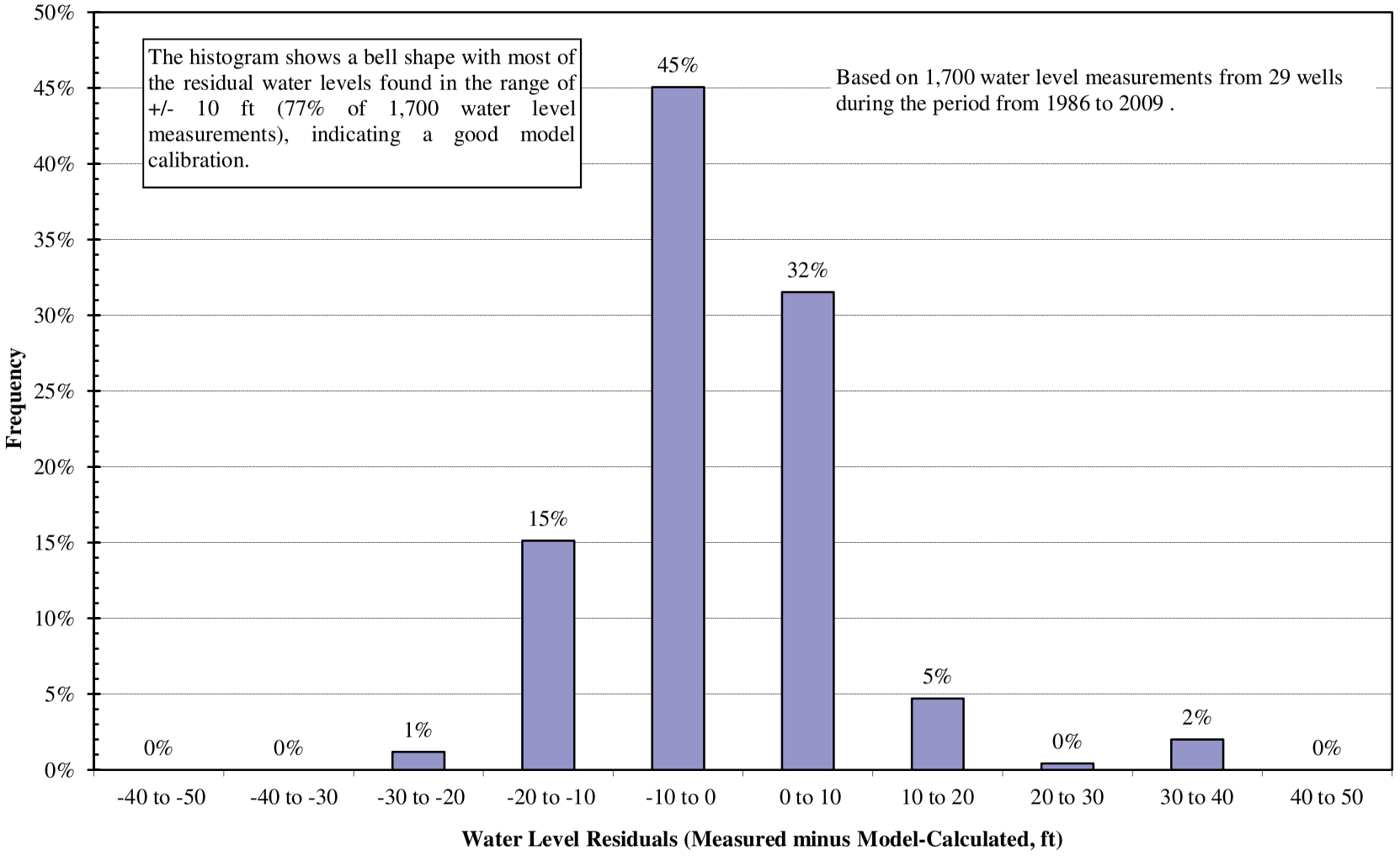


Figure 39

Histogram of Water Level Residuals
Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr

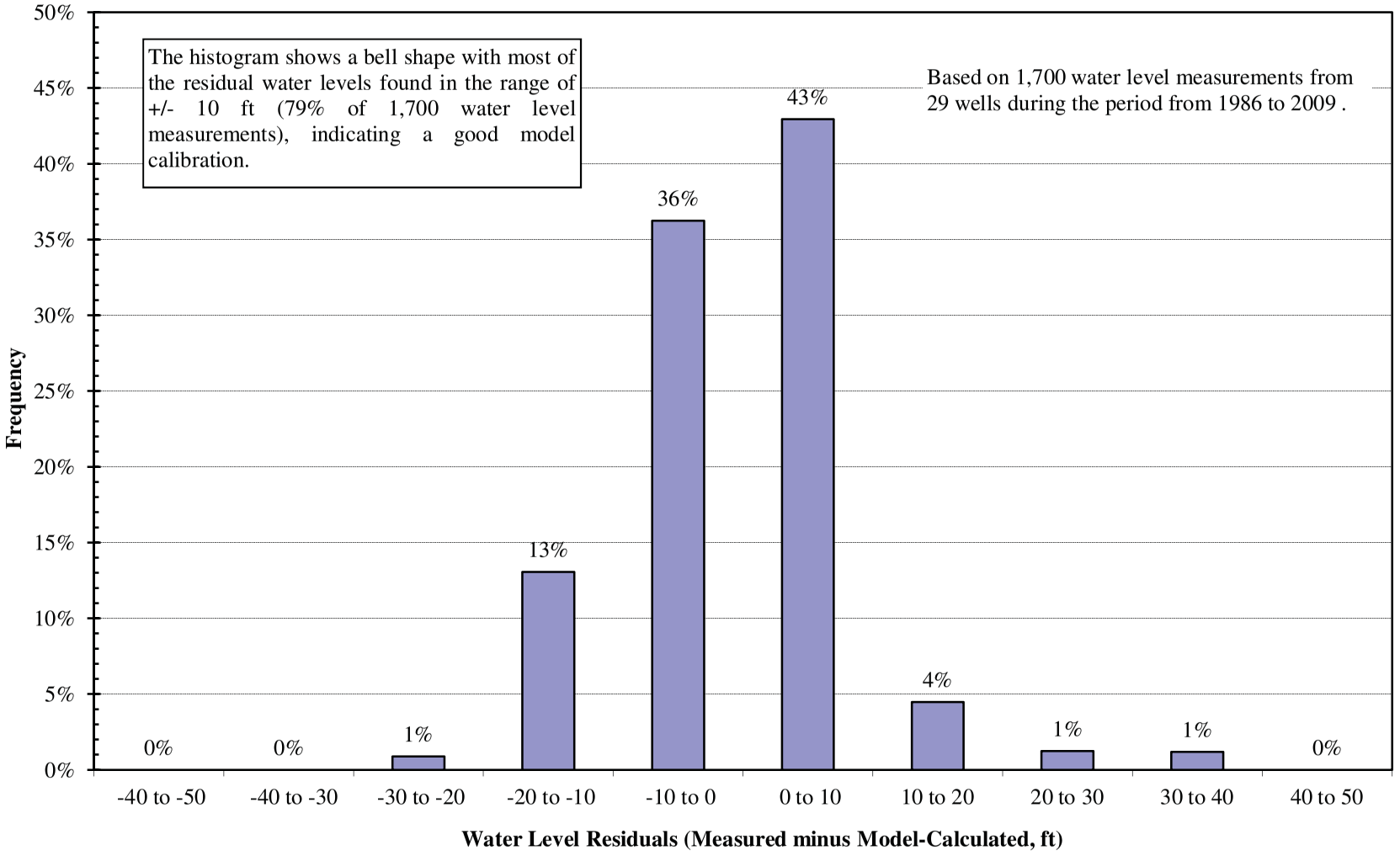
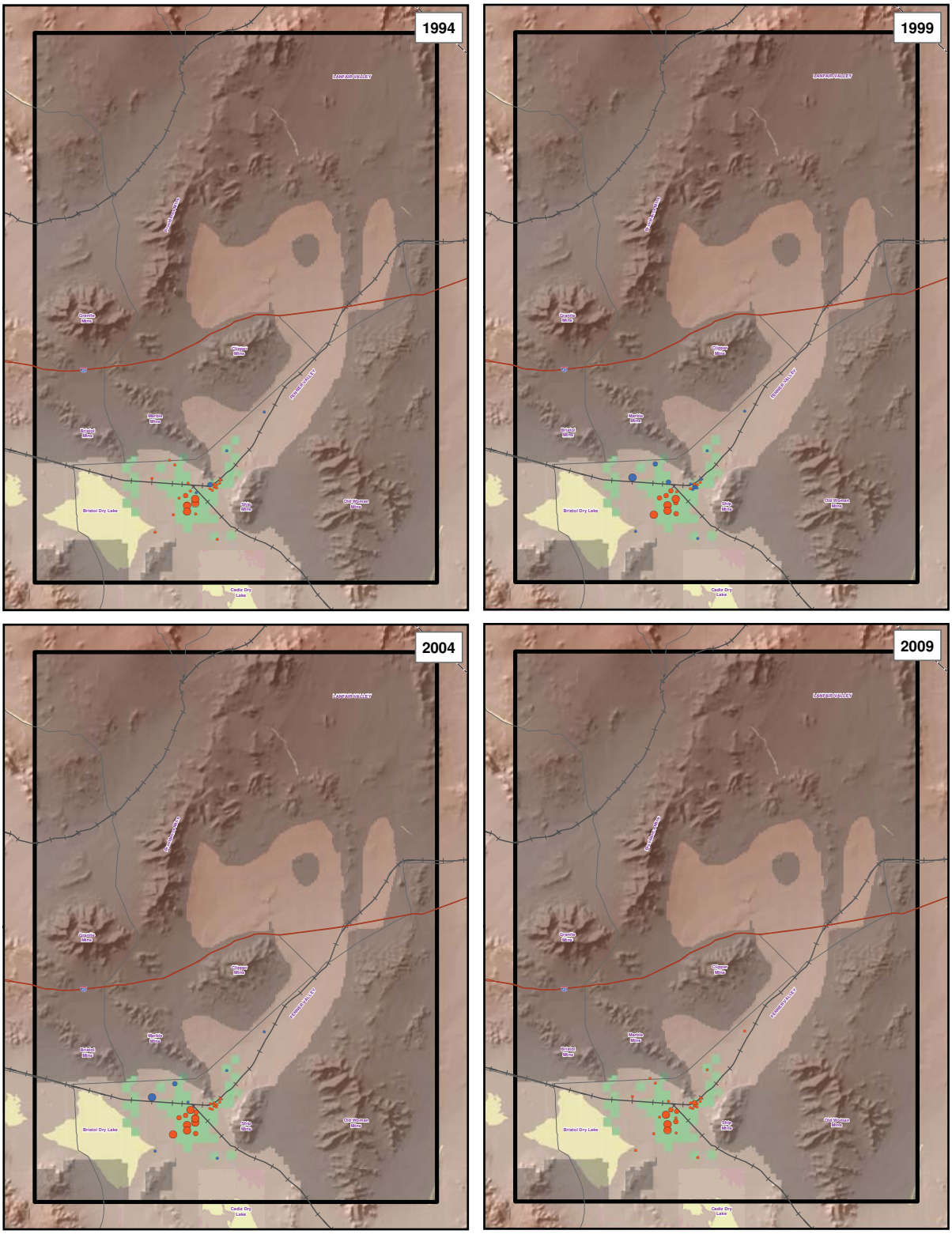


Figure 40



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Groundwater Level Residuals (ft)
(measured water levels minus model-generated water levels)

- <-10
- -10 to -5
- -5 to 0
- 0 to 5
- 5 to 10
- >-10

NORTH

0 6 12 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

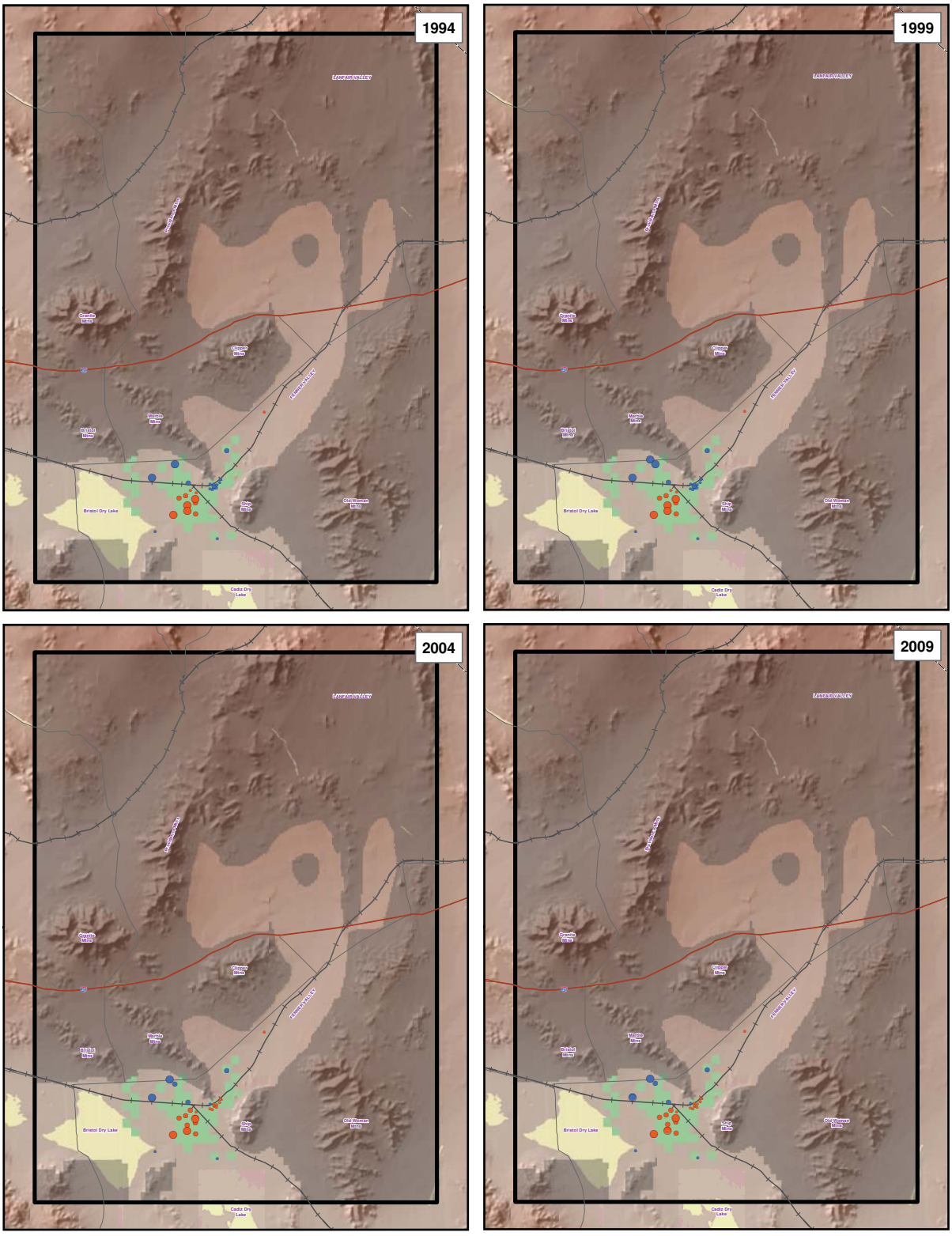
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 32,000 ACRE-FT/YR

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 41

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_41_residuals_transient_32k_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Groundwater Level Residuals (ft)
(measured water levels minus model-generated water levels)

- <-10
- -10 to -5
- -5 to 0
- 0 to 5
- 5 to 10
- >-10

NORTH

0 6 12 Miles

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

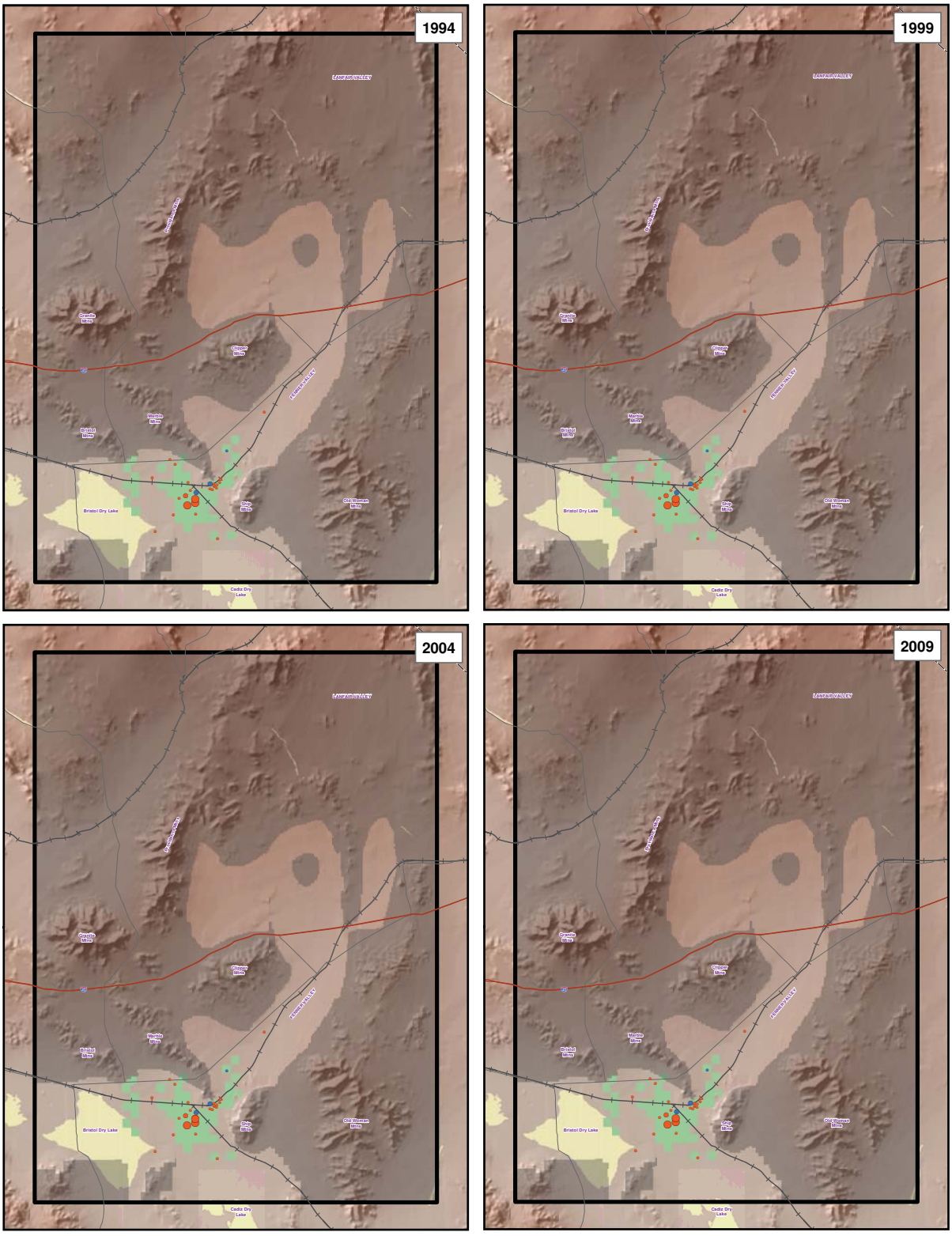
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 16,000 ACRE-FT/YR

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 42

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_42_residuals_transient_16k_9-11.mxd



1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

SPATIAL DISTRIBUTION OF WATER LEVEL RESIDUALS - TRANSIENT MODEL CALIBRATION FOR NATURAL RECHARGE OF 5,000 ACRE-FT/YR

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 43

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_43_residuals_transient_5k_9-11.mxd

Temporal Distribution of Water Level Residuals
Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

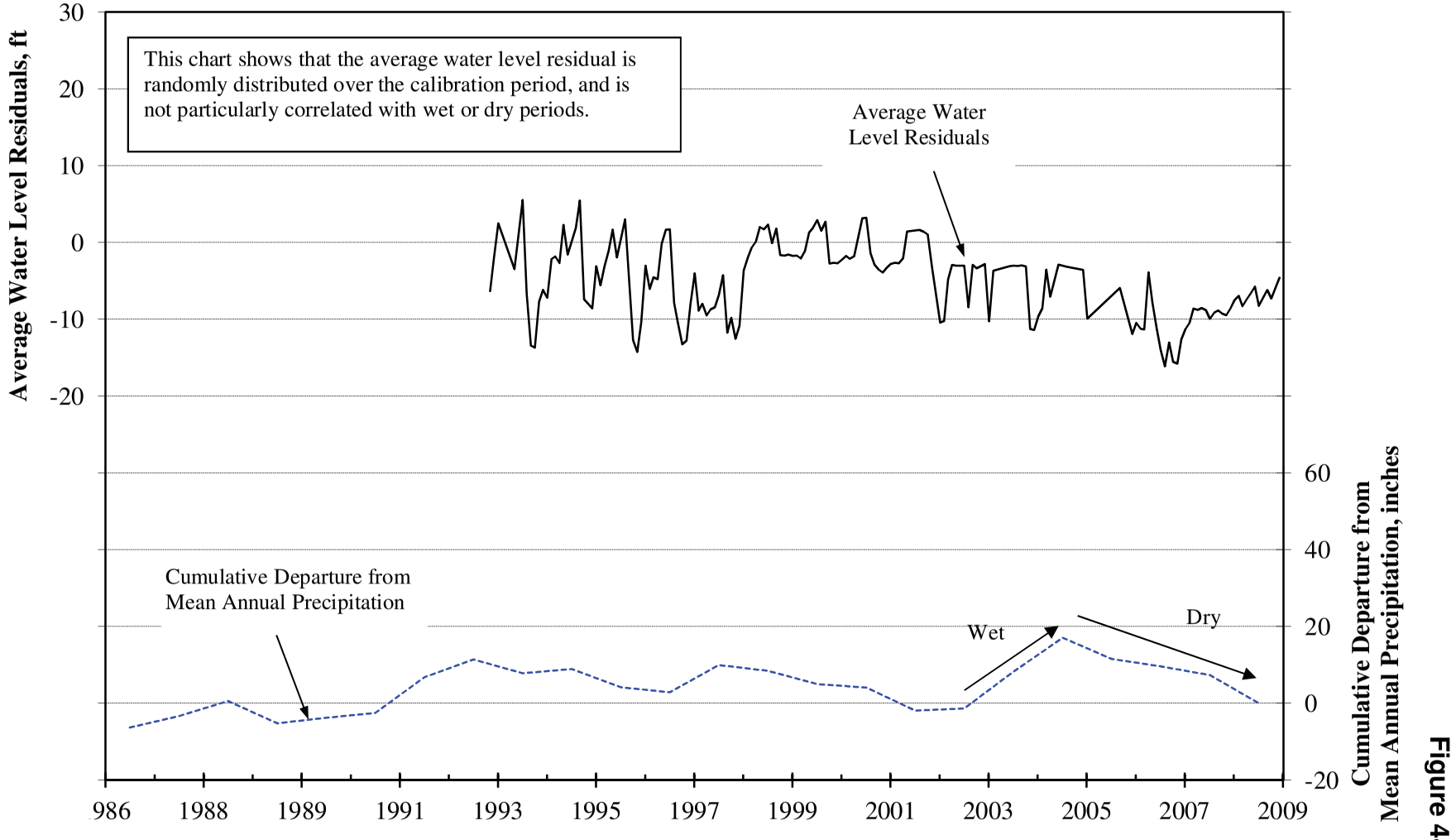


Figure 44

Temporal Distribution of Water Level Residuals
Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr

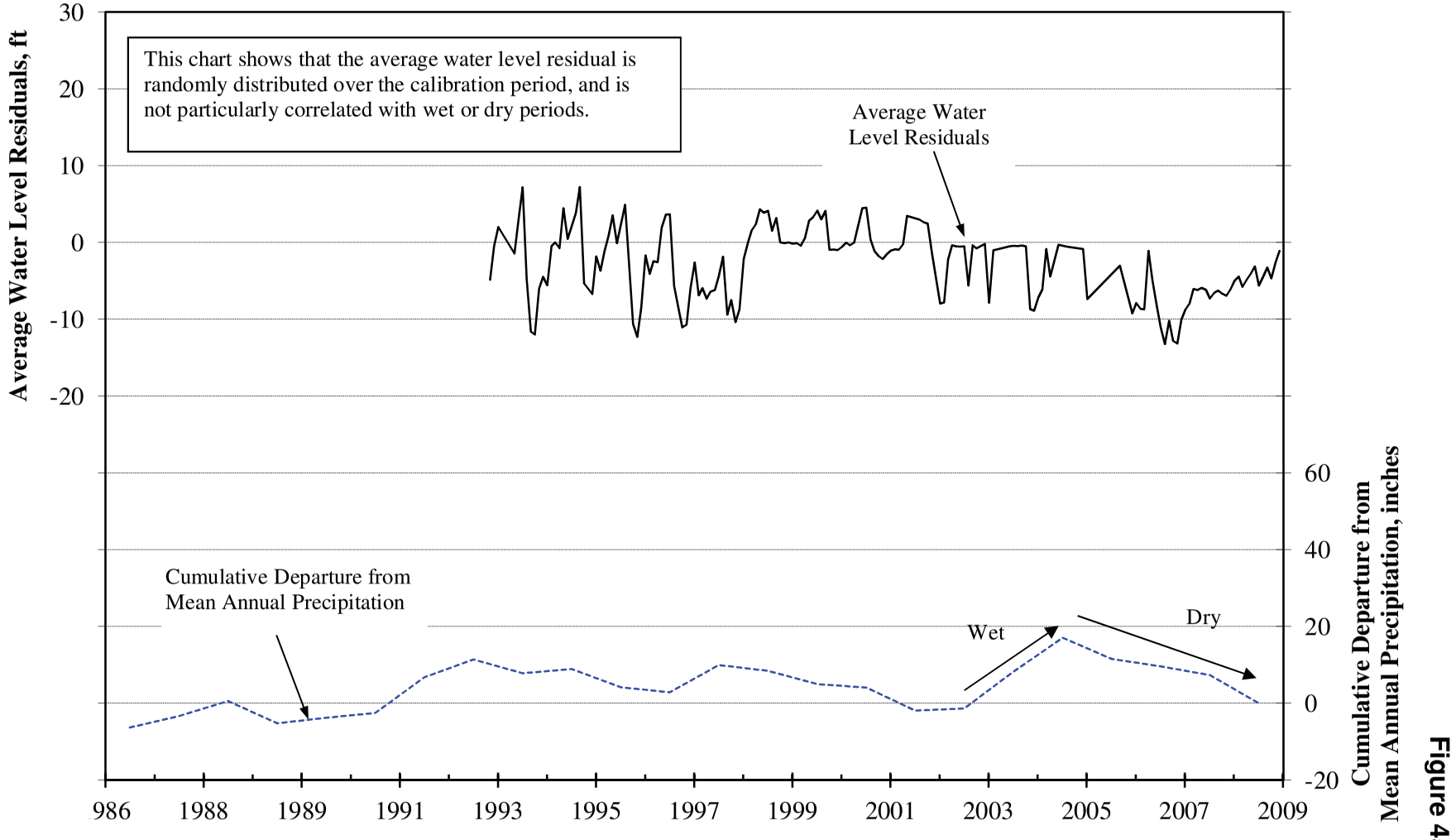


Figure 45

Temporal Distribution of Water Level Residuals
Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr

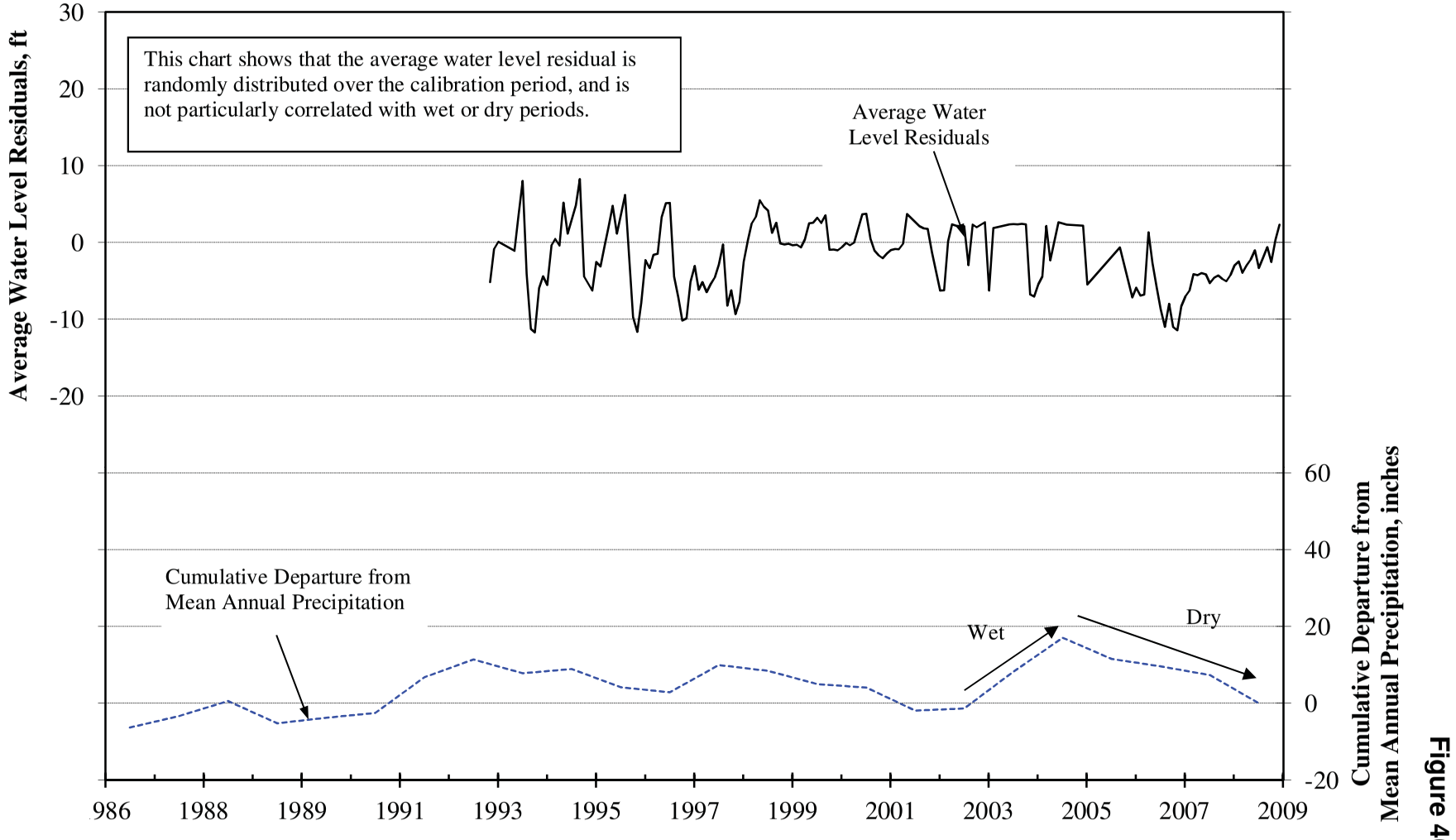


Figure 46

Normalized Sensitivity of Selected Model Parameters

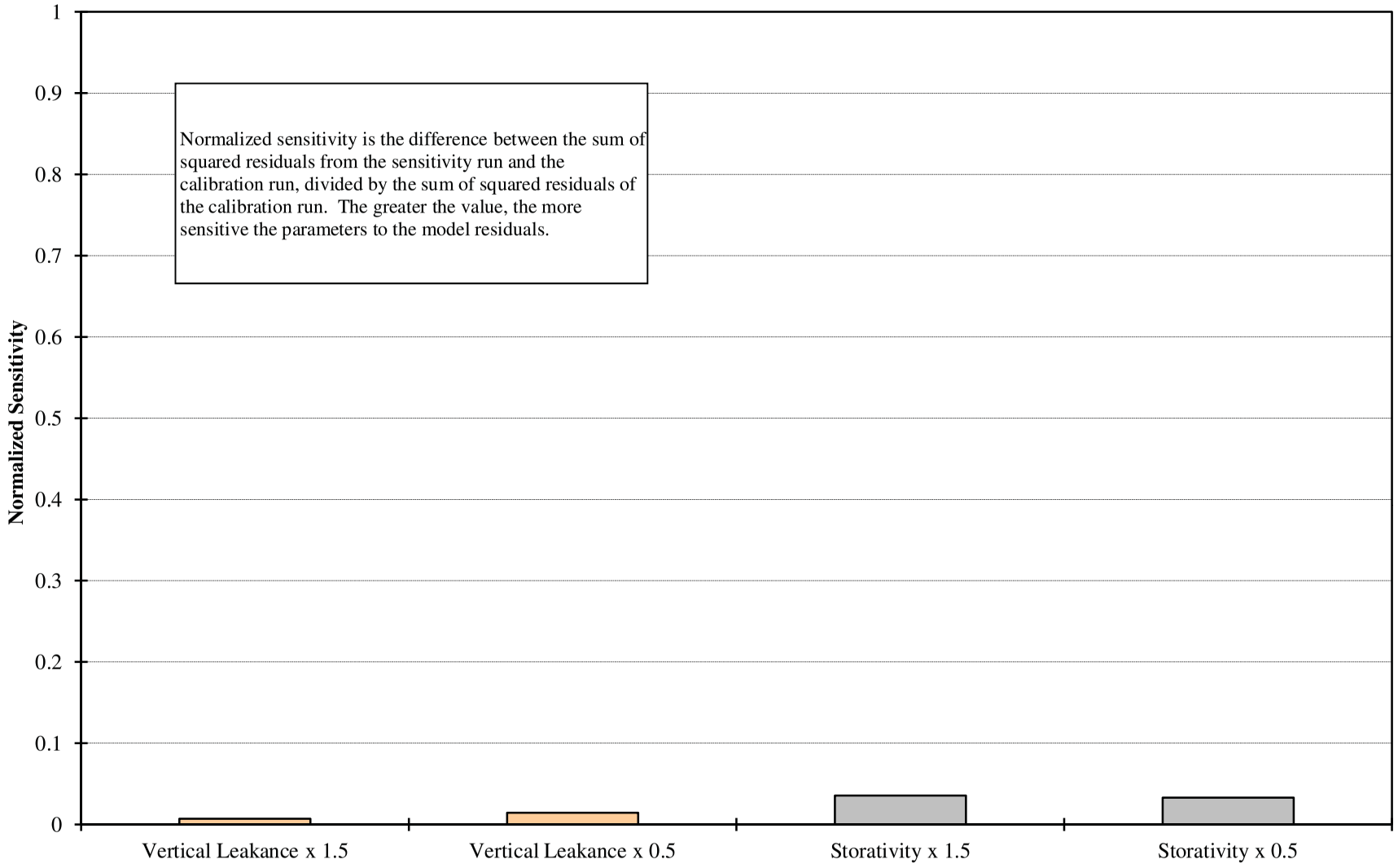
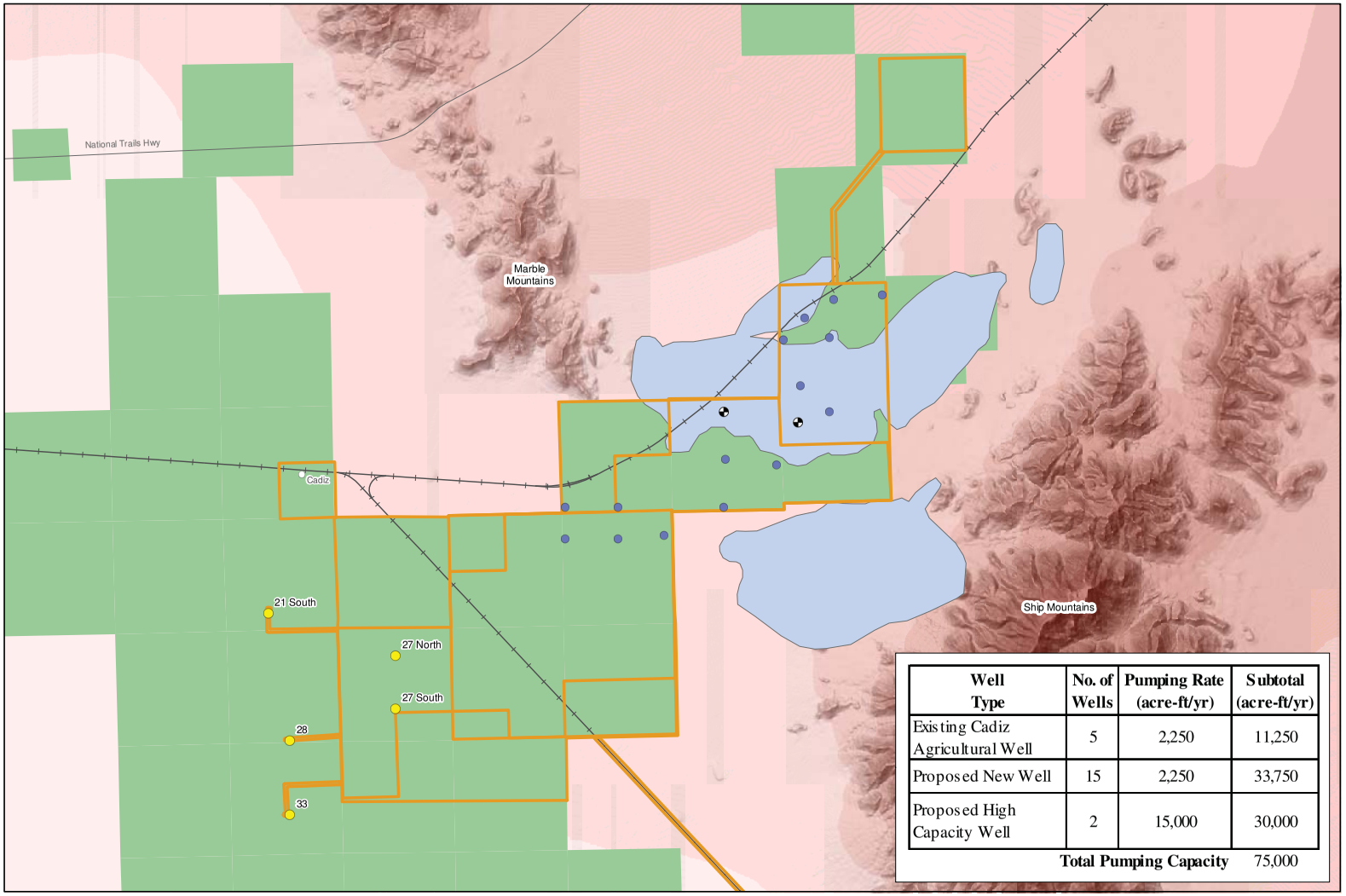


Figure 47

CADIZ CONSERVATION PROJECT SCENARIO WELLFIELD CONFIGURATION A



EXPLANATION

- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- Projected Surface Extent of Carbonate Unit (See Appendix B)
- Existing Cadiz Agricultural Well (pumping 2,250 acre-ft/yr each)
- Proposed New Well (pumping 2,250 acre-ft/yr each)
- Proposed High Capacity Well (pumping 15,000 acre-ft/yr each)

Well Type	No. of Wells	Pumping Rate (acre-ft/yr)	Subtotal (acre-ft/yr)
Existing Cadiz Agricultural Well	5	2,250	11,250
Proposed New Well	15	2,250	33,750
Proposed High Capacity Well	2	15,000	30,000
		Total Pumping Capacity	75,000

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5,000 10,000 Feet

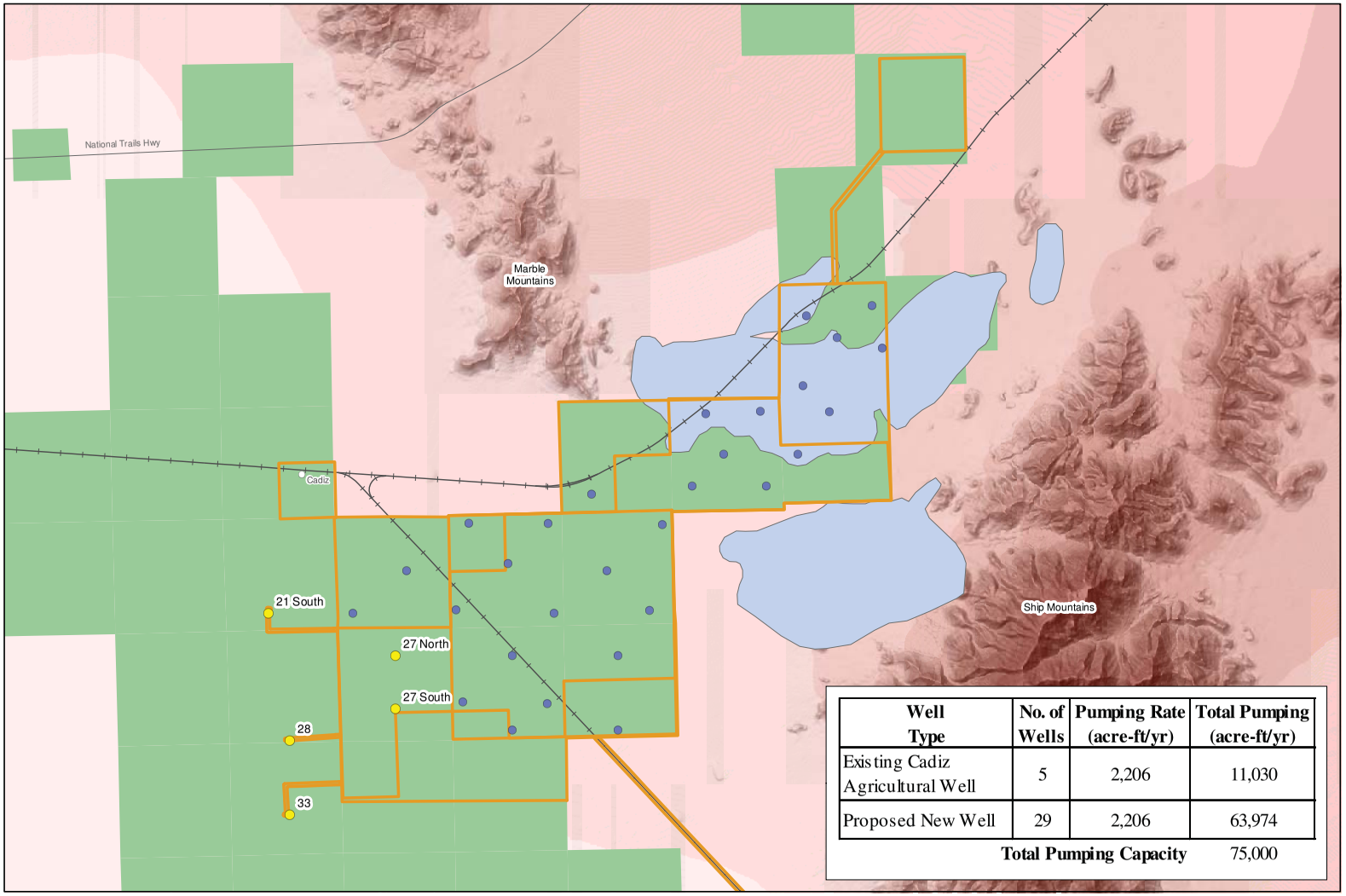
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 48

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_48_wellfield_config_A_9-11.mxd

CADIZ CONSERVATION SENSITIVITY SCENARIOS WELLFIELD CONFIGURATION B



EXPLANATION

- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- Projected Surface Extent of Carbonate Unit (See Appendix B)
- Existing Cadiz Agricultural Well (pumping 2,206 acre-ft/yr each)
- Proposed New Well (pumping 2,206 acre-ft/yr each)

Well Type	No. of Wells	Pumping Rate (acre-ft/yr)	Total Pumping (acre-ft/yr)
Existing Cadiz Agricultural Well	5	2,206	11,030
Proposed New Well	29	2,206	63,974
		Total Pumping Capacity	75,000

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5,000 10,000 Feet

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 49

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_49_wellfield_config_B_9-11.mxd

Cadiz Groundwater Conservation and Storage Project
Annual Pumping for Project Conservation Scenario

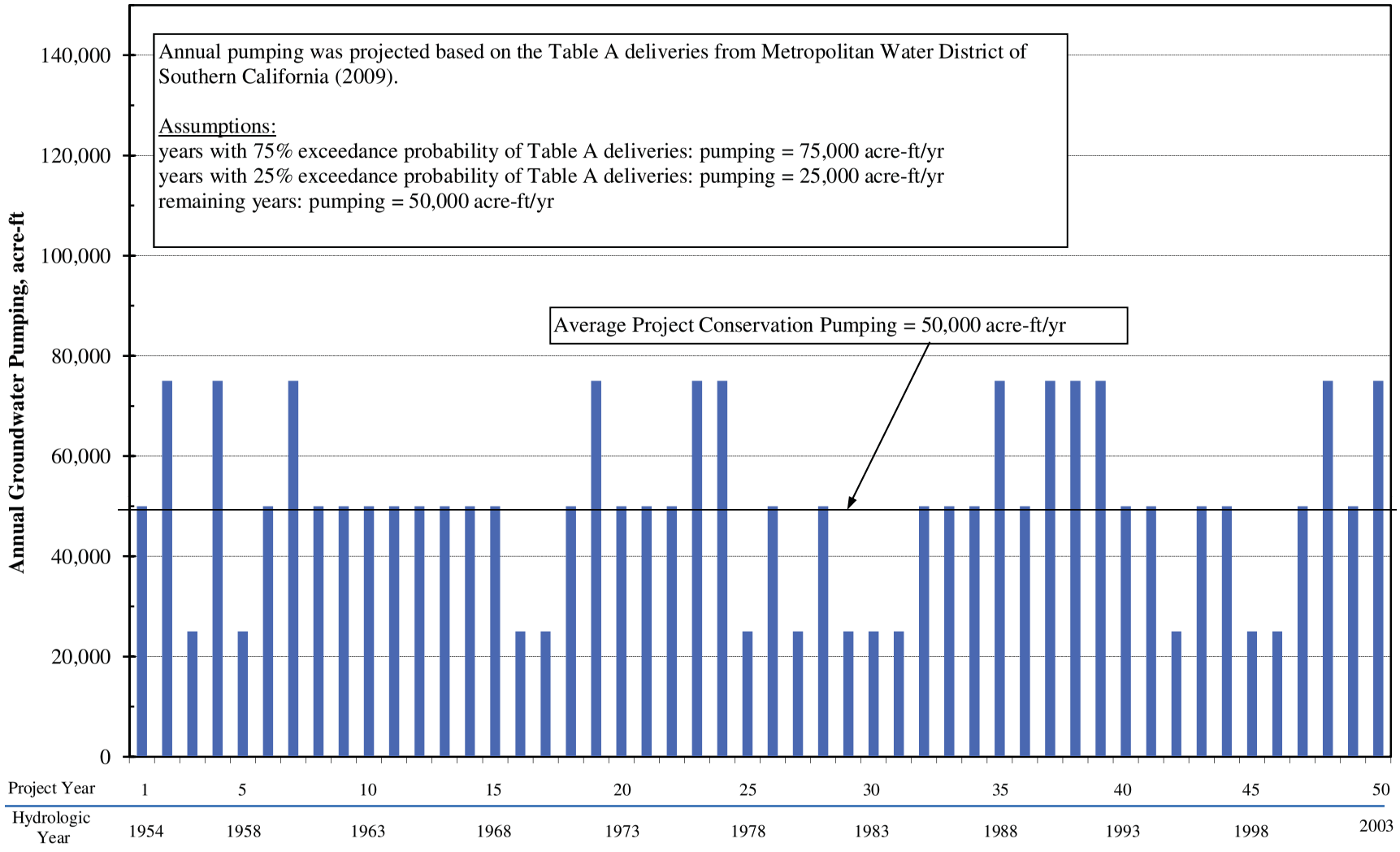
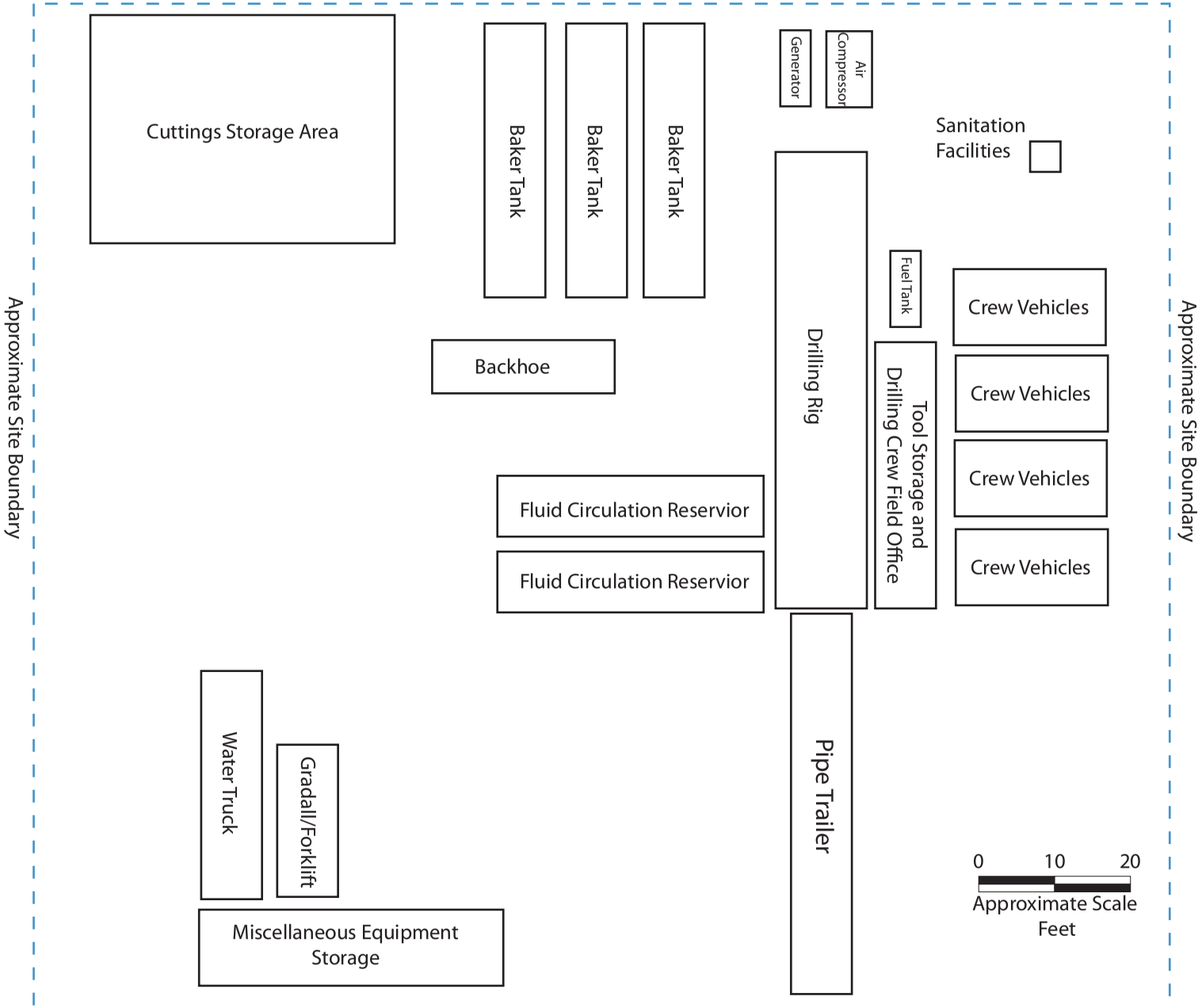


Figure 50



X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\79) 1_Sep_11_Modeling_Report\Figures\Fig_51 Cadiz_Proposal_Site_layout.ai

Figure 51

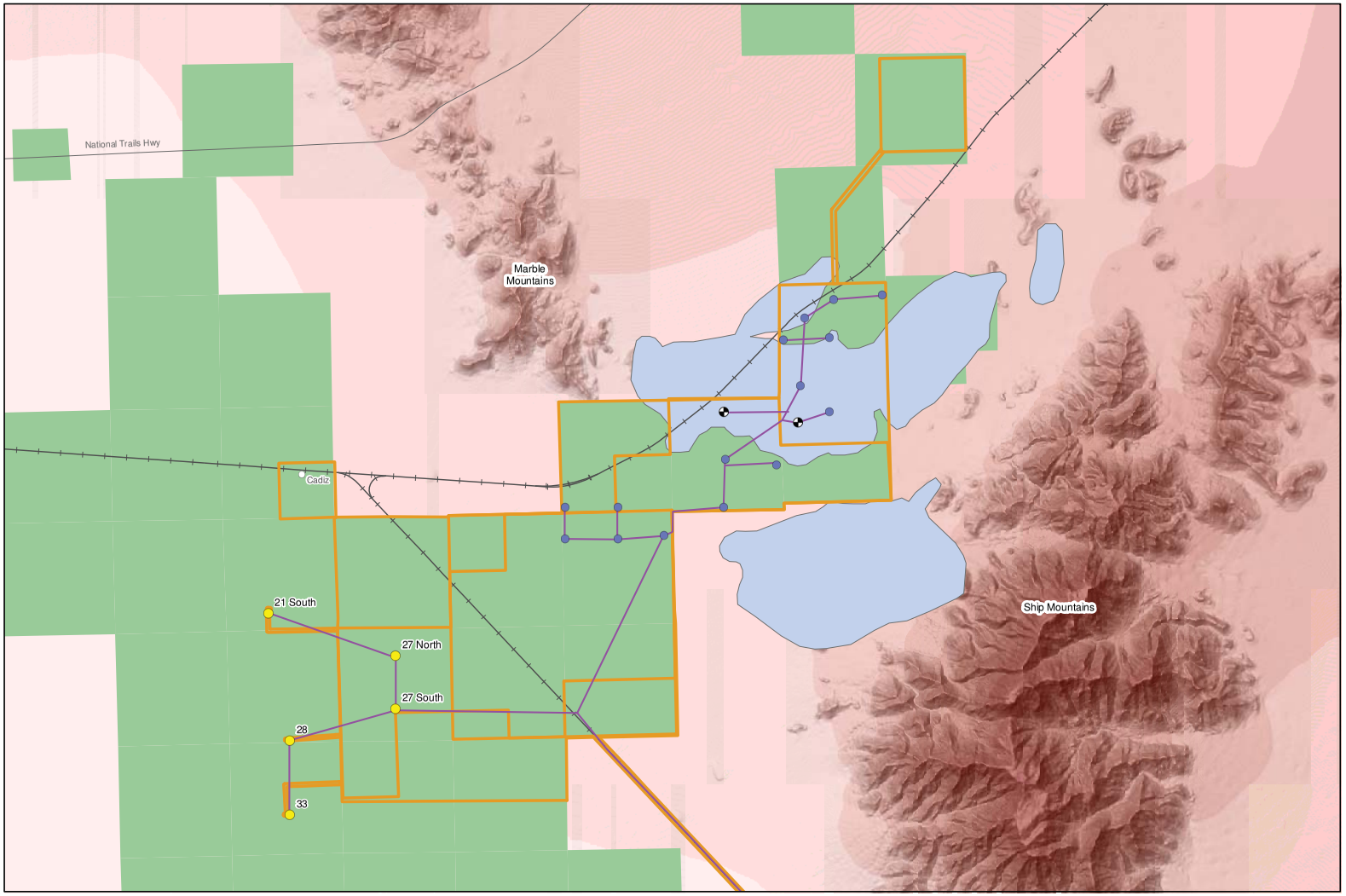
Drawn: CSC
Checked:
Approved:
Date: 1-Sep-11

BROWNSTEIN HYATT FARBER SCHRECK, LLP

CONCEPTUAL DRILL SITE LAYOUT

GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

CADIZ CONSERVATION PROJECT SCENARIO SCHEMATIC OF PROPOSED MANIFOLD SYSTEM



EXPLANATION

- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- Projected Surface Extent of Carbonate Unit (See Appendix B)
- Schematic - Proposed Manifold System
- Existing Cadiz Agricultural Well (pumping 2,250 acre-ft/yr each)
- Proposed New Well (pumping 2,250 acre-ft/yr each)
- Proposed High Capacity Well (pumping 15,000 acre-ft/yr each)

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

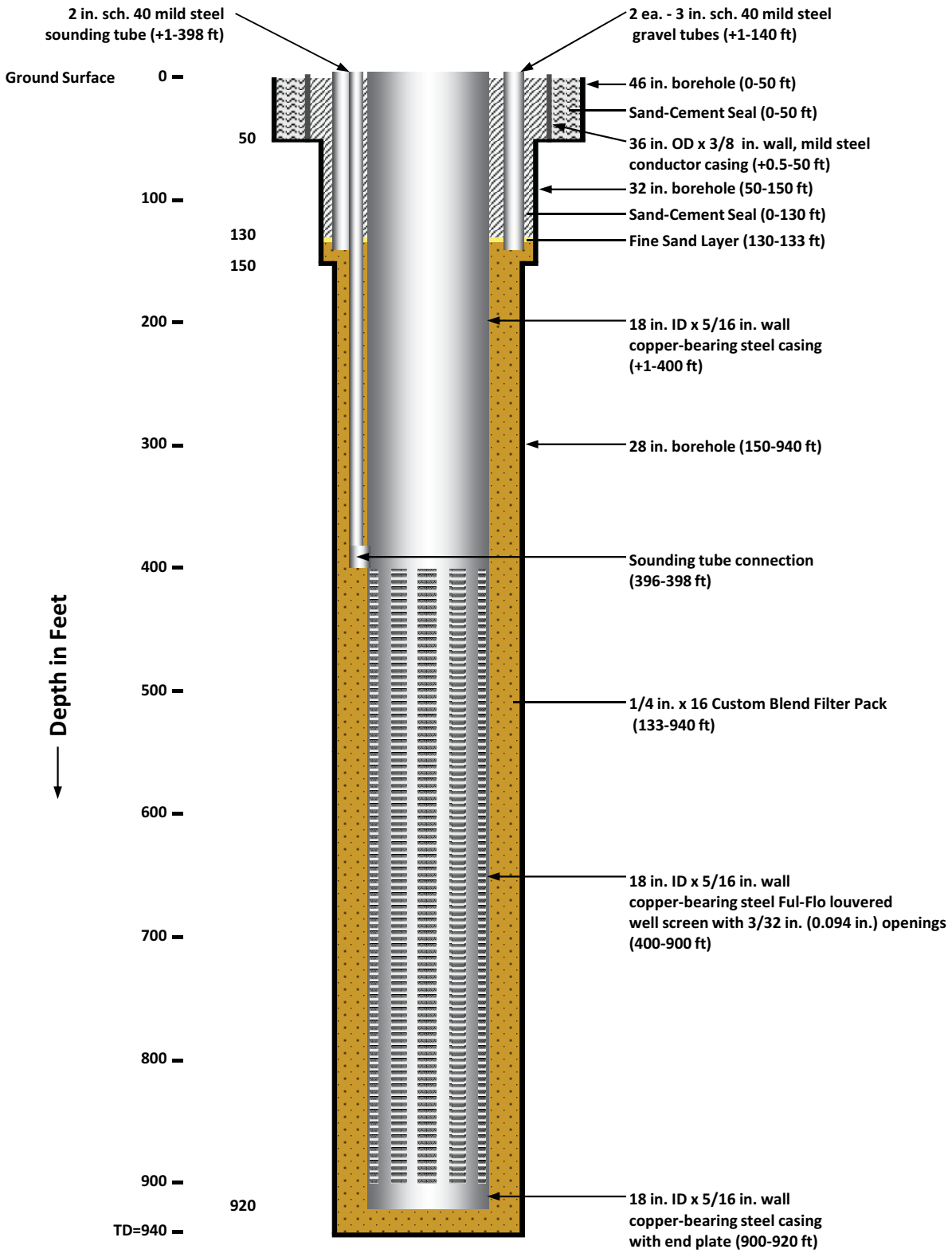
0 5,000 10,000 Feet

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 52

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_52_prop_manifold_sys_9-11.mxd



1-Sep-11

NOT TO SCALE

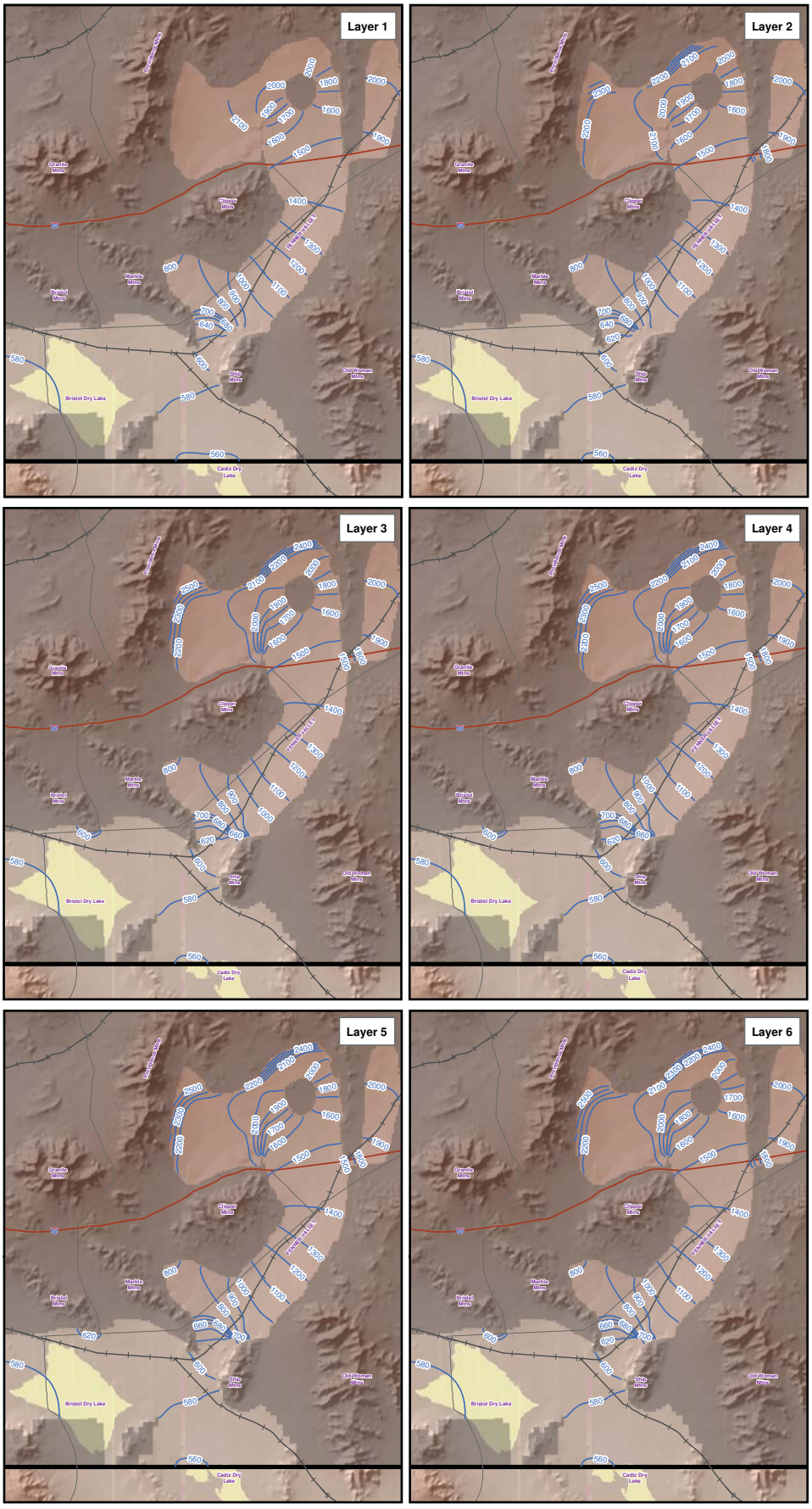
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

BROWNSTEIN HYATT FARBER SCHRECK, LLP

CONCEPTUAL WELL DESIGN DIAGRAM

Figure 53

X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\72) 16_June_2011_Modelling_TM_Draft\figuresFig 07 Well_Design_v2.3.xls



EXPLANATION

—700— Groundwater Elevation (ft amsl)

Groundwater Model Boundary

No Flow Model Cell

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

INITIAL GROUNDWATER ELEVATIONS FOR PROJECT SCENARIO NATURAL RECHARGE OF 32,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

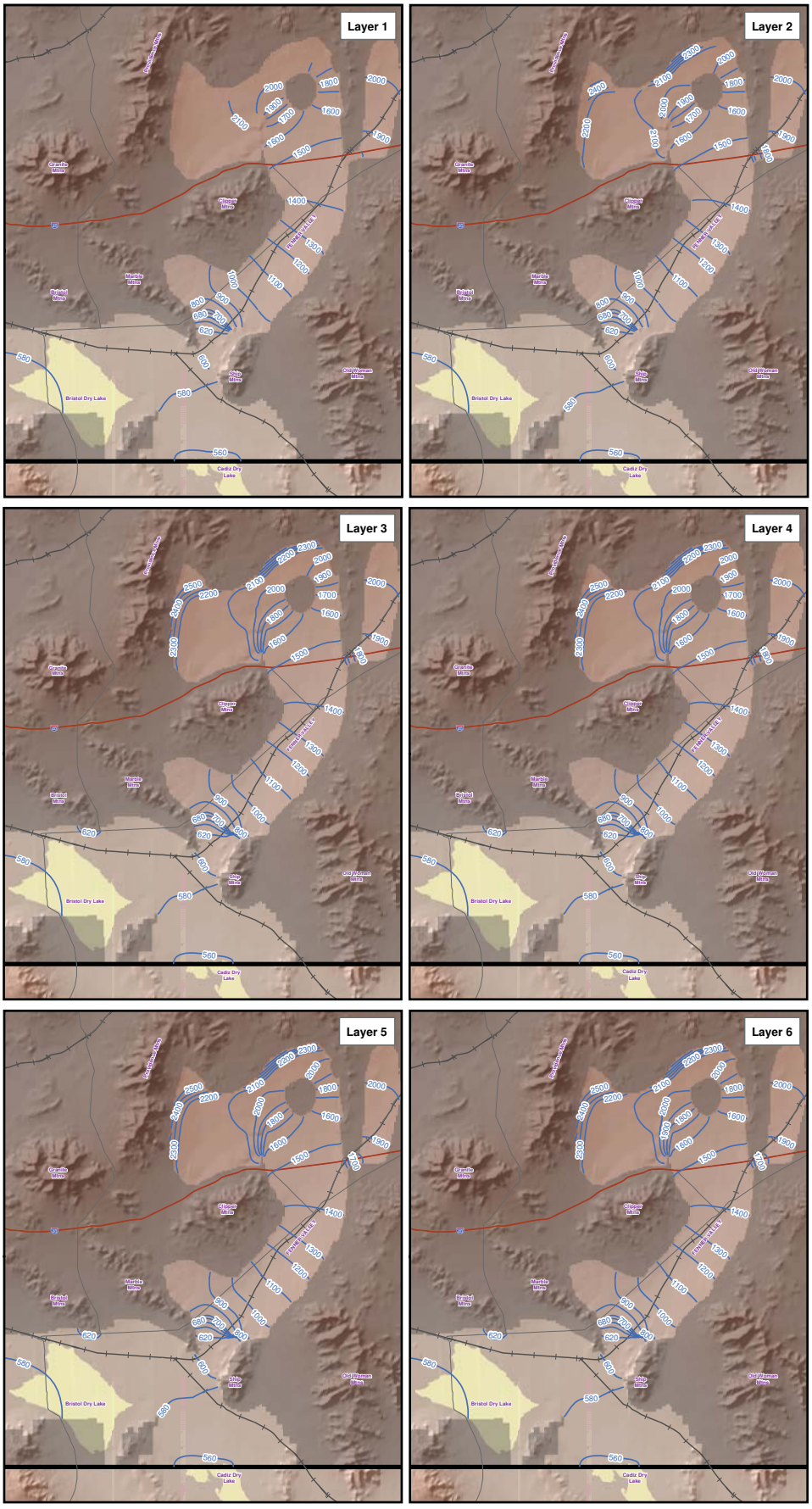
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 54

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_54_6panel_init_gw_elev_32k_proj_scen_9-11.mxd



EXPLANATION

700 — Initial Groundwater Elevation (ft amsl)

Groundwater Model Boundary

No Flow Model Cell

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

INITIAL GROUNDWATER ELEVATIONS FOR SENSITIVITY SCENARIO 1 NATURAL RECHARGE OF 16,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

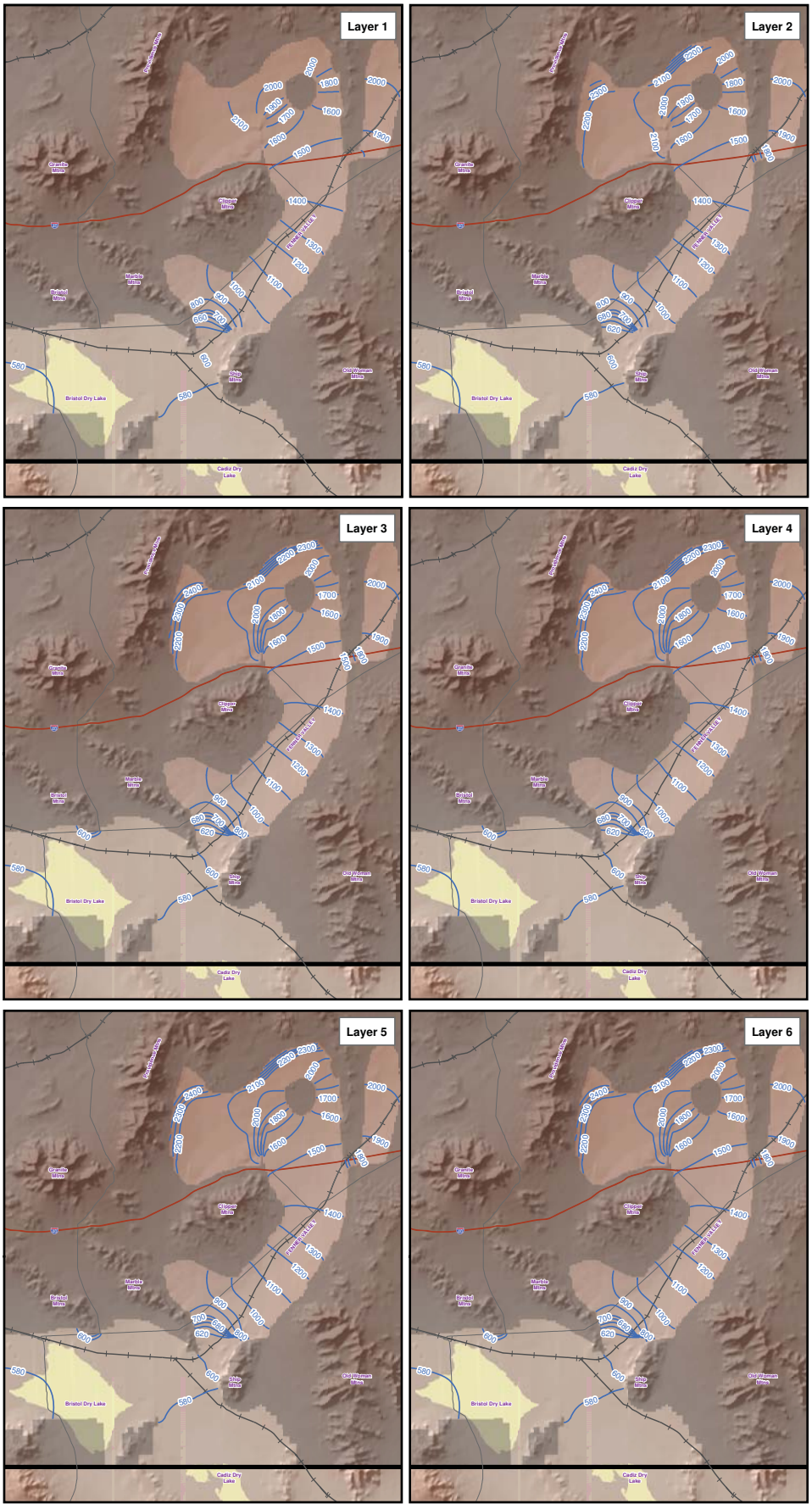
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 55

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_55_6panel_init_gw_elev_16k_scen1_9-11.mxd



EXPLANATION

—700— Initial Groundwater Elevation (ft amsl)

Groundwater Model Boundary

No Flow Model Cell

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

INITIAL GROUNDWATER ELEVATIONS FOR SENSITIVITY SCENARIO 2 NATURAL RECHARGE OF 5,000 ACRE-FT/YR

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

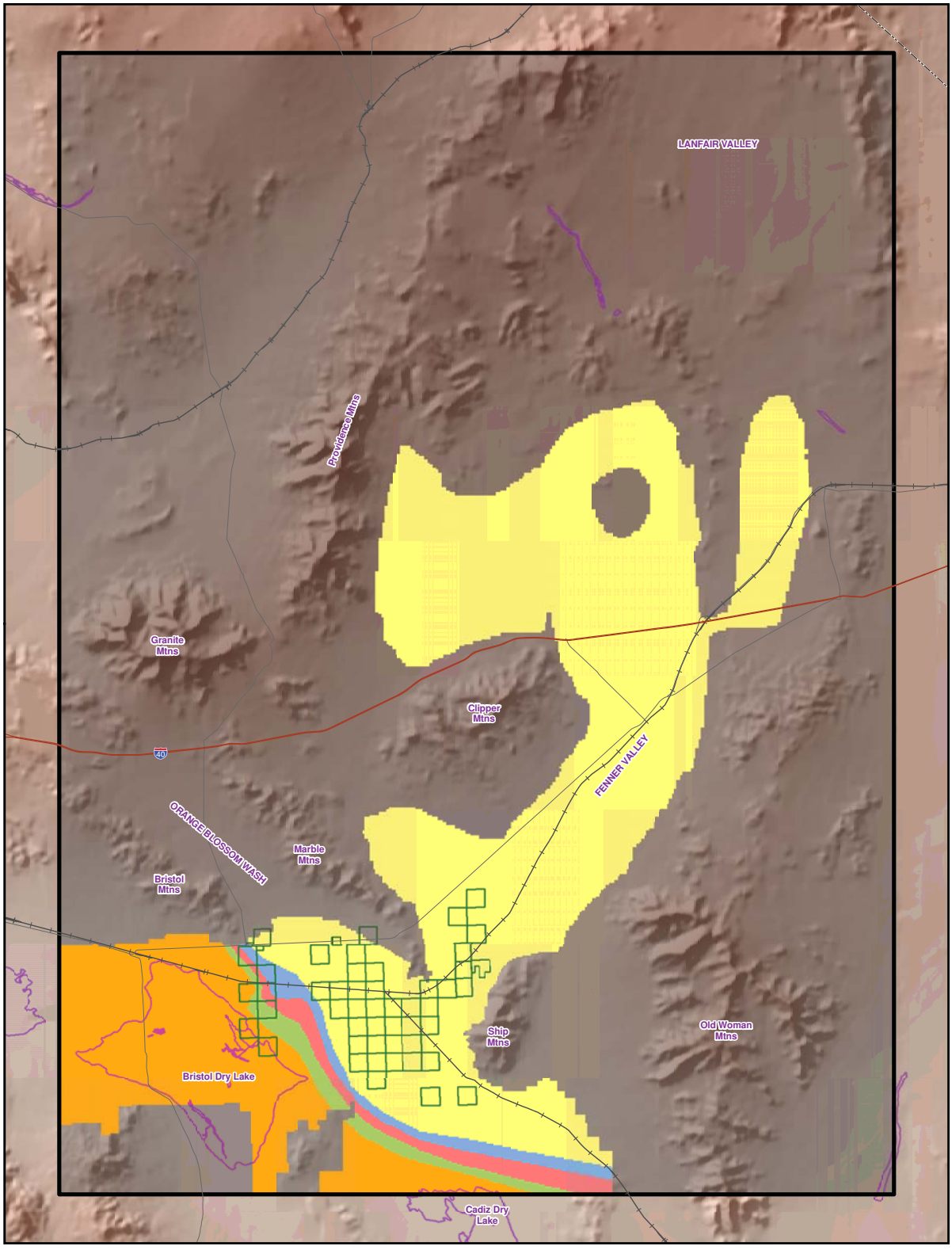
0 5.5 11 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 56

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_56_6panel_init_gw_elev_5k_scen2_9-11.mxd



INITIAL TDS CONCENTRATIONS FOR PROJECT SCENARIO, SENSITIVITY SCENARIO 1 AND SENSITIVITY SCENARIO 2

1-Sep-11

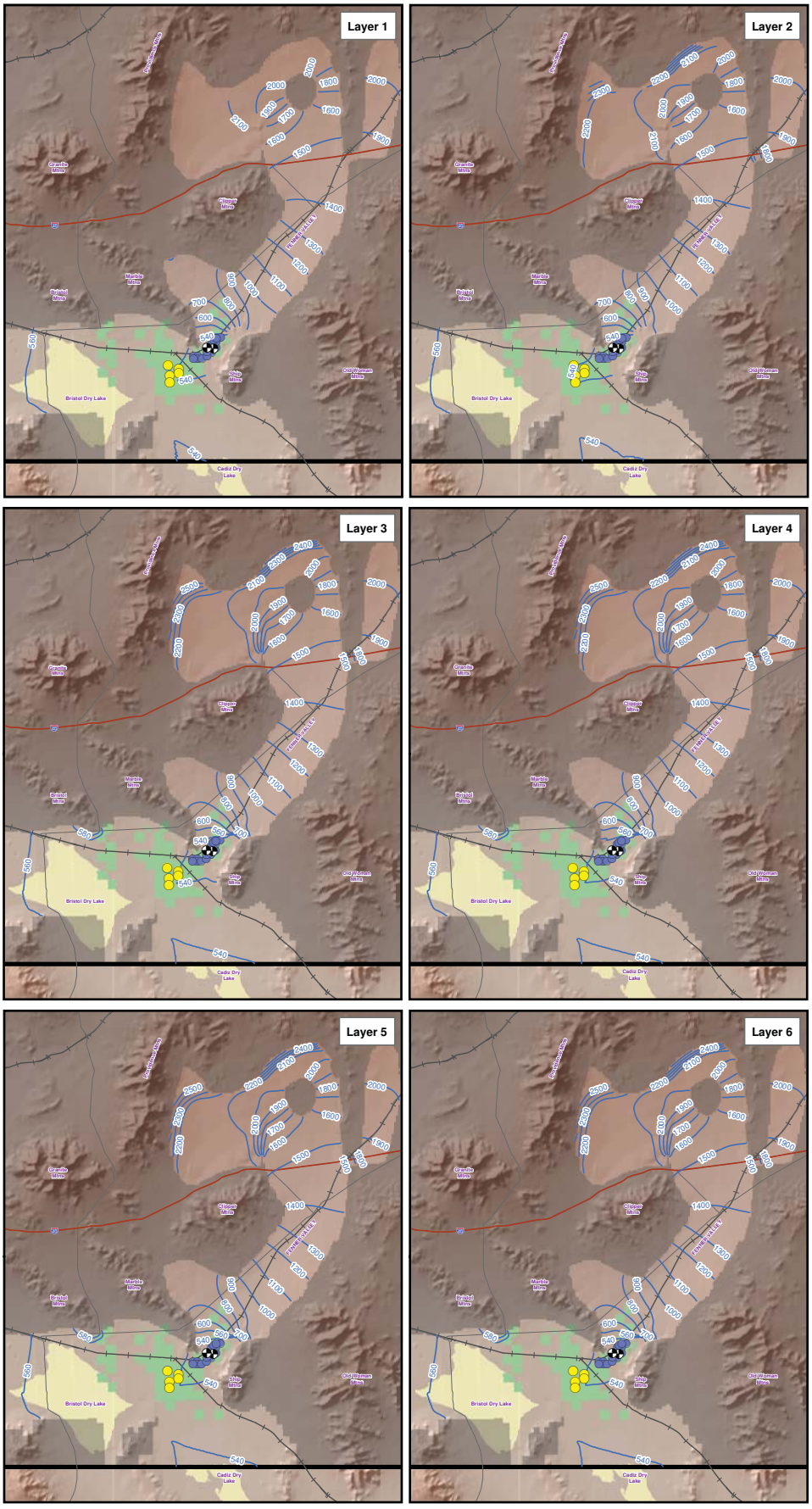
Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 57

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_57_sce_TDS_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 50 YEARS

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

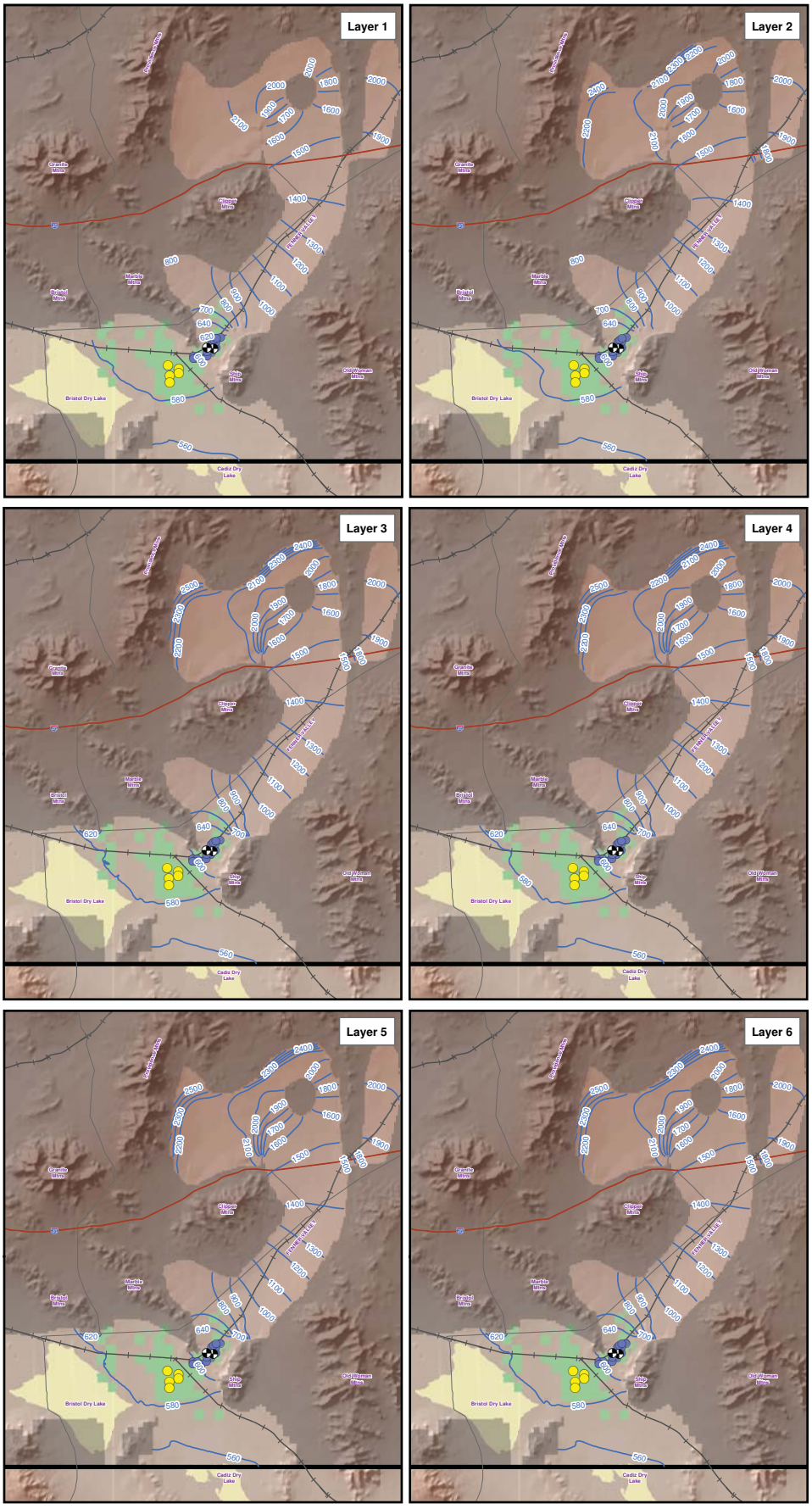
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 58

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_58_32k_gw_elev_50yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 100 YEARS

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

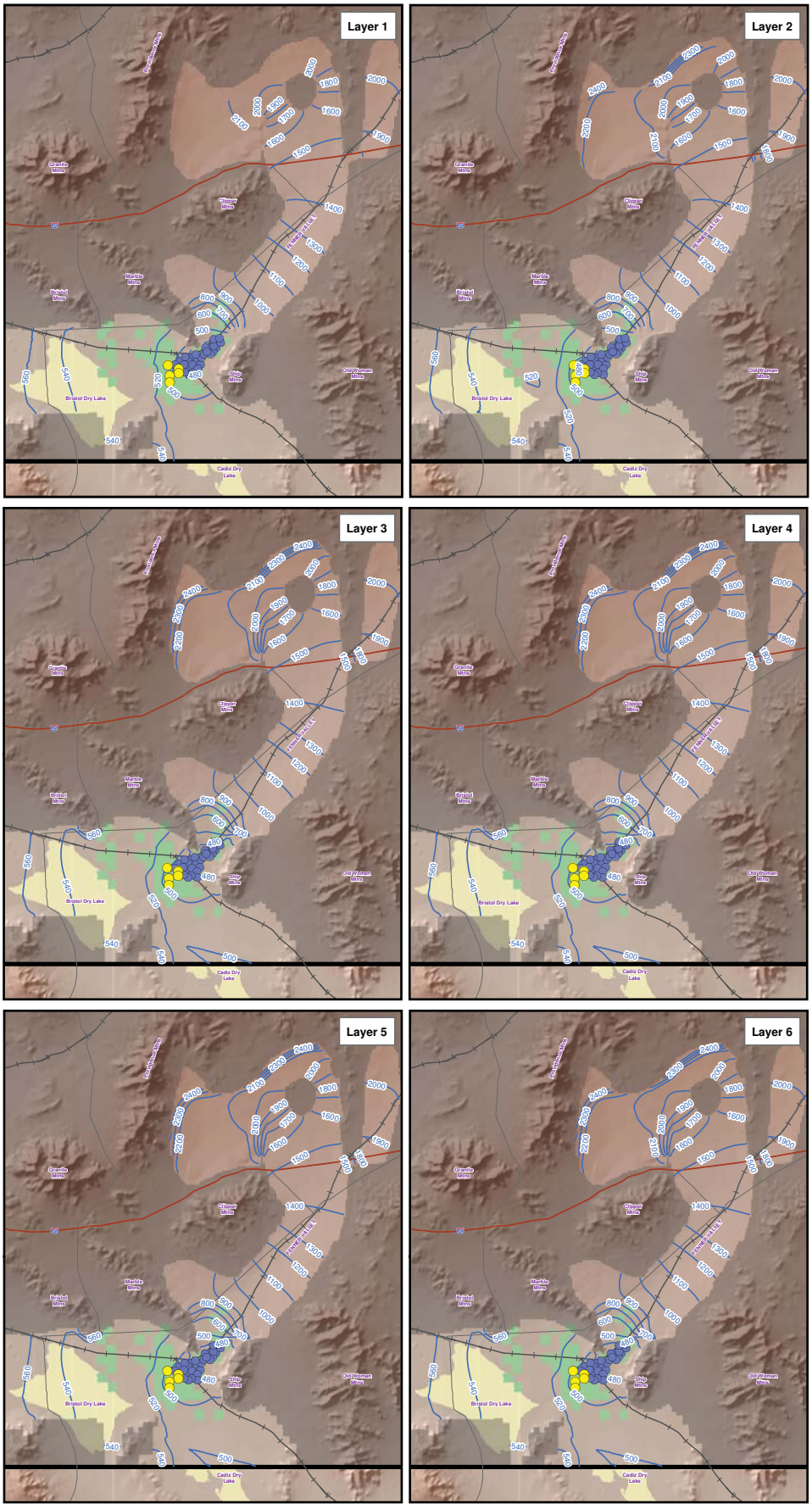
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 59

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_59_32k_gw_elev_100yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 50 YEARS

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

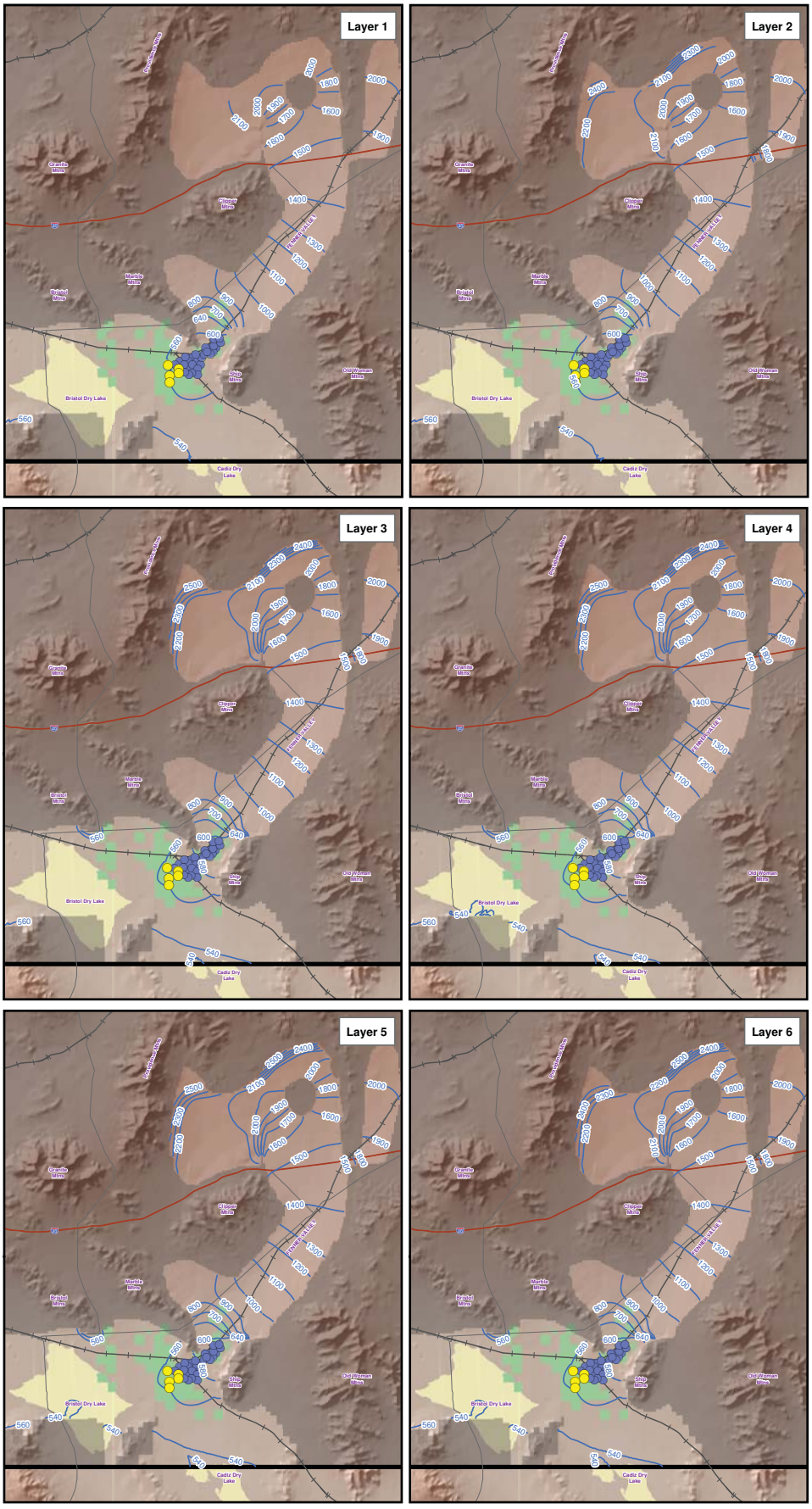
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

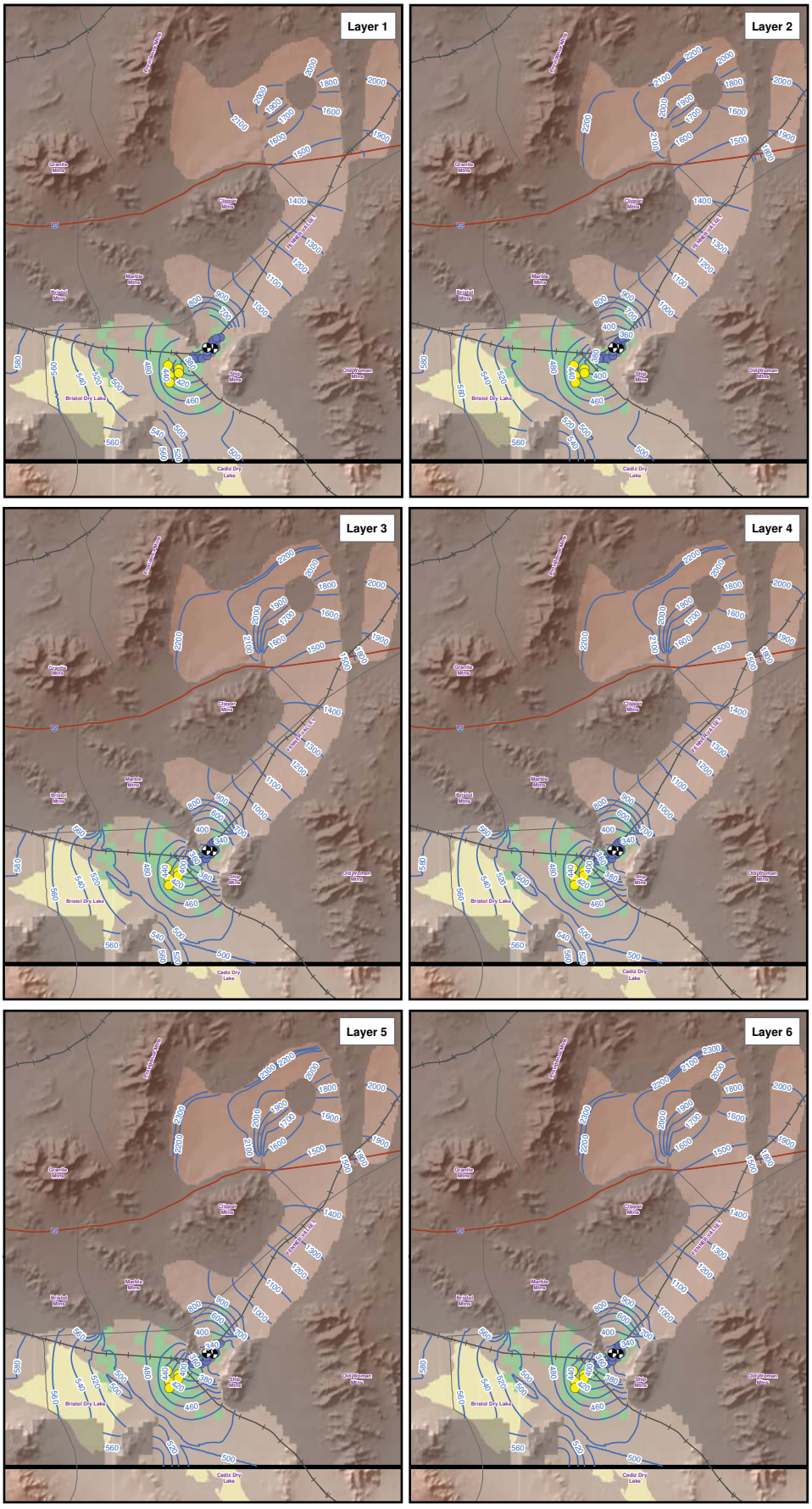
NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 60

GIS_proj/brownstein_cadiz_techmemo_gw_model_8-11/0_Fig_60_16k_gw_elev_50yr_9-11.mxd


Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6
Granite Mtns
Chiriaco Mtns
Marble Mtns
Rattlesnake Mtns
Old Woman Mtns
Bristol Dry Lake
Cadiz Dry Lake
Piute Valley
Danby Dry Lake
Orange Blossom Wash
Piute Wash
Milepost 240
Milepost 241
Milepost 242
Milepost 243
Milepost 244
Milepost 245
Milepost 246
Milepost 247
Milepost 248
Milepost 249
Milepost 250
Milepost 251
Milepost 252
Milepost 253
Milepost 254
Milepost 255
Milepost 256
Milepost 257
Milepost 258
Milepost 259
Milepost



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 50 YEARS

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

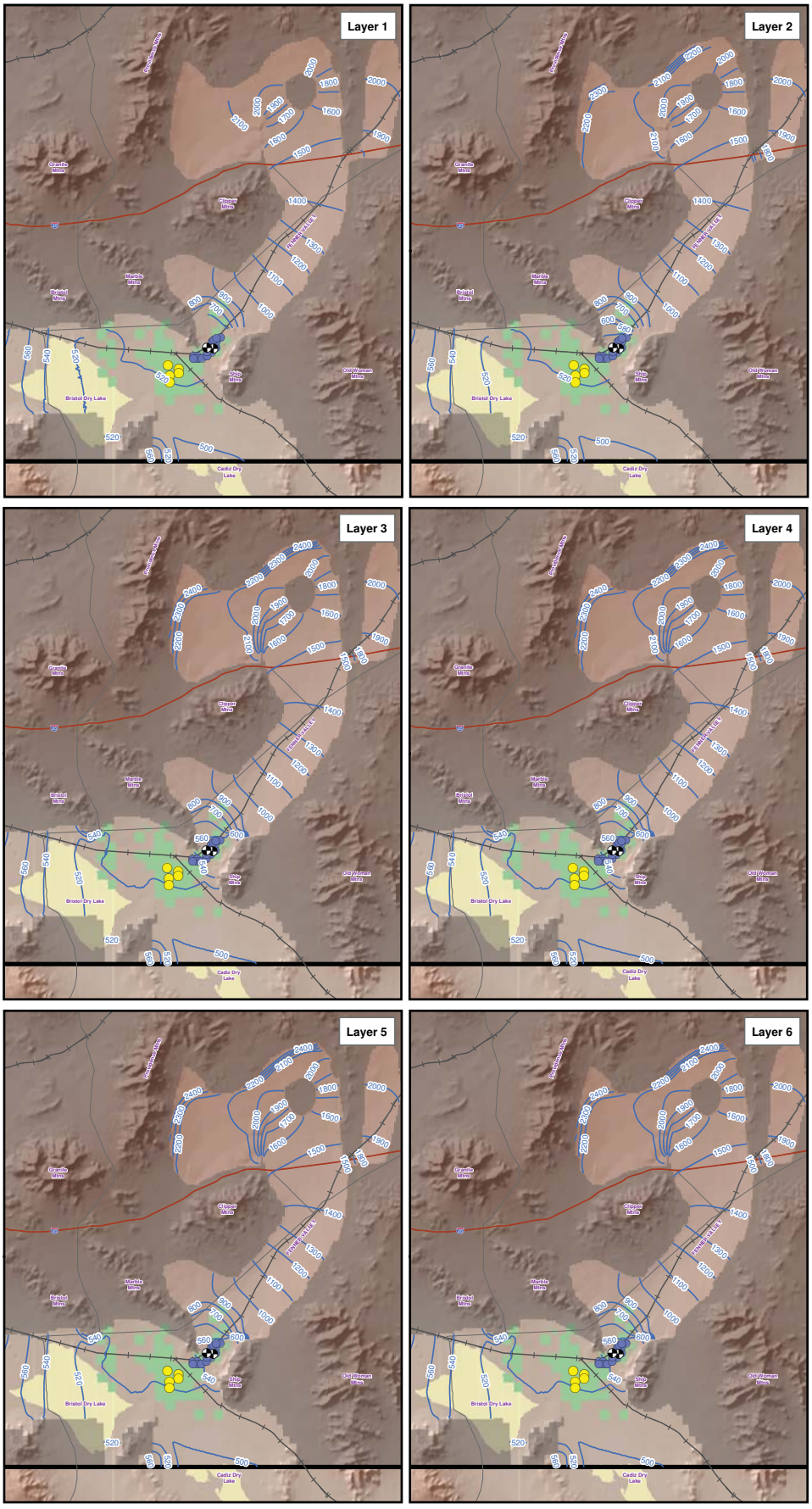
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 62

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_62_5k_gw_elev_50yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

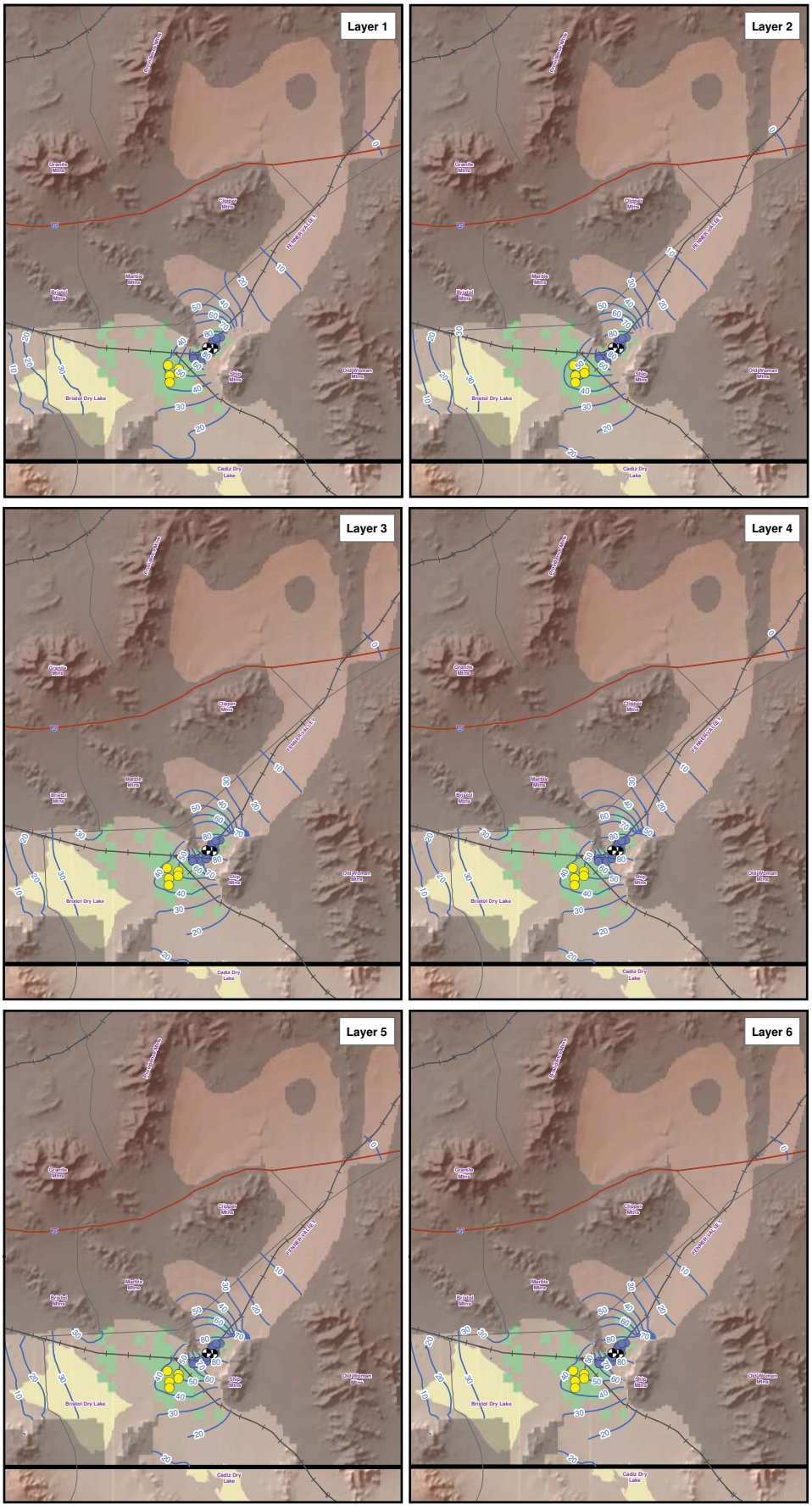
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 63

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_63_5k_gw_elev_100yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

REGIONAL DRAWDOWN AT THE END OF 50 YEARS

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

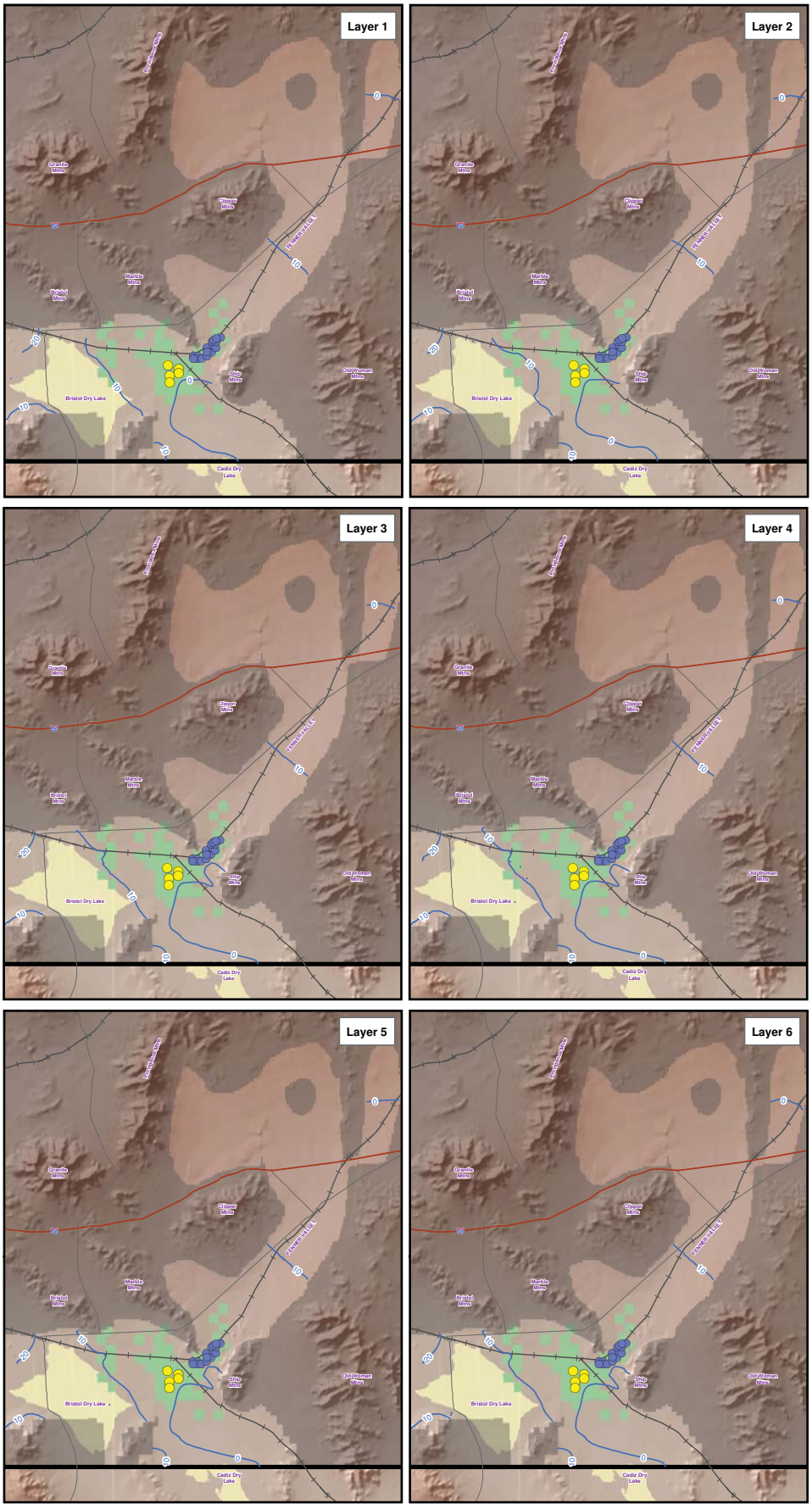
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 64

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_64_32k_dd_50yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

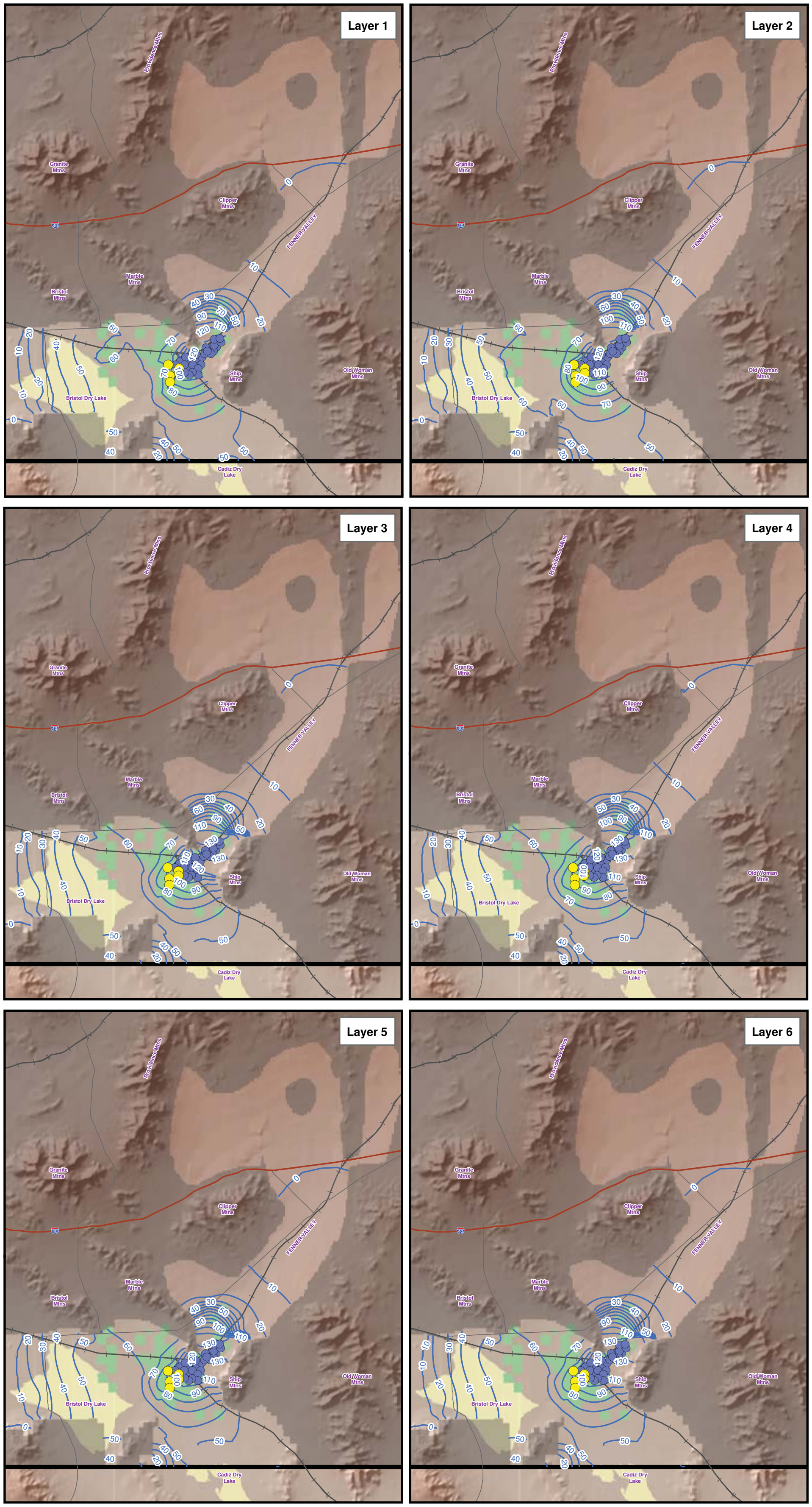
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 65

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_65_32k_dd_100yr_9-11.mxd

BROWNSTEIN HYATT
FARBER SCHRECK, LLP

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 50 YEARS

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

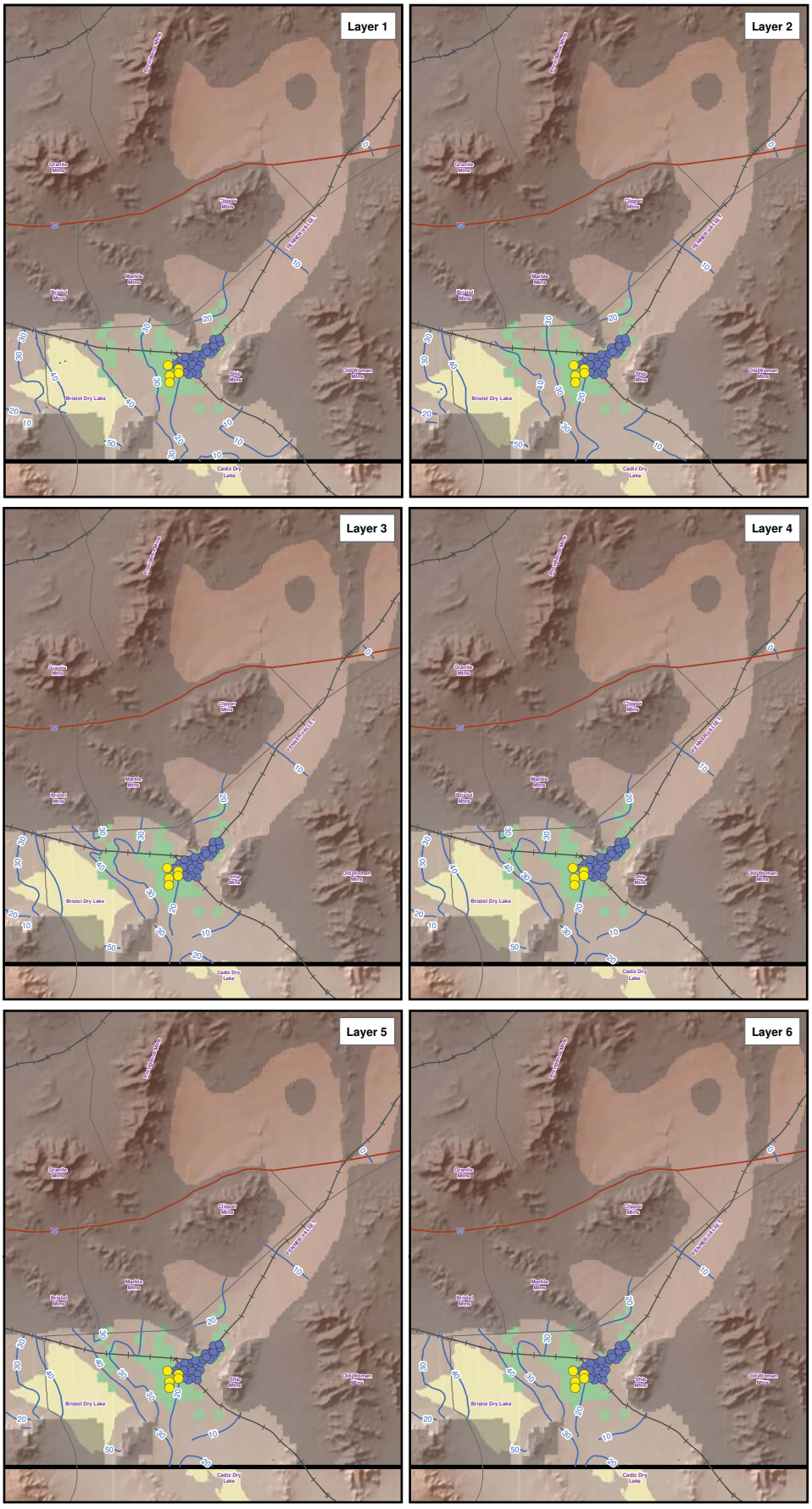
NORTH

0 5.5 11 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 66

GIS_proj/brownstein_cadiz_techmemo_gw_model_8-11/0_Fig_66_16k_dd_50yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

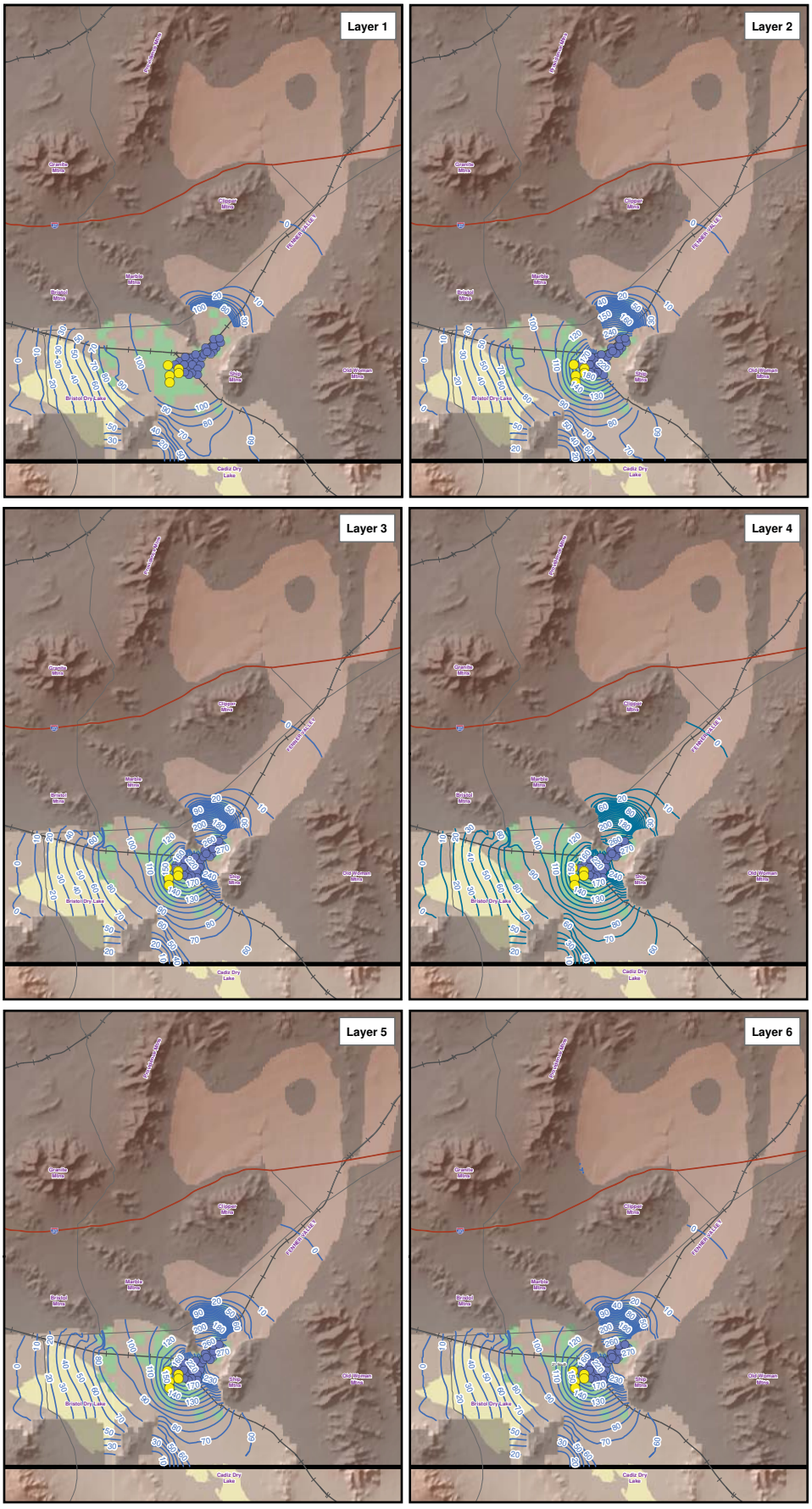
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH
0 5.5 11
Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 67

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_67_16k_dd_100yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 50 YEARS

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

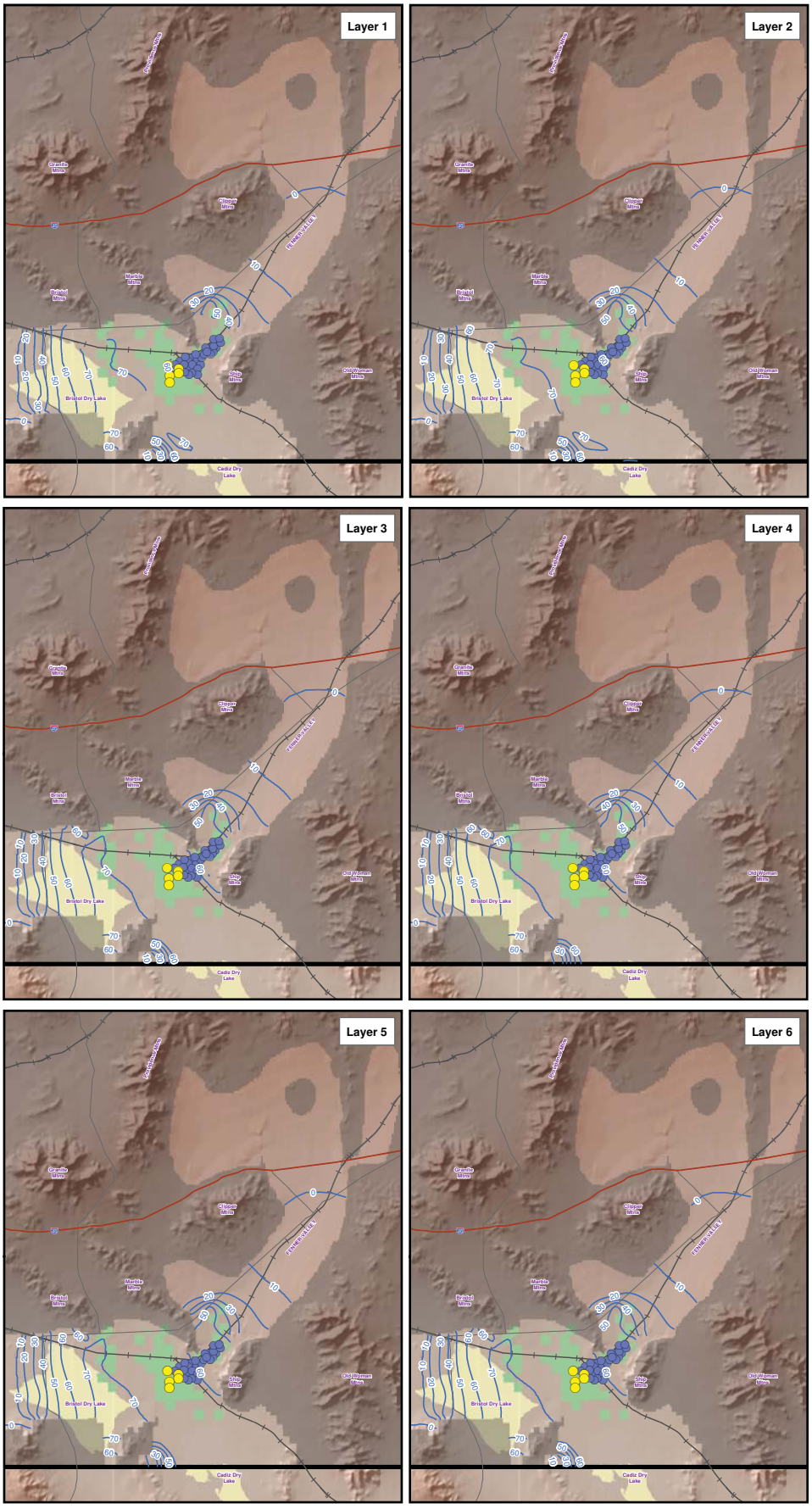
NORTH

0 5.5 11 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 68

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_68_5k_dd_50yr_9-11.mxd



EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

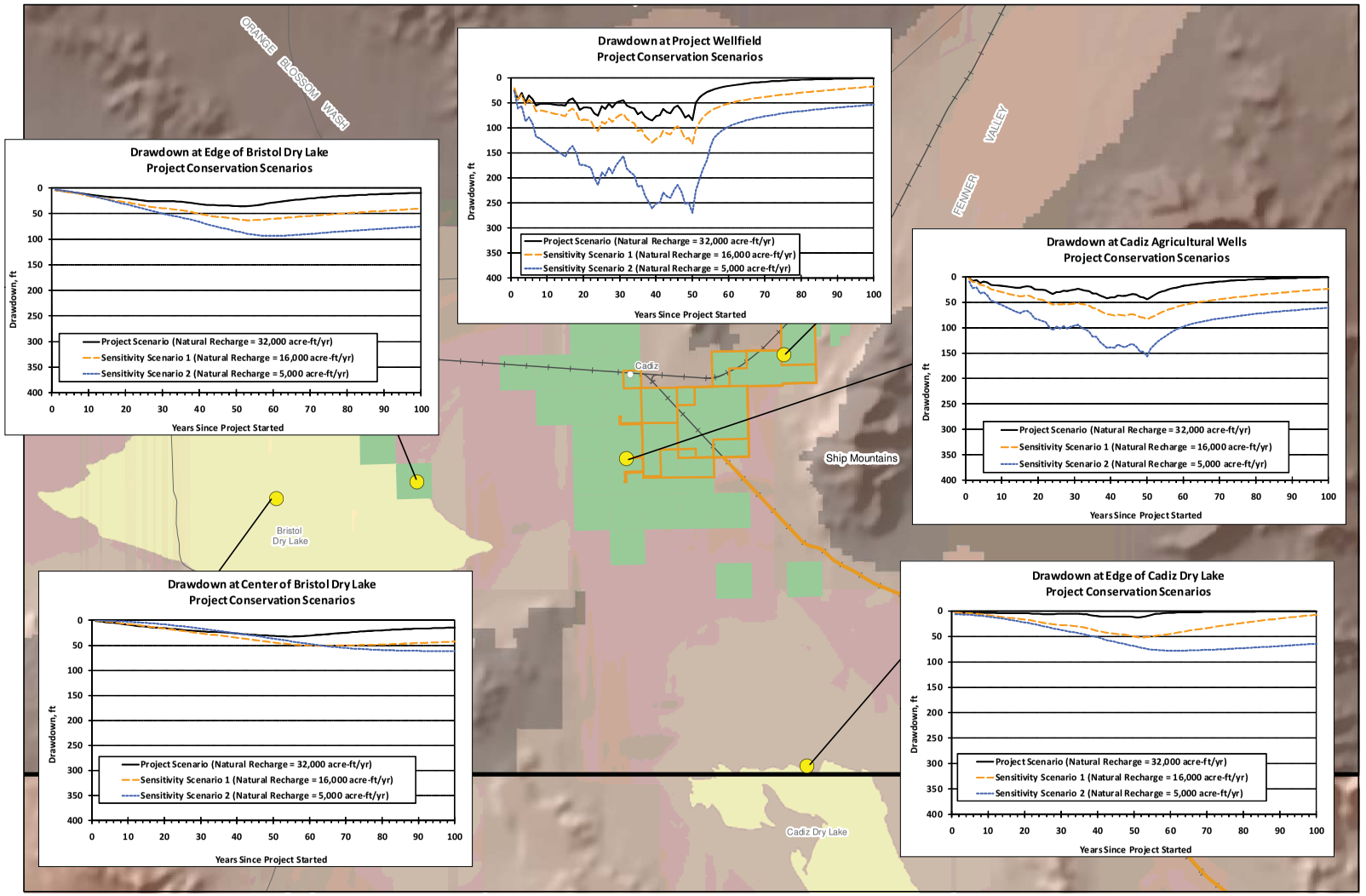
NORTH
0 5.5 11 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 69

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_69_5k_dd_100yr_9-11.mxd

MODEL-CALCULATED DRAWDOWN AT SELECTED LOCATIONS



EXPLANATION

- Location with Drawdown Over Time
- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- No Flow Model Cell

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 3 6 Miles

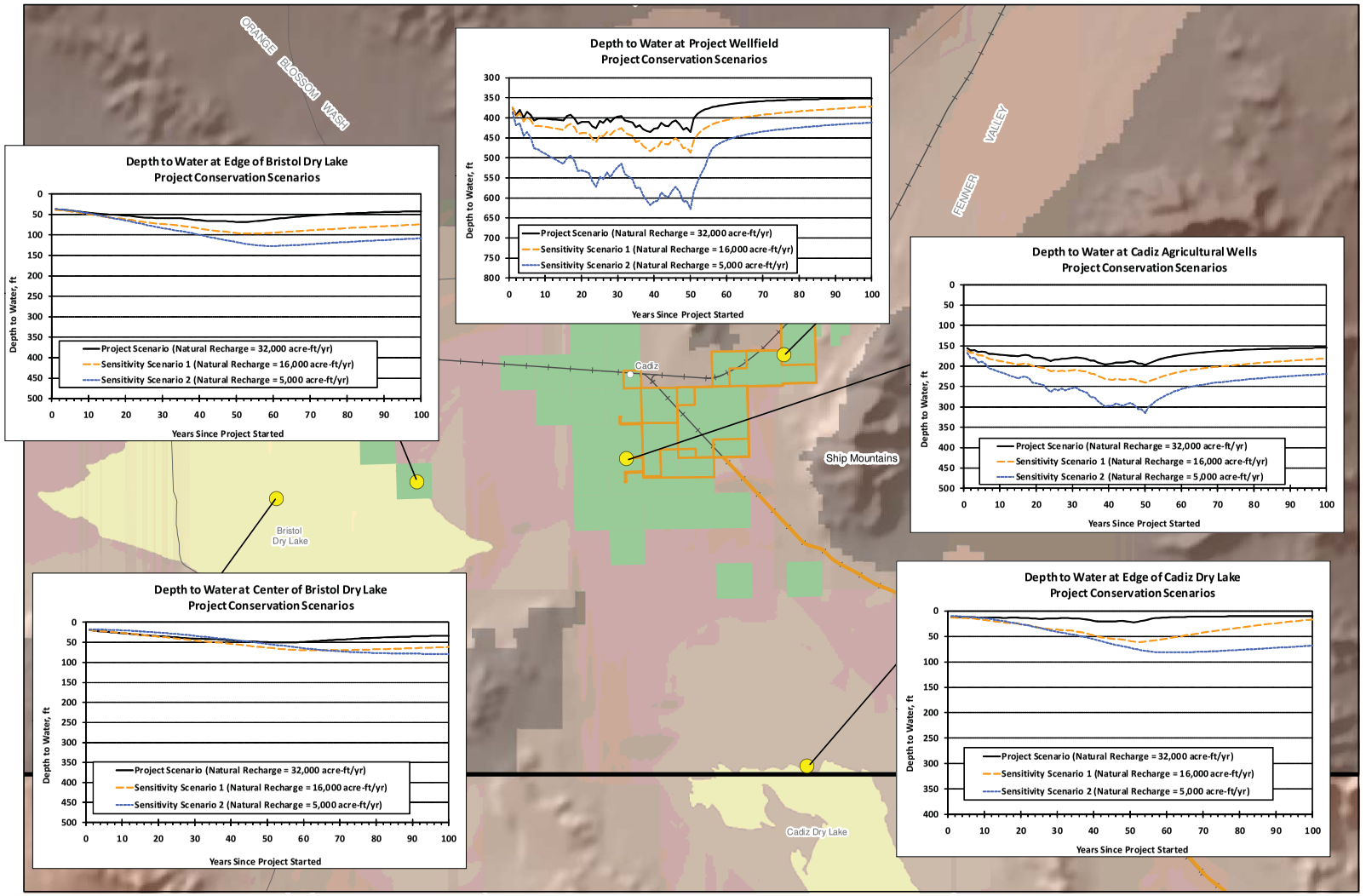
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 70

GIS_proj/brownstein_cadiz_techmemo_gw_model_8-11.0_Fig_70_DD_hydrographs_9-11.mxd

MODEL-CALCULATED DEPTH TO WATER AT SELECTED LOCATIONS



EXPLANATION

- Location with Depth to Water Over Time
- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- No Flow Model Cell

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

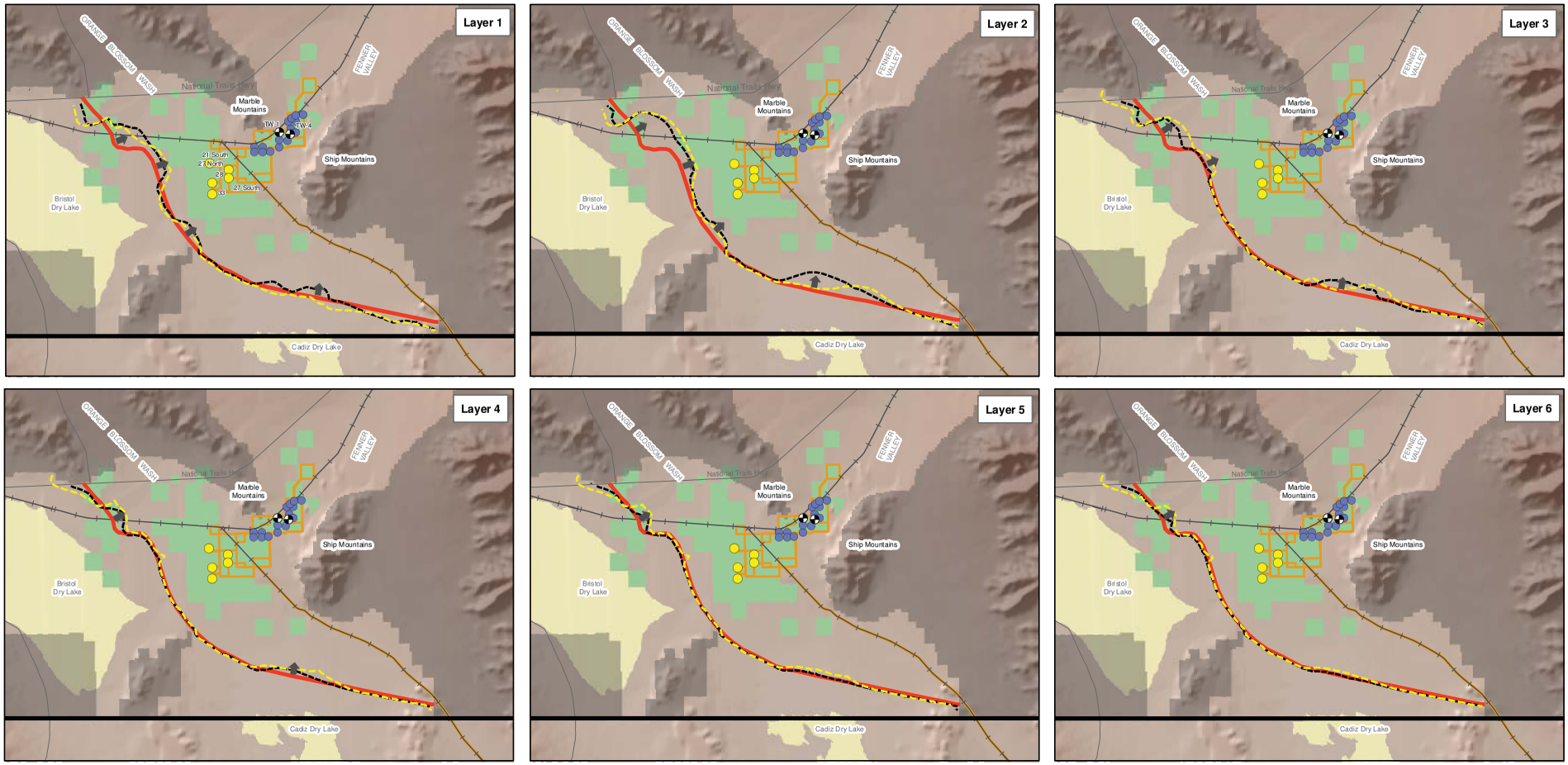
0 3 6 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 71

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_71_DTW_hydrographs_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Proposed Wellfield Development Areas and Pipeline

Existing Cadiz Agricultural Well

Proposed New Well

Proposed High Capacity Well

Direction of Saline Water / Freshwater Interface Movement

Current Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

Model-Generated Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

At the End of 50 Years (end of project pumping)

At the End of 100 Years (end of model simulation)

NORTH

0 6 12 Miles

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

MODEL-GENERATED SALINE WATER AND FRESHWATER INTERFACE (TDS = 1,000 mg/L)

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

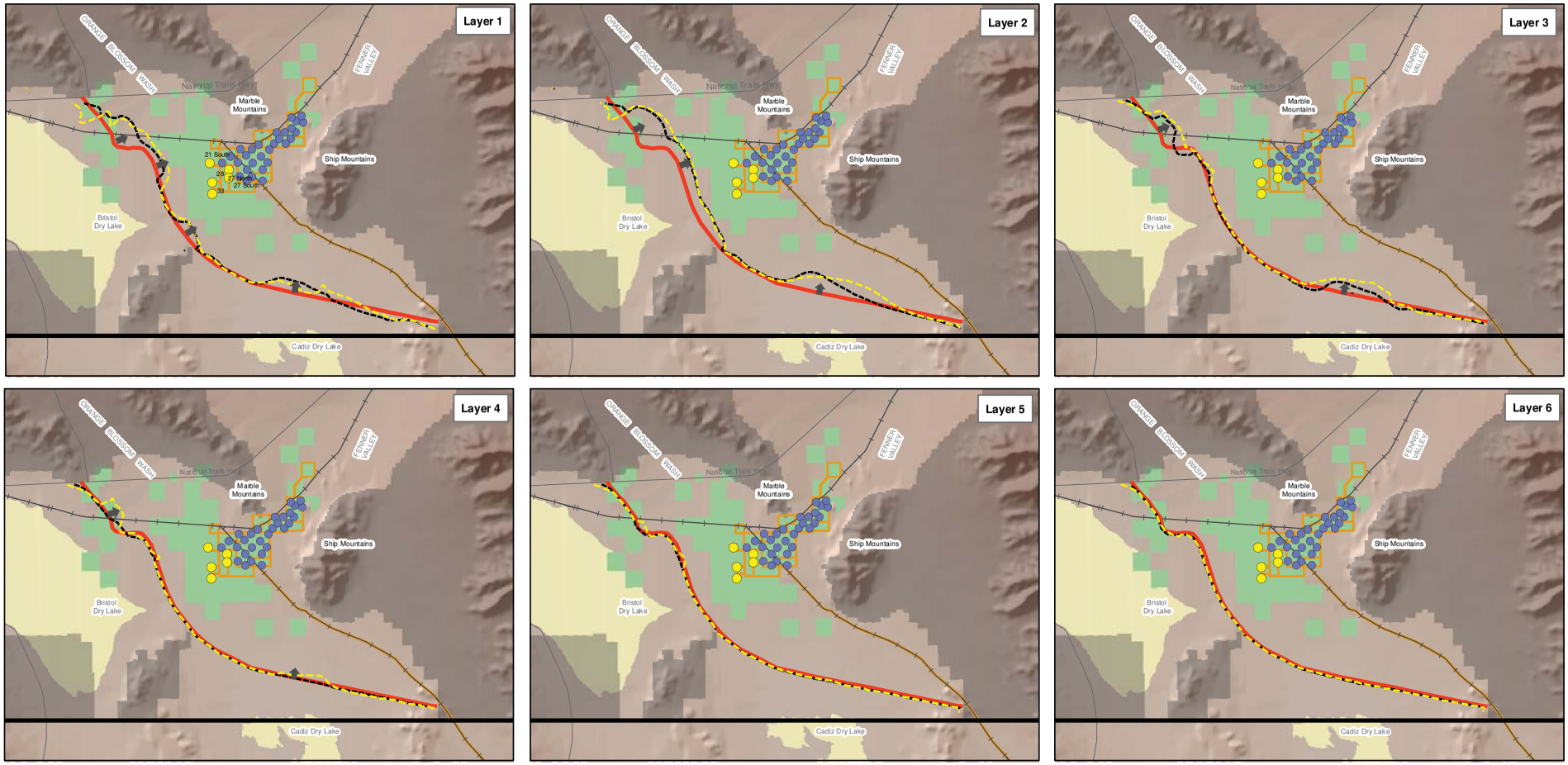
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 72

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_72_6panel_saline_32k_50and100yr_9-11.mxd



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Proposed Wellfield Development Areas and Pipeline

Existing Cadiz Agricultural Well

Proposed New Well

Direction of Saline Water / Freshwater Interface Movement

Current Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

Model-Generated
Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

- - - At the End of 50 Years (end of project pumping)

- - - At the End of 100 Years (end of model simulation)

NORTH

0 6 12 Miles

Sensitivity Scenario 1

Natural Recharge of
16,000 acre-ft/yr

Wellfield Configuration B
(5 Existing Cadiz Wells
and 29 New Wells)

MODEL-GENERATED SALINE WATER AND FRESHWATER INTERFACE (TDS = 1,000 mg/L)

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

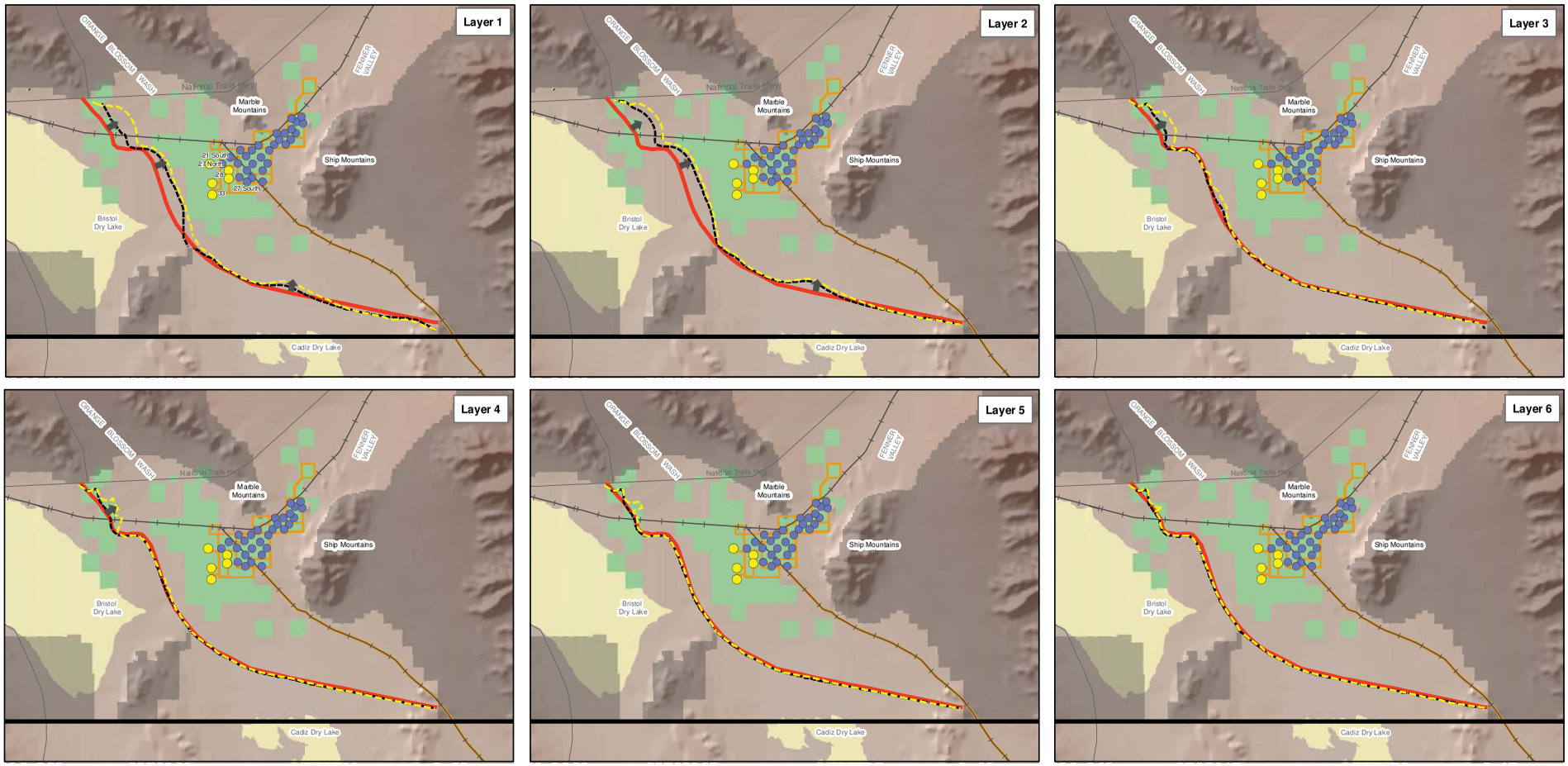
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 73

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_73_6panel_saline_SC_16k_scen1_50and100yr_9-11.mxd



1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

Sensitivity Scenario 2

Natural Recharge of
5,000 acre-ft/yr

Wellfield Configuration B
(5 Existing Cadiz Wells
and 29 New Wells)

MODEL-GENERATED SALINE WATER AND FRESHWATER INTERFACE (TDS = 1,000 mg/L)

SENSITIVITY SCENARIO 2

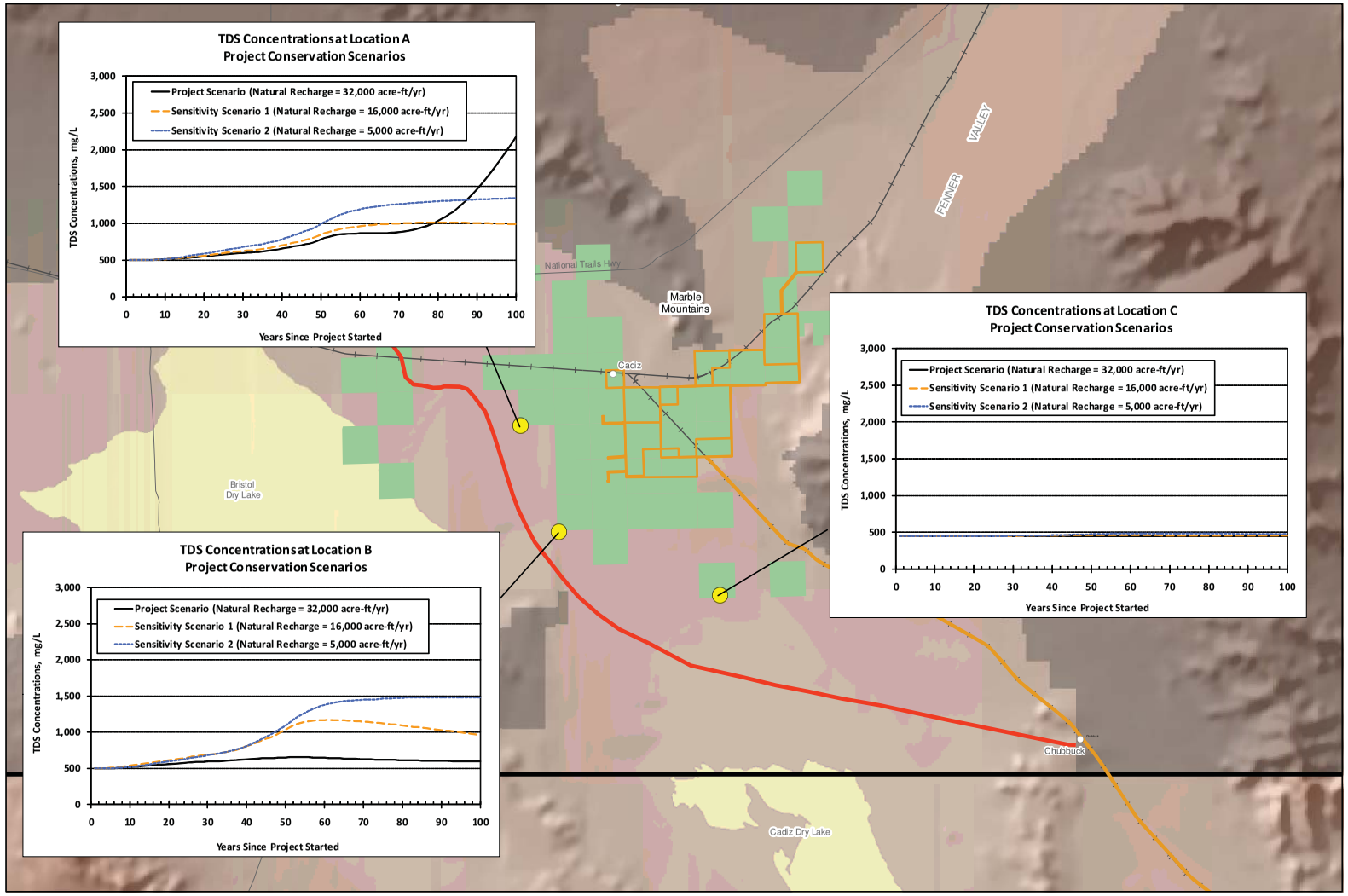
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 74

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_74_6panel_saline_5k_scen2_50and100yr_9-11.mxd

MODEL-CALCULATED TDS CONCENTRATIONS AT SELECTED LOCATIONS



EXPLANATION

- Location with TDS Concentration Over Time
- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- No Flow Model Cell
- Current Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 3 6 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 75

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_75_Chemo_hydrographs_9-11.mxd

Cumulative Annual Changes in Groundwater Storage
Conservation Scenarios

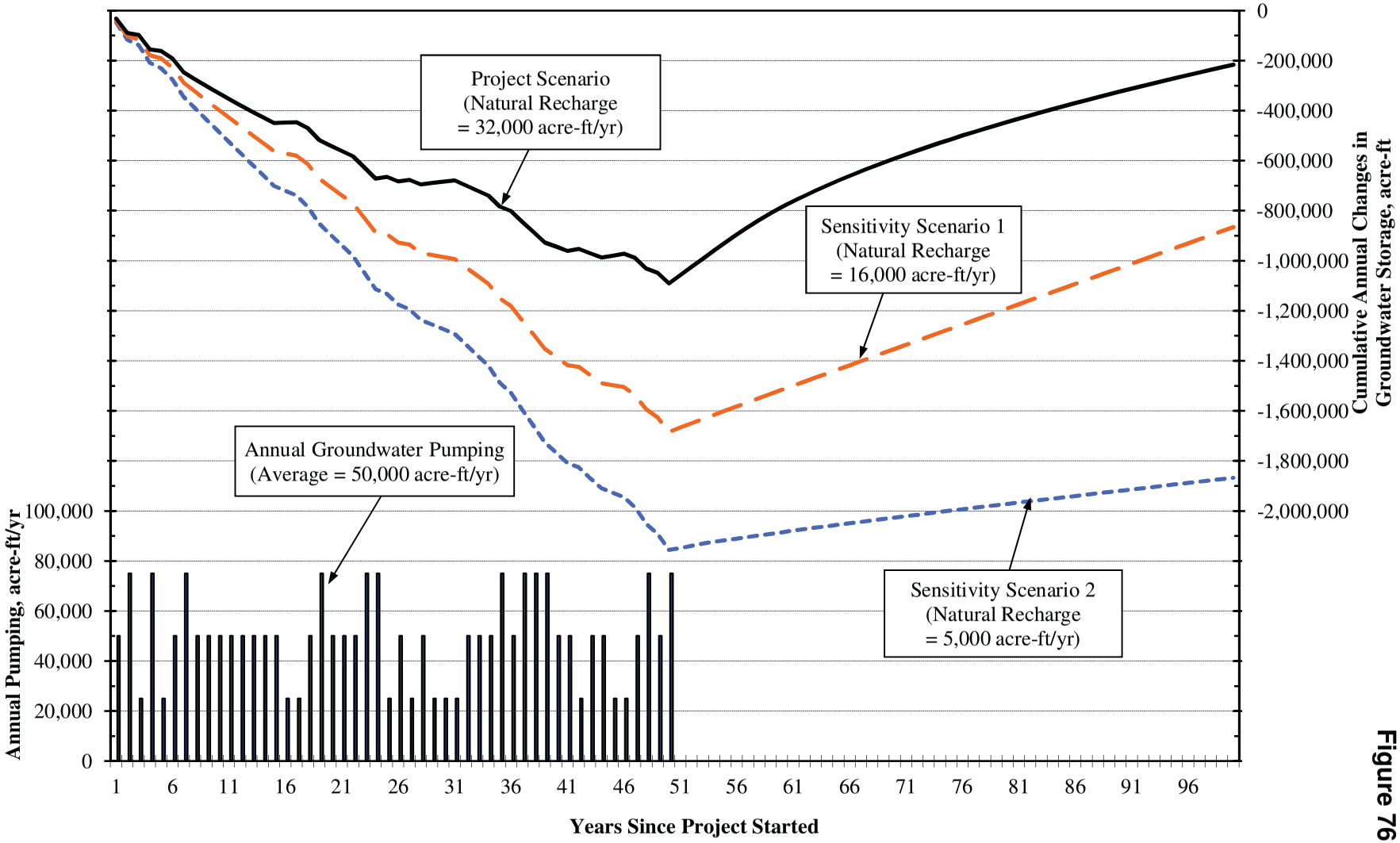
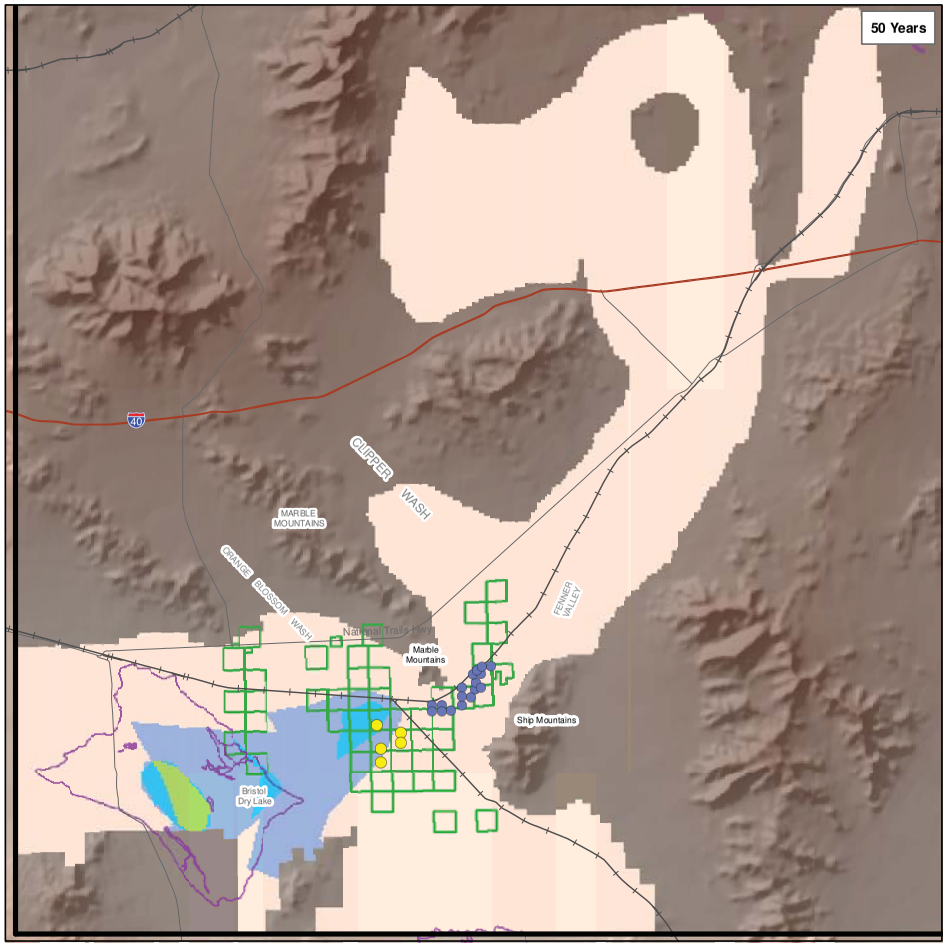
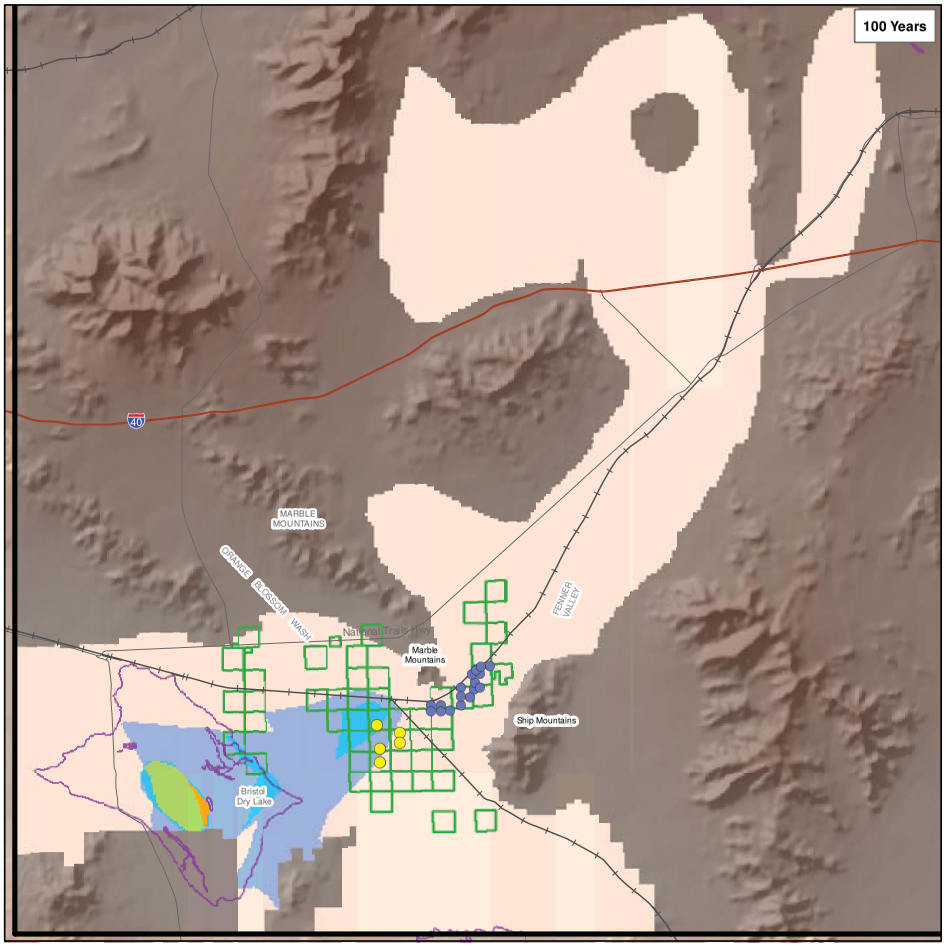


Figure 76





Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Potential Land Subsidence (ft)

0 - 0.25	1.25 - 1.50
0.25 - 0.50	1.50 - 1.75
0.50 - 0.75	1.75 - 2.00
0.75 - 1.00	2.00 - 2.25
1.00 - 1.25	2.25 - 2.50
	2.50 - 3.13

Existing Cadiz Agricultural Well

Proposed New Well

Project Scenario

Natural Recharge of
32,000 acre-ft/yr

Wellfield Configuration A
(5 Existing Cadiz Wells
and 17 New Wells)

NORTH

0 6 12 Miles

MODEL-CALCULATED POTENTIAL LAND SUBSIDENCE

PROJECT SCENARIO

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

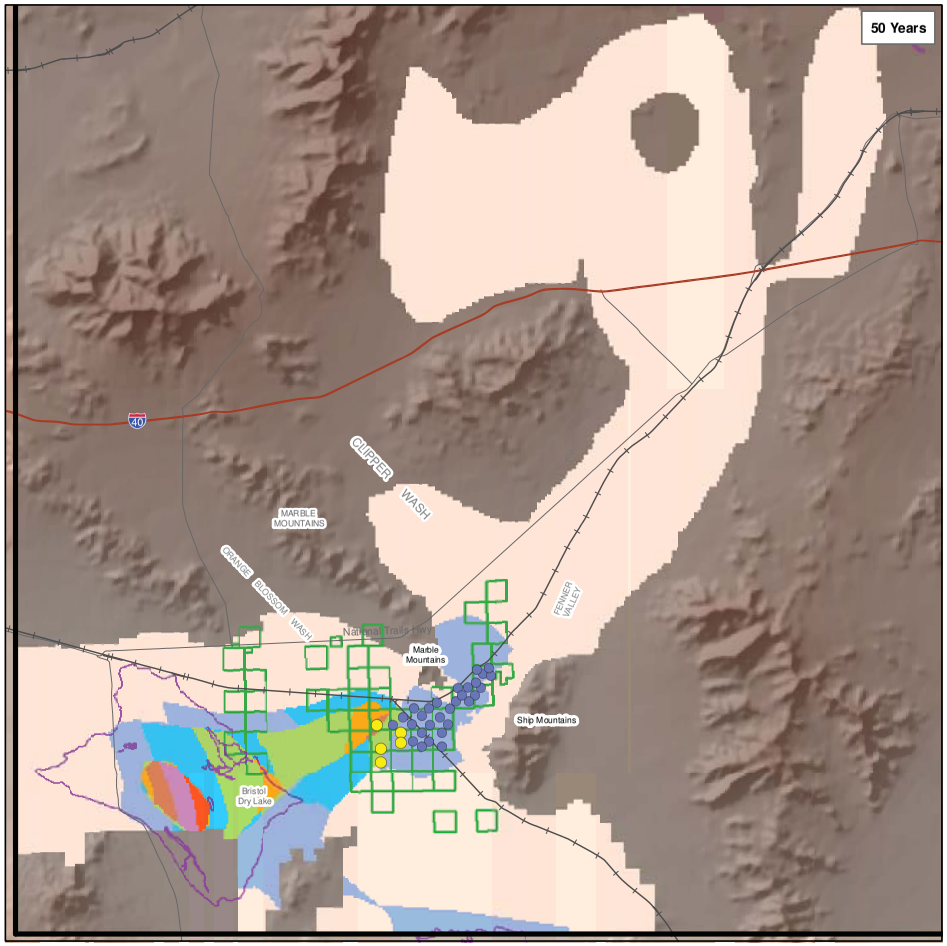
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

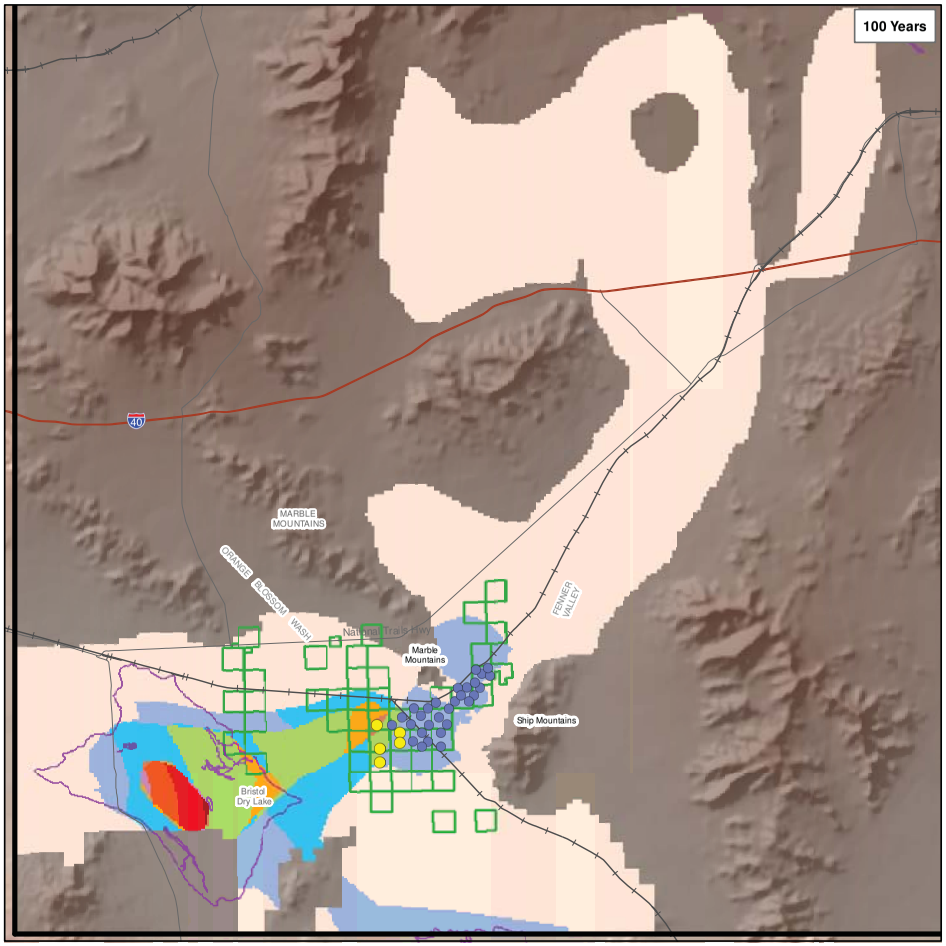
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 77

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_77_2panel_subsidence_16k_scen1_50and100yr_9-11.mxd





Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Potential Land Subsidence (ft)

0 - 0.25	1.25 - 1.50
0.25 - 0.50	1.50 - 1.75
0.50 - 0.75	1.75 - 2.00
0.75 - 1.00	2.00 - 2.25
1.00 - 1.25	2.25 - 2.50
	2.50 - 3.13

Existing Cadiz Agricultural Well

Proposed New Well

NORTH

0 6 12 Miles

Sensitivity Scenario 1

Natural Recharge of
16,000 acre-ft/yr

Wellfield Configuration B
(5 Existing Cadiz Wells
and 29 New Wells)

MODEL-CALCULATED POTENTIAL LAND SUBSIDENCE

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

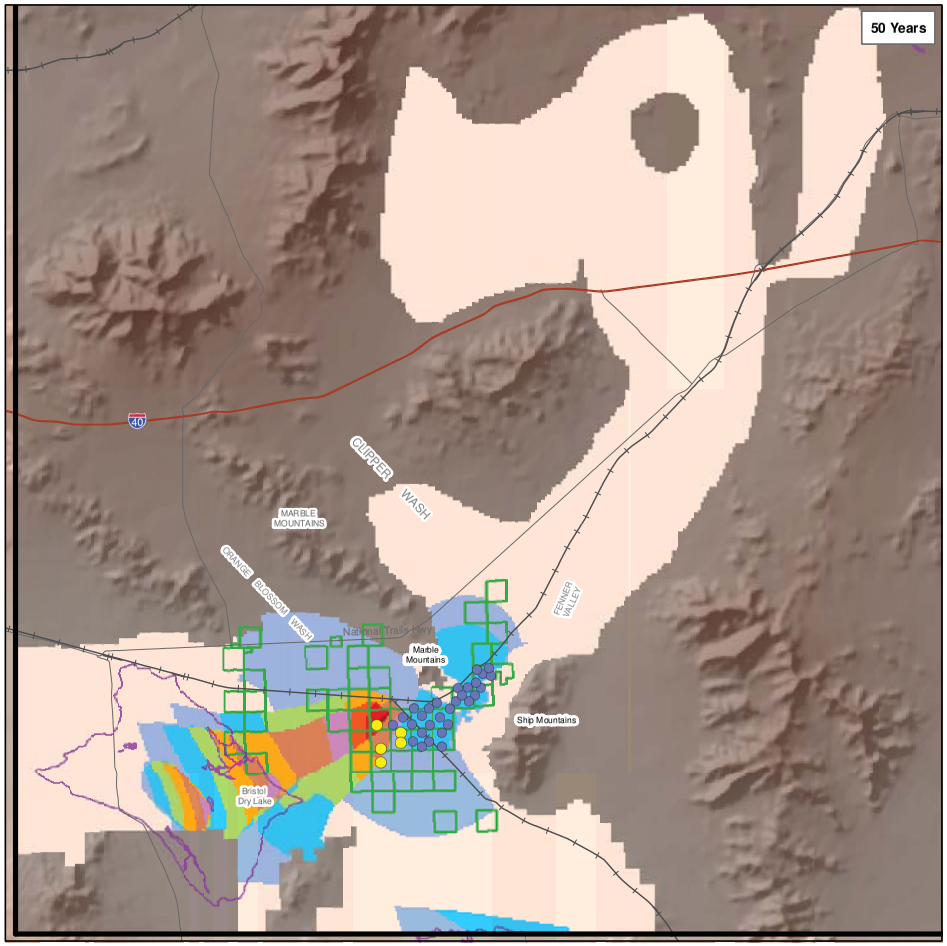
© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

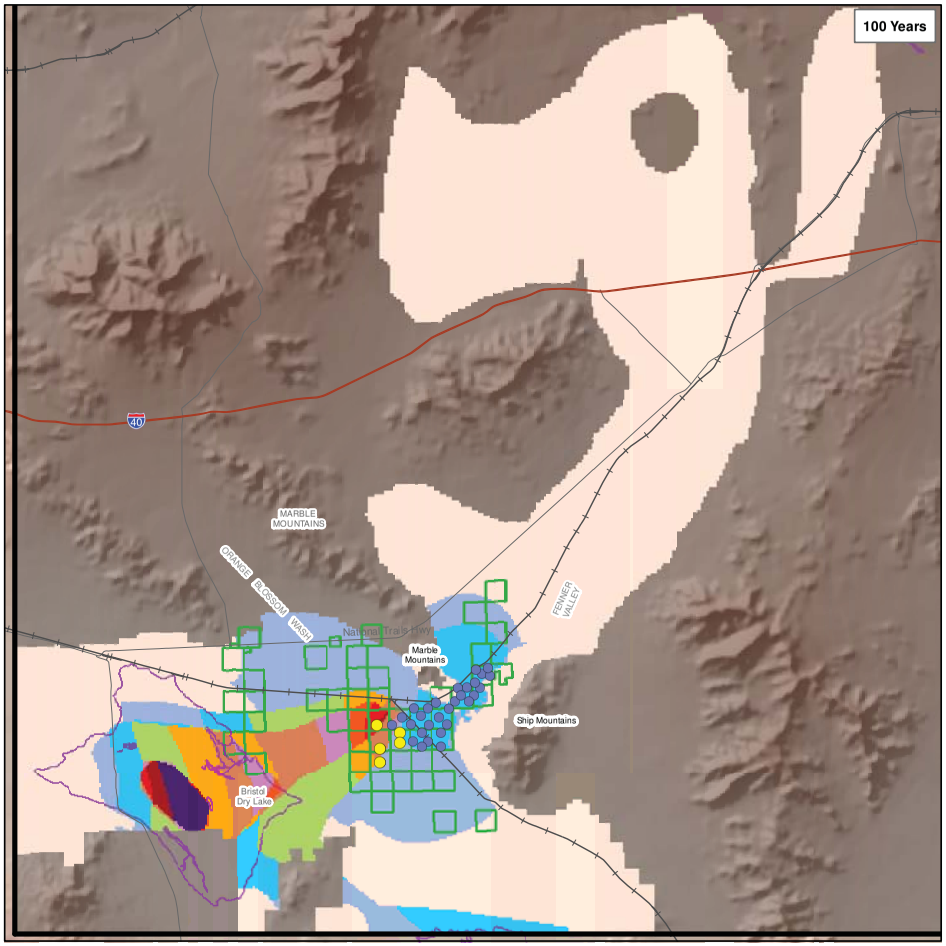
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 78

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_78_2panel_subsidence_16k_scen1_50and100yr_9-11.mxd





Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Potential Land Subsidence (ft)

0 - 0.25	1.25 - 1.50
0.25 - 0.50	1.50 - 1.75
0.50 - 0.75	1.75 - 2.00
0.75 - 1.00	2.00 - 2.25
1.00 - 1.25	2.25 - 2.50
	2.50 - 3.13

Existing Cadiz Agricultural Well

Proposed New Well

NORTH

0 6 12 Miles

Sensitivity Scenario 2

Natural Recharge of
5,000 acre-ft/yr

Wellfield Configuration B
(5 Existing Cadiz Wells
and 29 New Wells)

MODEL-CALCULATED POTENTIAL LAND SUBSIDENCE

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

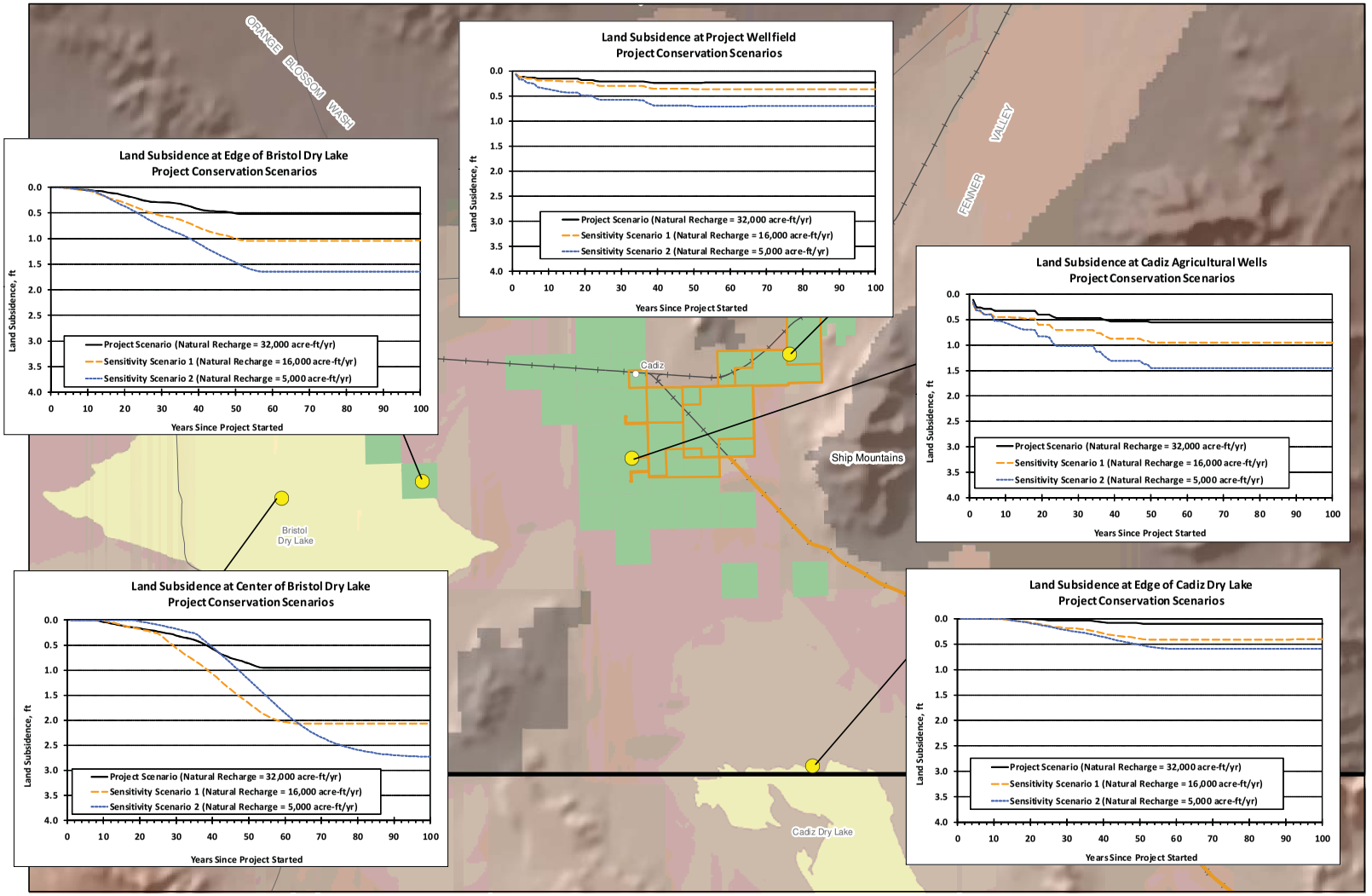
GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 79

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_79_2panel_subsidence_50k_scen2_50and100yr_9-11.mxd

MODEL-CALCULATED POTENTIAL LAND SUBSIDENCE AT SELECTED LOCATIONS



EXPLANATION

- Location with Potential Land Subsidence Over Time
- Cadiz Owned Land
- Wellfield Development Areas and Pipelines
- No Flow Model Cell

Project Scenario

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

Sensitivity Scenario 1

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 3 6 Miles

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 80

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_Fig_80_Subsidence_hydrographs_9-11.mxd

TABLES

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
1	**1986**	0	570	0	660	840	390	510	0	2,970
2	**1987**	0	646	0	748	952	442	578	0	3,366
3	**1988**	0	779	0	902	1,148	533	697	0	4,059
4	**1989**	0	1,140	0	1,320	1,680	780	1,020	0	5,940
5	**1990**	0	1,291	0	1,485	1,894	858	1,161	0	6,689
6	**Jan-91**	0	9	0	11	10	7	11	0	48
7	**Feb-91**	0	21	0	14	26	20	28	0	109
8	**Mar-91**	0	17	0	22	17	27	37	0	120
9	**Apr-91**	0	32	0	87	36	73	93	0	321
10	**May-91**	0	108	0	93	0	122	161	0	484
11	**Jun-91**	0	102	0	92	213	39	179	0	625
12	**Jul-91**	0	134	0	92	275	0	152	0	653
13	**Aug-91**	0	51	0	96	195	0	115	0	457
14	**Sep-91**	0	31	0	75	100	0	73	0	279
15	**Oct-91**	0	43	0	76	71	0	13	0	203
16	**Nov-91**	0	35	0	52	52	0	12	0	151
17	**Dec-91**	0	37	0	42	36	0	21	0	136
18	**Jan-92**	0	2	0	6	0	0	5	0	13
19	**Feb-92**	0	20	0	56	31	0	36	0	143
20	**Mar-92**	0	53	0	53	98	0	83	0	287
21	**Apr-92**	0	90	0	88	107	57	137	0	479
22	**May-92**	0	102	0	109	158	49	174	0	592
23	**Jun-92**	0	107	0	121	212	0	154	0	594
24	**Jul-92**	0	94	0	319	242	0	142	0	797
25	**Aug-92**	0	59	0	102	131	0	103	0	395
26	**Sep-92**	0	52	0	17	101	28	87	0	285
27	**Oct-92**	0	0	0	0	56	0	0	0	56
28	**Nov-92**	0	0	0	0	46	0	0	0	46
29	**Dec-92**	0	0	0	0	77	0	0	0	77
30	**Jan-93**	0	27	0	0	28	7	65	0	127
31	**Feb-93**	0	43	0	0	61	16	37	0	157
32	**Mar-93**	0	64	0	0	80	70	14	0	228
33	**Apr-93**	0	66	0	0	76	83	94	0	319
34	**May-93**	0	111	0	91	133	139	148	0	622
35	**Jun-93**	0	181	0	110	118	148	190	0	747
36	**Jul-93**	0	152	0	117	121	193	198	0	781
37	**Aug-93**	0	44	0	101	105	118	111	0	479
38	**Sep-93**	0	24	0	80	85	12	148	0	349
39	**Oct-93**	0	14	0	61	98	0	122	0	295
40	**Nov-93**	0	0	0	52	67	0	5	0	125

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
41	**Dec-93**	0	0	0	46	0	0	0	0	46
42	**Jan-94**	0	0	0	40	25	18	5	0	88
43	**Feb-94**	0	0	0	20	53	45	37	0	155
44	**Mar-94**	0	7	0	71	111	43	100	0	331
45	**Apr-94**	0	92	0	127	203	29	168	0	619
46	**May-94**	0	172	0	197	237	1	189	0	796
47	**Jun-94**	0	190	0	209	202	117	177	0	895
48	**Jul-94**	0	221	0	218	163	104	152	0	858
49	**Aug-94**	0	39	7	137	27	108	156	0	475
50	**Sep-94**	0	21	21	2	31	65	94	0	235
51	**Oct-94**	0	15	14	0	1	12	41	0	84
52	**Nov-94**	0	0	11	0	30	0	5	0	47
53	**Dec-94**	0	79	10	0	53	12	0	0	154
54	**Jan-95**	0	0	4	0	22	9	0	0	35
55	**Feb-95**	0	20	13	23	85	54	55	0	249
56	**Mar-95**	0	45	19	63	102	62	91	0	382
57	**Apr-95**	137	82	21	73	107	56	101	0	577
58	**May-95**	134	110	37	152	199	115	212	0	960
59	**Jun-95**	205	177	39	152	188	124	348	0	1,233
60	**Jul-95**	39	158	32	140	148	88	0	0	605
61	**Aug-95**	106	58	35	145	112	60	108	0	624
62	**Sep-95**	123	45	38	140	106	48	88	0	589
63	**Oct-95**	124	17	32	118	94	11	22	0	417
64	**Nov-95**	53	0	13	35	67	3	0	0	171
65	**Dec-95**	28	0	3	45	51	0	0	0	127
66	**Jan-96**	21	16	9	55	21	32	2	0	156
67	**Feb-96**	33	40	18	65	0	51	68	0	275
68	**Mar-96**	88	88	35	98	59	84	159	0	612
69	**Apr-96**	54	148	37	107	139	97	188	0	770
70	**May-96**	101	164	41	135	178	105	195	0	919
71	**Jun-96**	120	162	37	151	185	107	190	0	951
72	**Jul-96**	85	126	41	130	185	95	193	0	855
73	**Aug-96**	2	35	42	102	106	61	71	0	418
74	**Sep-96**	13	33	36	94	142	50	61	0	428
75	**Oct-96**	3	19	32	74	50	17	23	0	217
76	**Nov-96**	0	3	7	4	36	3	4	0	57
77	**Dec-96**	1	2	8	30	18	1	2	0	62
78	**Jan-97**	0	35	7	7	34	0	30	0	114
79	**Feb-97**	0	59	10	15	48	0	63	0	195
80	**Mar-97**	67	71	25	93	64	30	82	0	433

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
81	**Apr-97**	20	133	33	116	118	85	155	0	659
82	**May-97**	64	136	41	129	146	94	204	0	814
83	**Jun-97**	210	177	39	105	148	98	192	0	969
84	**Jul-97**	187	120	39	129	128	93	166	0	863
85	**Aug-97**	93	81	37	117	123	51	92	0	593
86	**Sep-97**	63	51	25	80	75	35	58	0	387
87	**Oct-97**	18	10	25	83	93	12	21	0	262
88	**Nov-97**	11	4	5	25	25	6	0	0	76
89	**Dec-97**	16	6	1	33	37	8	0	0	101
90	**Jan-98**	6	25	0	27	35	14	14	0	120
91	**Feb-98**	2	9	0	18	24	11	25	0	88
92	**Mar-98**	31	43	18	43	44	32	46	0	257
93	**Apr-98**	70	63	47	56	60	48	98	0	442
94	**May-98**	196	101	60	64	53	95	190	0	758
95	**Jun-98**	195	143	97	3	93	97	182	0	810
96	**Jul-98**	229	124	109	54	114	96	183	0	909
97	**Aug-98**	194	95	93	71	96	63	164	0	776
98	**Sep-98**	48	39	89	63	73	11	69	0	393
99	**Oct-98**	18	30	44	55	62	20	61	0	290
100	**Nov-98**	23	9	15	18	27	15	6	0	114
101	**Dec-98**	20	19	10	20	46	6	8	0	130
102	**Jan-99**	12	7	3	26	36	0	12	0	95
103	**Feb-99**	27	17	2	25	35	0	38	0	145
104	**Mar-99**	57	37	1	43	60	2	70	192	461
105	**Apr-99**	181	128	50	47	74	53	139	106	779
106	**May-99**	182	137	74	103	142	92	176	47	954
107	**Jun-99**	198	168	139	112	123	93	160	159	1,151
108	**Jul-99**	198	138	148	118	109	89	168	261	1,228
109	**Aug-99**	199	106	114	111	107	9	170	230	1,046
110	**Sep-99**	146	73	42	96	87	5	124	123	696
111	**Oct-99**	99	43	44	56	55	6	40	0	344
112	**Nov-99**	23	8	76	59	12	3	0	0	179
113	**Dec-99**	9	5	38	32	18	14	0	0	116
114	**Jan-00**	10	12	29	27	8	20	0	0	106
115	**Feb-00**	49	24	47	11	19	9	34	0	192
116	**Mar-00**	85	39	41	39	41	19	86	0	351
117	**Apr-00**	117	74	71	62	57	37	131	0	550
118	**May-00**	166	119	115	55	96	71	176	0	799
119	**Jun-00**	184	161	125	92	123	189	178	0	1,053
120	**Jul-00**	187	139	99	113	117	61	184	0	900

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
121	**Aug-00**	181	83	139	128	101	24	167	0	823
122	**Sep-00**	157	73	104	83	81	25	131	0	655
123	**Oct-00**	102	33	87	68	60	50	2	0	401
124	**Nov-00**	16	16	30	29	22	6	33	0	152
125	**Dec-00**	9	9	5	31	33	0	23	0	109
126	**Jan-01**	24	21	23	25	33	0	34	0	159
127	**Feb-01**	60	67	29	28	51	30	71	0	335
128	**Mar-01**	62	75	38	25	55	42	80	0	378
129	**Apr-01**	83	82	48	35	70	61	103	0	482
130	**May-01**	130	144	108	76	111	56	146	0	771
131	**Jun-01**	169	157	148	109	129	77	161	0	949
132	**Jul-01**	165	101	127	98	107	61	150	0	809
133	**Aug-01**	53	51	98	74	91	20	64	0	452
134	**Sep-01**	53	41	79	65	64	19	54	0	374
135	**Oct-01**	63	54	39	33	34	15	55	0	294
136	**Nov-01**	18	27	10	21	30	8	37	0	151
137	**Dec-01**	14	5	24	0	22	10	7	0	82
138	**Jan-02**	**24**	7	15	9	23	1	10	0	89
139	**Feb-02**	47	27	0	26	25	0	38	0	164
140	**Mar-02**	58	50	8	31	31	0	53	0	231
141	**Apr-02**	89	74	17	47	42	0	74	0	343
142	**May-02**	216	186	229	219	203	165	162	0	1,380
143	**Jun-02**	178	147	130	91	98	80	149	0	872
144	**Jul-02**	161	143	135	108	96	83	157	0	882
145	**Aug-02**	171	96	103	81	23	69	142	0	684
146	**Sep-02**	70	77	71	71	0	42	125	0	456
147	**Oct-02**	12	59	59	48	0	44	78	0	300
148	**Nov-02**	6	16	31	27	0	11	24	0	116
149	**Dec-02**	**14**	**5**	**24**	**0**	**22**	**10**	**7**	0	82
150	**Jan-03**	4	3	27	23	0	6	10	0	73
151	**Feb-03**	7	20	15	18	3	14	21	0	98
152	**Mar-03**	54	43	16	10	21	24	44	0	213
153	**Apr-03**	84	66	24	42	83	39	73	0	411
154	**May-03**	178	134	67	109	190	76	140	0	896
155	**Jun-03**	174	138	114	132	181	79	132	0	950
156	**Jul-03**	187	130	121	120	203	81	134	0	975
157	**Aug-03**	141	98	106	101	65	56	100	0	666
158	**Sep-03**	102	76	19	74	57	30	84	0	442
159	**Oct-03**	42	56	19	31	59	0	22	0	229
160	**Nov-03**	18	5	1	22	18	0	0	0	63

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
161	**Dec-03**	22	5	0	29	24	0	0	0	82
162	**Jan-04**	27	23	3	29	21	0	0	0	103
163	**Feb-04**	16	21	0	19	19	0	0	0	75
164	**Mar-04**	49	61	9	44	60	15	32	0	270
165	**Apr-04**	40	167	23	39	68	42	17	0	396
166	**May-04**	64	85	24	80	92	55	98	0	498
167	**Jun-04**	75	99	50	70	110	64	117	0	584
168	**Jul-04**	72	83	101	142	111	31	112	0	652
169	**Aug-04**	56	65	119	148	88	75	135	0	687
170	**Sep-04**	80	76	115	127	0	57	105	0	558
171	**Oct-04**	30	30	52	62	0	22	35	0	231
172	**Nov-04**	8	3	27	32	0	12	34	0	115
173	**Dec-04**	7	0	21	27	0	5	1	0	61
174	**Jan-05**	2	9	10	9	0	2	5	0	37
175	**Feb-05**	1	16	2	0	0	6	8	0	33
176	**Mar-05**	30	46	5	13	14	26	48	0	181
177	**Apr-05**	35	53	15	18	43	31	58	0	252
178	**May-05**	80	41	49	64	95	58	103	0	490
179	**Jun-05**	82	178	127	129	157	80	136	0	889
180	**Jul-05**	78	165	132	122	189	79	140	0	905
181	**Aug-05**	65	101	57	129	190	76	141	0	760
182	**Sep-05**	33	52	52	130	101	47	90	0	504
183	**Oct-05**	19	25	103	94	16	12	31	0	299
184	**Nov-05**	122	9	34	34	0	3	6	0	208
185	**Dec-05**	5	0	27	29	0	0	0	0	61
186	**Jan-06**	6	7	26	32	0	1	4	0	75
187	**Feb-06**	21	29	23	13	0	0	23	0	109
188	**Mar-06**	26	37	30	31	22	0	44	0	188
189	**Apr-06**	30	42	27	34	27	8	86	0	252
190	**May-06**	69	100	70	89	71	44	62	0	504
191	**Jun-06**	120	134	106	120	66	68	134	0	748
192	**Jul-06**	143	118	109	127	7	40	146	0	690
193	**Aug-06**	157	129	113	129	0	0	138	0	666
194	**Sep-06**	145	119	111	89	0	0	103	0	567
195	**Oct-06**	14	62	109	38	0	0	66	0	291
196	**Nov-06**	0	31	110	106	0	5	30	0	282
197	**Dec-06**	0	0	27	33	0	0	5	0	64
198	**Jan-07**	24	3	17	33	5	0	6	0	88
199	**Feb-07**	1	27	0	26	23	0	10	0	86
200	**Mar-07**	0	44	26	33	24	0	4	0	130

Groundwater Pumping for the Transient Model Calibration - 1986 to 2009

Stress Period	Time	21N	21S	22	27N	27S	28	33	PW-1	Total
		[acre-ft]								
201	**Apr-07**	200	98	40	53	3	30	48	0	472
202	**May-07**	62	63	66	80	112	35	94	0	512
203	**Jun-07**	99	85	110	104	100	0	131	0	629
204	**Jul-07**	108	87	0	69	100	0	130	0	493
205	**Aug-07**	88	70	0	147	89	0	34	0	428
206	**Sep-07**	65	51	0	106	33	0	62	0	317
207	**Oct-07**	27	34	0	96	0	0	37	0	193
208	**Nov-07**	16	19	0	103	0	0	16	0	153
209	**Dec-07**	17	1	18	50	0	0	0	0	86
210	**Jan-08**	12	2	0	16	28	0	0	0	58
211	**Feb-08**	11	13	0	8	22	0	0	0	54
212	**Mar-08**	25	21	0	0	64	0	0	0	109
213	**Apr-08**	48	44	0	1	76	0	0	0	169
214	**May-08**	51	46	0	42	60	0	0	0	200
215	**Jun-08**	100	67	0	78	100	1	0	0	346
216	**Jul-08**	86	51	0	86	119	1	0	0	344
217	**Aug-08**	33	23	0	57	80	0	2	0	194
218	**Sep-08**	40	27	0	50	69	0	1	0	187
219	**Oct-08**	36	24	0	57	55	0	2	0	174
220	**Nov-08**	14	8	0	26	40	0	1	0	89
221	**Dec-08**	8	3	0	14	21	0	0	0	45
222	**Jan-09**	7	3	0	18	11	0	0	0	38
223	**Feb-09**	22	6	0	7	14	0	0	0	48
224	**Mar-09**	23	29	0	52	40	0	0	0	144
225	**Apr-09**	45	43	0	57	60	0	11	0	216
226	**May-09**	62	53	3	20	61	0	27	0	226
227	**Jun-09**	66	78	9	0	0	0	78	0	230
228	**Jul-09**	158	106	13	0	0	0	120	0	397
229	**Aug-09**	66	49	13	0	0	0	108	0	236
230	**Sep-09**	43	0	12	0	0	0	98	0	152
231	**Oct-09**	48	0	7	0	0	0	60	0	115
232	**Nov-09**	33	0	4	0	18	0	0	0	55
233	**Dec-09**	13	0	1	0	12	0	0	0	26
Total		**12,356**	**17,942**	**7,662**	**19,514**	**21,962**	**10,332**	**20,680**	**1,118**	**111,566**

Values in bold indicate the amount of groundwater pumping was estimated based on records from previous year.

Groundwater Budget for Project Scenario - Natural Recharge of 32,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
1	32,425	726	15,218	50,003	7	-32,078	-32,078
2	32,425	1,033	16,174	75,005	1	-57,722	-89,800
3	32,425	156	15,700	25,002	8	-8,129	-97,928
4	32,425	870	15,319	75,005	0	-57,029	-154,957
5	32,425	277	14,217	25,002	10	-6,527	-161,484
6	32,425	371	13,661	50,003	0	-30,868	-192,352
7	32,425	1,151	12,884	75,005	0	-54,313	-246,666
8	32,425	629	11,295	50,003	2	-28,246	-274,911
9	32,425	638	10,024	50,003	0	-26,964	-301,875
10	32,425	651	9,190	50,003	0	-26,117	-327,992
11	32,425	667	8,520	50,003	0	-25,431	-353,423
12	32,425	670	7,927	50,003	0	-24,835	-378,259
13	32,425	680	7,387	50,003	0	-24,285	-402,544
14	32,425	678	6,873	50,003	0	-23,774	-426,318
15	32,425	672	6,379	50,003	0	-23,285	-449,603
16	32,425	439	5,994	25,002	9	1,859	-447,744
17	32,425	317	6,132	25,002	6	1,602	-446,142
18	32,425	354	6,514	50,003	1	-23,739	-469,881
19	32,425	1,051	6,339	75,005	0	-47,868	-517,749
20	32,425	696	5,423	50,003	2	-22,307	-540,057
21	32,425	642	4,632	50,003	0	-21,568	-561,625
22	32,425	627	4,072	50,003	0	-21,023	-582,649
23	32,425	1,276	3,506	75,005	0	-44,811	-627,459
24	32,425	1,338	2,548	75,005	0	-43,790	-671,250
25	32,425	711	1,621	25,002	16	6,497	-664,753
26	32,425	539	1,392	50,003	1	-18,432	-683,185
27	32,425	448	1,363	25,002	10	6,498	-676,687
28	32,425	330	1,550	50,003	1	-18,799	-695,486
29	32,425	365	1,669	25,002	9	6,110	-689,376

Table 2

Groundwater Budget for Project Scenario - Natural Recharge of 32,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
30	32,425	294	2,004	25,002	6	5,707	-683,669
31	32,425	188	2,574	25,002	4	5,032	-678,637
32	32,425	226	3,111	50,003	1	-20,464	-699,101
33	32,425	209	3,135	50,003	0	-20,504	-719,605
34	32,425	386	2,806	50,003	0	-19,998	-739,603
35	32,425	730	2,269	75,005	0	-44,119	-783,722
36	32,425	667	1,409	50,003	3	-18,323	-802,045
37	32,425	1,228	775	75,005	0	-42,128	-844,173
38	32,425	1,423	386	75,005	0	-41,543	-885,716
39	32,425	1,494	331	75,005	0	-41,417	-927,133
40	32,425	1,080	304	50,003	6	-16,809	-943,942
41	32,425	915	277	50,003	2	-16,942	-960,884
42	32,425	727	249	25,002	12	7,889	-952,995
43	32,425	591	222	50,003	1	-17,210	-970,206
44	32,425	366	200	50,003	0	-17,413	-987,619
45	32,425	500	177	25,002	10	7,736	-979,883
46	32,425	390	153	25,002	7	7,652	-972,231
47	32,425	338	132	50,003	1	-17,373	-989,603
48	32,425	559	113	75,005	0	-42,134	-1,031,738
49	32,425	612	97	50,003	2	-17,065	-1,048,802
50	32,425	1,095	82	75,005	0	-41,568	-1,090,370
51	32,425	654	68	0	28	32,984	-1,057,386
52	32,425	402	53	0	19	32,754	-1,024,633
53	32,425	273	39	0	17	32,642	-991,991
54	32,425	169	27	0	16	32,551	-959,440
55	32,425	102	18	0	15	32,493	-926,947
56	32,425	69	424	0	15	32,054	-894,893
57	32,425	53	2,307	0	14	30,156	-864,737
58	32,425	45	4,343	0	13	28,114	-836,622

Table 2

Groundwater Budget for Project Scenario - Natural Recharge of 32,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
59	32,425	39	6,206	0	12	26,247	-810,376
60	32,425	35	7,818	0	11	24,631	-785,745
61	32,425	32	9,199	0	10	23,248	-762,496
62	32,425	24	10,365	0	8	22,077	-740,420
63	32,425	22	11,344	0	7	21,095	-719,324
64	32,425	17	12,204	0	5	20,232	-699,092
65	32,425	25	12,976	0	8	19,466	-679,627
66	32,425	18	13,665	0	6	18,771	-660,856
67	32,425	13	14,266	0	5	18,167	-642,689
68	32,425	12	14,809	0	5	17,624	-625,065
69	32,425	15	15,307	0	6	17,127	-607,937
70	32,425	15	15,757	0	6	16,677	-591,261
71	32,425	17	16,226	0	7	16,208	-575,052
72	32,425	16	16,650	0	6	15,784	-559,268
73	32,425	9	17,050	0	4	15,381	-543,887
74	32,425	6	17,388	0	3	15,040	-528,847
75	32,425	11	17,722	0	5	14,709	-514,138
76	32,425	8	18,057	0	4	14,372	-499,766
77	32,425	10	18,351	0	5	14,080	-485,686
78	32,425	7	18,619	0	3	13,810	-471,877
79	32,425	10	18,876	0	5	13,555	-458,322
80	32,425	7	19,116	0	3	13,313	-445,009
81	32,425	4	19,352	0	2	13,075	-431,934
82	32,425	7	19,575	0	3	12,854	-419,080
83	32,425	6	19,813	0	3	12,615	-406,465
84	32,425	5	19,991	0	2	12,436	-394,029
85	32,425	5	20,168	0	2	12,259	-381,770
86	32,425	5	20,355	0	2	12,073	-369,697
87	32,425	8	20,558	0	4	11,871	-357,826

Table 2

Groundwater Budget for Project Scenario - Natural Recharge of 32,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
88	32,425	6	20,736	0	3	11,693	-346,134
89	32,425	8	20,886	0	4	11,543	-334,591
90	32,425	4	21,045	0	2	11,381	-323,210
91	32,425	2	21,182	0	1	11,243	-311,966
92	32,425	0	21,313	0	0	11,111	-300,855
93	32,425	4	21,438	0	2	10,989	-289,866
94	32,425	4	21,579	0	2	10,848	-279,018
95	32,425	1	21,710	0	1	10,716	-268,303
96	32,425	5	21,841	0	3	10,587	-257,716
97	32,425	3	21,969	0	2	10,458	-247,258
98	32,425	4	22,090	0	2	10,336	-236,922
99	32,425	0	22,205	0	0	10,220	-226,702
100	32,425	2	22,316	0	1	10,110	-216,592

Average of Year 1 to 50	**32,425**	**660**	**4,887**	**50,003**	**3**	**-21,807**
Average of Year 1 to 100	**32,425**	**352**	**9,937**	**25,002**	**4**	**-2,166**

[1] Model input data
[2] Model-calculated
[3] Model-calculated
[4] Model input data
[5] Model-calculated
[6] = [1] + [2] - [3] - [4] - [5]
[7] cumulative values based on [6]

Table 2

Groundwater Budget for Sensitivity Scenario 1 - Natural Recharge of 16,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
1	16,212	909	5,934	50,003	5	-38,820	-38,820
2	16,212	1,330	5,776	75,005	1	-63,239	-102,059
3	16,212	239	5,427	25,001	6	-13,983	-116,043
4	16,212	1,243	4,941	75,005	0	-62,491	-178,534
5	16,212	387	4,257	25,001	8	-12,667	-191,201
6	16,212	565	3,619	50,003	0	-36,845	-228,046
7	16,212	1,465	3,125	75,005	0	-60,453	-288,499
8	16,212	815	2,542	50,003	1	-35,518	-324,017
9	16,212	857	1,988	50,003	0	-34,922	-358,939
10	16,212	893	1,578	50,003	0	-34,475	-393,414
11	16,212	947	1,272	50,003	0	-34,116	-427,531
12	16,212	1,006	1,062	50,003	0	-33,847	-461,378
13	16,212	1,038	967	50,003	0	-33,720	-495,097
14	16,212	1,066	921	50,003	0	-33,646	-528,743
15	16,212	1,073	875	50,003	0	-33,593	-562,336
16	16,212	773	830	25,001	9	-8,855	-571,191
17	16,212	673	784	25,001	5	-8,905	-580,096
18	16,212	788	739	50,003	0	-33,743	-613,839
19	16,212	1,629	695	75,005	0	-57,859	-671,697
20	16,212	1,114	652	50,003	1	-33,330	-705,027
21	16,212	1,135	609	50,003	0	-33,265	-738,293
22	16,212	1,159	569	50,003	0	-33,200	-771,493
23	16,212	1,896	530	75,005	0	-57,426	-828,919
24	16,212	1,928	492	75,005	0	-57,356	-886,275
25	16,212	1,217	455	25,001	15	-8,043	-894,318
26	16,212	1,195	423	50,003	0	-33,019	-927,336
27	16,212	1,064	392	25,001	10	-8,126	-935,463
28	16,212	1,108	361	50,003	0	-33,044	-968,507
29	16,212	989	331	25,001	8	-8,139	-976,646

Table 3

Groundwater Budget for Sensitivity Scenario 1 - Natural Recharge of 16,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
30	16,212	900	304	25,001	5	-8,197	-984,843
31	16,212	642	279	25,001	3	-8,428	-993,271
32	16,212	931	255	50,003	0	-33,114	-1,026,385
33	16,212	1,073	230	50,003	0	-32,948	-1,059,332
34	16,212	1,157	208	50,003	0	-32,841	-1,092,173
35	16,212	1,711	186	75,005	0	-57,268	-1,149,441
36	16,212	1,378	166	50,003	2	-32,581	-1,182,022
37	16,212	2,063	148	75,005	0	-56,877	-1,238,899
38	16,212	2,124	131	75,005	0	-56,799	-1,295,699
39	16,212	2,162	115	75,005	0	-56,746	-1,352,444
40	16,212	1,658	99	50,003	5	-32,236	-1,384,681
41	16,212	1,591	83	50,003	2	-32,284	-1,416,965
42	16,212	1,360	68	25,001	13	-7,509	-1,424,474
43	16,212	1,330	54	50,003	0	-32,515	-1,456,989
44	16,212	1,368	40	50,003	0	-32,463	-1,489,453
45	16,212	1,190	28	25,001	10	-7,637	-1,497,089
46	16,212	1,066	16	25,001	6	-7,745	-1,504,835
47	16,212	1,108	7	50,003	0	-32,690	-1,537,525
48	16,212	1,635	2	75,005	0	-57,159	-1,594,684
49	16,212	1,076	0	50,003	1	-32,716	-1,627,400
50	16,212	2,028	0	75,005	0	-56,765	-1,684,165
51	16,212	1,230	0	0	28	17,415	-1,666,750
52	16,212	972	0	0	19	17,166	-1,649,584
53	16,212	794	0	0	15	16,992	-1,632,592
54	16,212	679	0	0	13	16,878	-1,615,714
55	16,212	591	0	0	12	16,792	-1,598,922
56	16,212	509	0	0	11	16,710	-1,582,212
57	16,212	443	0	0	11	16,645	-1,565,568
58	16,212	388	0	0	10	16,590	-1,548,977

Table 3

Groundwater Budget for Sensitivity Scenario 1 - Natural Recharge of 16,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
59	16,212	326	0	0	10	16,529	-1,532,448
60	16,212	289	0	0	10	16,492	-1,515,956
61	16,212	157	0	0	6	16,364	-1,499,592
62	16,212	213	0	0	9	16,416	-1,483,177
63	16,212	181	0	0	9	16,384	-1,466,792
64	16,212	125	0	0	7	16,331	-1,450,461
65	16,212	139	0	0	8	16,343	-1,434,119
66	16,212	99	0	0	7	16,304	-1,417,814
67	16,212	106	0	0	8	16,310	-1,401,504
68	16,212	76	0	0	6	16,282	-1,385,222
69	16,212	55	0	0	5	16,262	-1,368,960
70	16,212	63	0	0	6	16,269	-1,352,691
71	16,212	33	0	0	4	16,242	-1,336,449
72	16,212	54	0	0	6	16,261	-1,320,188
73	16,212	53	0	0	6	16,259	-1,303,929
74	16,212	39	0	0	5	16,246	-1,287,683
75	16,212	37	0	0	5	16,245	-1,271,438
76	16,212	33	0	0	5	16,241	-1,255,197
77	16,212	33	0	0	5	16,241	-1,238,957
78	16,212	31	0	0	5	16,238	-1,222,718
79	16,212	38	0	0	6	16,244	-1,206,474
80	16,212	29	0	0	5	16,237	-1,190,237
81	16,212	28	0	0	5	16,235	-1,174,002
82	16,212	17	0	0	3	16,227	-1,157,775
83	16,212	25	0	0	5	16,233	-1,141,542
84	16,212	24	0	0	5	16,232	-1,125,310
85	16,212	23	0	0	5	16,231	-1,109,080
86	16,212	22	0	0	4	16,230	-1,092,850
87	16,212	28	0	0	6	16,234	-1,076,615

Table 3

Groundwater Budget for Sensitivity Scenario 1 - Natural Recharge of 16,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
88	16,212	25	0	0	6	16,232	-1,060,383
89	16,212	26	0	0	6	16,232	-1,044,151
90	16,212	13	0	0	3	16,222	-1,027,929
91	16,212	18	0	0	4	16,226	-1,011,704
92	16,212	21	0	0	5	16,228	-995,476
93	16,212	16	0	0	4	16,224	-979,251
94	16,212	20	0	0	5	16,227	-963,024
95	16,212	11	0	0	3	16,220	-946,804
96	16,212	19	0	0	6	16,226	-930,578
97	16,212	10	0	0	3	16,219	-914,359
98	16,212	13	0	0	4	16,222	-898,138
99	16,212	8	0	0	3	16,218	-881,920
100	16,212	16	0	0	5	16,223	-865,697

Average of Year 1 to 50	**16,212**	**1,201**	**1,091**	**50,003**	**2**	**-33,683**
Average of Year 1 to 100	**16,212**	**683**	**546**	**25,002**	**5**	**-8,657**

[1] Model input data
[2] Model-calculated
[3] Model-calculated
[4] Model input data
[5] Model-calculated
[6] = [1] + [2] - [3] - [4] - [5]
[7] cumulative values based on [6]

Table 3

Groundwater Budget for Sensitivity Scenario 2 - Natural Recharge of 5,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
1	5,066	1,066	2,722	50,003	3	-46,596	-46,596
2	5,066	1,645	2,223	75,005	1	-70,517	-117,113
3	5,066	488	2,105	25,001	3	-21,555	-138,668
4	5,066	1,622	1,992	75,005	0	-70,309	-208,977
5	5,066	622	1,857	25,001	5	-21,176	-230,153
6	5,066	928	1,698	50,003	0	-45,707	-275,860
7	5,066	1,761	1,525	75,005	0	-69,703	-345,563
8	5,066	1,149	1,340	50,003	0	-45,128	-390,691
9	5,066	1,207	1,133	50,003	0	-44,863	-435,554
10	5,066	1,233	908	50,003	0	-44,612	-480,166
11	5,066	1,250	696	50,003	0	-44,383	-524,549
12	5,066	1,274	559	50,003	0	-44,221	-568,770
13	5,066	1,302	474	50,003	0	-44,110	-612,880
14	5,066	1,324	423	50,003	0	-44,035	-656,915
15	5,066	1,344	394	50,003	0	-43,987	-700,901
16	5,066	999	380	25,001	9	-19,325	-720,226
17	5,066	904	372	25,001	5	-19,408	-739,634
18	5,066	1,045	366	50,003	0	-44,258	-783,892
19	5,066	1,932	362	74,354	0	-67,717	-851,609
20	5,066	1,400	356	49,327	1	-43,218	-894,827
21	5,066	1,429	351	49,327	0	-43,183	-938,010
22	5,066	1,463	345	49,327	0	-43,142	-981,152
23	5,066	2,077	339	73,350	0	-66,546	-1,047,698
24	5,066	2,123	333	73,350	0	-66,494	-1,114,191
25	5,066	1,417	326	24,450	15	-18,307	-1,132,499
26	5,066	1,397	319	48,900	0	-42,755	-1,175,254
27	5,066	1,279	311	24,450	11	-18,426	-1,193,680
28	5,066	1,329	303	48,900	0	-42,808	-1,236,488
29	5,066	1,224	295	24,450	9	-18,464	-1,254,952

Table 4

Groundwater Budget for Sensitivity Scenario 2 - Natural Recharge of 5,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
30	5,066	1,143	287	24,450	7	-18,534	-1,273,486
31	5,066	1,082	278	24,450	7	-18,586	-1,292,072
32	5,066	1,176	269	48,900	0	-42,926	-1,334,998
33	5,066	1,335	259	48,900	0	-42,759	-1,377,757
34	5,066	1,448	250	48,900	0	-42,636	-1,420,393
35	5,066	2,033	241	73,350	0	-66,492	-1,486,885
36	5,066	1,667	231	48,900	1	-42,399	-1,529,283
37	5,066	2,286	221	73,255	0	-66,124	-1,595,407
38	5,066	2,330	211	72,953	0	-65,767	-1,661,174
39	5,066	2,355	201	72,225	0	-65,005	-1,726,179
40	5,066	1,900	191	48,150	4	-41,380	-1,767,560
41	5,066	1,838	182	48,150	1	-41,429	-1,808,989
42	5,066	1,662	172	24,075	13	-17,532	-1,826,521
43	5,066	1,659	163	48,150	0	-41,588	-1,868,110
44	5,066	1,727	154	48,150	0	-41,512	-1,909,621
45	5,066	1,585	145	24,075	11	-17,580	-1,927,201
46	5,066	1,498	136	24,075	7	-17,655	-1,944,856
47	5,066	1,537	127	48,150	0	-41,674	-1,986,530
48	5,066	2,012	118	72,225	0	-65,266	-2,051,796
49	5,066	1,816	110	48,150	2	-41,380	-2,093,176
50	5,066	5,106	102	72,077	3	-62,010	-2,155,186
51	5,066	2,065	94	0	30	7,007	-2,148,179
52	5,066	4,072	87	0	39	9,013	-2,139,166
53	5,066	3,561	81	0	54	8,492	-2,130,674
54	5,066	2,326	74	0	49	7,269	-2,123,405
55	5,066	1,727	68	0	62	6,664	-2,116,742
56	5,066	992	63	0	73	5,923	-2,110,819
57	5,066	1,622	57	0	50	6,582	-2,104,237
58	5,066	934	52	0	25	5,923	-2,098,313

Table 4

Groundwater Budget for Sensitivity Scenario 2 - Natural Recharge of 5,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
59	5,066	1,706	48	0	43	6,682	-2,091,631
60	5,066	1,424	43	0	13	6,434	-2,085,197
61	5,066	1,328	39	0	46	6,309	-2,078,888
62	5,066	1,341	34	0	58	6,315	-2,072,573
63	5,066	996	30	0	57	5,974	-2,066,599
64	5,066	614	26	0	22	5,632	-2,060,967
65	5,066	583	23	0	22	5,604	-2,055,363
66	5,066	1,112	20	0	13	6,145	-2,049,218
67	5,066	533	17	0	31	5,551	-2,043,668
68	5,066	509	14	0	26	5,535	-2,038,133
69	5,066	986	12	0	10	6,031	-2,032,102
70	5,066	449	9	0	15	5,490	-2,026,612
71	5,066	901	7	0	13	5,947	-2,020,664
72	5,066	446	5	0	43	5,464	-2,015,200
73	5,066	641	4	0	74	5,630	-2,009,570
74	5,066	654	2	0	11	5,707	-2,003,863
75	5,066	323	1	0	5	5,384	-1,998,479
76	5,066	305	0	0	5	5,366	-1,993,113
77	5,066	291	0	0	5	5,353	-1,987,760
78	5,066	278	0	0	5	5,339	-1,982,421
79	5,066	260	0	0	5	5,321	-1,977,100
80	5,066	246	0	0	5	5,308	-1,971,793
81	5,066	234	0	0	5	5,296	-1,966,497
82	5,066	223	0	0	4	5,284	-1,961,212
83	5,066	212	0	0	4	5,273	-1,955,939
84	5,066	201	0	0	4	5,263	-1,950,676
85	5,066	191	0	0	4	5,253	-1,945,423
86	5,066	182	0	0	4	5,244	-1,940,179
87	5,066	173	0	0	4	5,235	-1,934,944

Table 4

Groundwater Budget for Sensitivity Scenario 2 - Natural Recharge of 5,000 acre-ft/yr

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	**Inflow**		**Outflow**			**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
	Natural Recharge	**Interbed Storage**	**ET**	**Project Pumping**	**Interbed Storage**		
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft]
88	5,066	165	0	0	4	5,227	-1,929,717
89	5,066	157	0	0	4	5,219	-1,924,498
90	5,066	149	0	0	4	5,212	-1,919,286
91	5,066	145	0	0	4	5,207	-1,914,080
92	5,066	136	0	0	4	5,198	-1,908,882
93	5,066	129	0	0	4	5,192	-1,903,690
94	5,066	123	0	0	4	5,186	-1,898,504
95	5,066	118	0	0	4	5,180	-1,893,324
96	5,066	113	0	0	4	5,175	-1,888,148
97	5,066	108	0	0	4	5,170	-1,882,978
98	5,066	103	0	0	4	5,165	-1,877,813
99	5,066	98	0	0	4	5,161	-1,872,652
100	5,066	94	0	0	4	5,156	-1,867,496

Average of Year 1 to 50	**5,066**	**1,549**	**577**	**49,139**	**2**	**-43,104**
Average of Year 1 to 100	**5,066**	**1,137**	**298**	**24,570**	**11**	**-18,675**

[1] Model input data
[2] Model-calculated
[3] Model-calculated
[4] Model input data and was adjusted by model due to dry cells
[5] Model-calculated
[6] = [1] + [2] - [3] - [4] - [5]
[7] cumulative values based on [6]

Table 4

VOLUME I

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638

VOLUME 2:
APPENDIX A

Cadiz Groundwater Modeling and Impact Analysis

September 1, 2011

Prepared for: Brownstein Hyatt Farber Schreck, LLP

Prepared by:

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS

TABLE OF CONTENTS

VOLUME 1 - REPORT

ABBREVIATIONS AND DEFINITIONS 1

1.0 EXECUTIVE SUMMARY 5

2.0 INTRODUCTION 15

2.1. Purpose and Scope 15

2.2. Description of Study Area 16

2.3. Previous Investigations 16

2.4. Recent Supplemental Geohydrologic Investigations 17

2.5. Sources of Data 18

3.0 GEOLOGY 19

3.1. Geologic Setting 19

3.2. Geologic Units 20

3.2.1. Alluvium 21

3.2.2. Tertiary Volcanics and Fanglomerates 21

3.2.3. Archaen and Jurassic Granitic and Metamorphic Bedrock 22

3.3. Geologic Structure 23

3.3.1. Overview of Geologic History and Structure 23

3.3.2. Geologic Structure in Fenner Gap 24

4.0 HYDROLOGY 26

4.1. Precipitation 26

4.2. Groundwater Occurrence and Movement 26
4.3. Aquifer Systems 27
4.4. Groundwater Storage 28
4.5. Groundwater Quality 28

5.0 MODEL DEVELOPMENT AND CONSTRUCTION 30
5.1. Conceptual Model 30
5.2. Computer Code 30
5.3. Model Domain, Grid and Time Discretization 31
5.4. Boundary Conditions 32
5.5. Aquifer Parameters 33
5.5.1. Lithologic Model in the Fenner Gap Area 33
5.5.2. Layer Elevations 34
5.5.3. Effective Porosity and Storativity 35
5.5.4. Hydraulic Conductivity 36
5.5.5. Vertical Leakance 38
5.5.6. Initial Groundwater Elevations 38
5.5.7. Dispersivity 39
5.5.8. Elastic and Inelastic Storage Coefficients 39
5.5.9. Preconsolidation Stress 39
5.6. Recharge and Discharge 40
5.6.1. Natural Recharge and Artificial Recharge 40
5.6.2. Groundwater Pumping 40
5.6.3. Evapotranspiration 41

6.0 MODEL CALIBRATION AND SENSITIVITY ANALYSIS....43

6.1. Model Calibration Approach....43

6.2. Steady State Model Calibration....45

6.3. Transient Model Calibration....46

6.4. Sensitivity Analysis....49

7.0 MODEL PREDICTIVE SCENARIOS....50

7.1. Description of Model Scenarios....50

7.2. Project Pumping....51

7.3. Natural Recharge....51

7.4. Project Extraction Wells....52

7.4.1. Wellfield Configuration....52

7.4.2. Conceptual Drill Site Layout and Wellfield Manifold System....53

7.4.3. Well Cross-Section....54

7.5. Initial conditions....55

8.0 IMPACT ANALYSIS....56

8.1. Groundwater Elevations....56

8.2. Drawdown Analysis....56

8.2.1. Regional Drawdown....56

8.2.2. Drawdown during Dry Year, Wet Year and Average Year Conditions....57

8.3. Depth to Groundwater....59

8.4. Saline Water/Freshwater Interface....60

8.5. Groundwater in Storage....61

8.6. Potential Land Subsidence....62

9.0 FINDINGS 64

10.0 MODEL LIMITATIONS AND UNCERTAINTY 69

11.0 REFERENCES 70

FIGURES, TABLES, APPENDICES (VOLUMES 2 AND 3)

FIGURES

No.	Description
1	General Project Location
2	2009 Groundwater Elevations
3	Total Dissolved Solids Concentrations
4	Cadiz Groundwater Model Boundary
5	Cadiz Groundwater Model Grid
6	Boundary Conditions of the Cadiz Groundwater Model
7	Fenner Gap Lithologic Model Boundary
8a	Lithologic Model Results – Cross Section 3-3’
8b	Lithologic Model Results – Cross Section 3-3’ Legend
9	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 4
10	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 5
11	Bottom Layer Elevations of the Cadiz Groundwater Model
12	Layer Thickness of the Cadiz Groundwater Model
13	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 32,000 acre-ft/yr
14	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 16,000 acre-ft/yr
15	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 5,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
16	Vertical Leakance of the Cadiz Groundwater Model
17	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 32,000 acre-ft/yr
18	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 16,000 acre-ft/yr
19	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 5,000 acre-ft/yr
20	Inelastic Storage Coefficient and Clay Thickness (ft) of the Cadiz Groundwater Model
21	Areal Distribution of Natural Recharge Rate of 32,000 acre-ft/yr
22	Annual Groundwater Pumping of Cadiz Agricultural Wells
23	PEST Hydraulic Conductivity Pilot Points
24	Location of Wells with Water Level Data Used for Steady State Model Calibration
25	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
26	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr
27	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
28	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
29	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
30	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
31	Location of Wells with Water Level Data Used for Transient Model Calibration
32	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
33	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
34	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
35	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
36	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
37	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
38	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
39	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
40	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
41	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
42	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
43	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
44	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
45	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
46	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
47	Normalized Sensitivity of Selected Model Parameters
48	Cadiz Conservation Project Scenario Wellfield Configuration A
49	Cadiz Conservation Sensitivity Scenarios Wellfield Configuration B
50	Cadiz Groundwater Conservation and Storage Project Annual Pumping for Project Conservation Scenario
51	Conceptual Drill Site Layout
52	Cadiz Conservation Project Scenario Schematic of Proposed Manifold System
53	Conceptual Well Design Diagram
54	Initial Groundwater Elevations for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
55	Initial Groundwater Elevations for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
56	Initial Groundwater Elevations for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr
57	Initial TDS Concentrations for Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2
58	Model-Calculated Groundwater Elevations at the End of 50 Years – Project Scenario
59	Model-Calculated Groundwater Elevations at the End of 100 Years – Project Scenario
60	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 1
61	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 1
62	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 2
63	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 2
64	Regional Drawdown at the End of 50 Years – Project Scenario
65	Regional Drawdown at the End of 100 Years – Project Scenario
66	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 1
67	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 1
68	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 2
69	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 2

FIGURES (CONTINUED)

No.	Description
70	Model Calculated Drawdown at Selected Locations
71	Model Calculated Depth to Water at Selected Locations
72	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Project Scenario
73	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 1
74	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 2
75	Model Calculated TDS Concentrations at Selected Locations
76	Cumulative Annual Changes in Groundwater Storage - Conservation Scenarios
77	Model-Calculated Potential Land Subsidence – Project Scenario
78	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 1
79	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 2
80	Model-Calculated Potential Land Subsidence at Selected Locations

TABLES

No.	Description
1	Groundwater Pumping for the Transient Model Calibration – 1986 to 2009
2	Groundwater Budget for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
3	Groundwater Budget for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr
4	Groundwater Budget for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr

APPENDICES

Ltr.	Description

VOLUME 2 – APPENDIX A

A	Cadiz Groundwater Conservation and Storage Project – Prepared by CH2M Hill

VOLUME 3 – APPENDICES B-G

B	Geologic Structural Evaluation of the Fenner Gap Region Located between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. Prepared by Dr. Miles Kenney
C	Geohydrologic Assessment of the Fenner Gap Area. Prepared by GEOSCIENCE Support Services, Inc.
D	Timeline – Chronology for Estimates of Natural Recharge to the Cadiz Project Area
E	Hydrographs for Transient Model Calibration with Natural Recharge of 32,000 acre-ft/yr
F	Hydrographs for Transient Model Calibration with Natural Recharge of 16,000 acre-ft/yr
G	Hydrographs for Transient Model Calibration with Natural Recharge of 5,000 acre-ft/yr

APPENDIX A

Cadiz Groundwater Conservation and Storage Project

(Prepared by CH2M Hill)

GEOSCIENCE

Cadiz Groundwater Conservation and Storage Project

Prepared for

CADIZ

550 South Hope Street, Suite 2850
Los Angeles, California 90071

Prepared by

CH2MHILL

325 East Hillcrest Drive, Suite 125
Thousand Oaks, California 91360

July 2010

Cadiz Groundwater Conservation and Storage Project

Prepared for

Cadiz, Inc.

550 South Hope Street, Suite 2850
Los Angeles, California 90071

July 2010

CH2MHILL

325 East Hillcrest Drive, Suite 125
Thousand Oaks, California 91360

Contents

Section **Page**

Acronyms and Abbreviations ..... **vi**

Executive Summary **ES-1**

1.0 Introduction **1-1**
1.1 Purpose 1-1
1.2 Scope 1-2

2.0 Setting **2-1**
2.1 Physiography 2-1
2.1.1 Overview of Setting 2-1
2.1.2 Topography 2-1
2.1.3 Vegetation 2-2
2.1.4 Dry Lakes (Playas) 2-2
2.2 Climate 2-2
2.2.1 Precipitation 2-3
2.2.2 Temperature 2-3
2.3 Geology 2-4
2.3.1 Regional Geology 2-4
2.3.2 Structural Geology 2-6
2.3.3 Surficial Geology and Soils 2-7
2.4 Hydrogeology 2-7
2.4.1 Hydrogeologic Units 2-9
2.4.2 Groundwater Movement 2-9

3.0 Groundwater in Storage **3-1**

4.0 Recoverable Water **4-1**
4.1 Application of INFIL3.0 - Watershed Soil Mositure Budget Model 4-1
4.1.1 Model Geometry and Grid 4-3
4.1.2 Topography 4-3
4.1.3 Climate Parameters 4-4
4.1.4 Soil Parameters 4-6
4.1.5 Hydrogeologic Parameters 4-6
4.1.6 Vegetation and Root Zone Parameters 4-7
4.1.7 INFIL3.0 Simulation Results 4-7
4.1.8 Discussion of Recoverable Water Results 4-8
4.2 Groundwater Flow through Fenner Gap 4-10
4.2.1 Local Hydrogeology of the Fenner Gap Area 4-11
4.2.2 Numerical Model Development 4-13
4.2.3 Application of PEST to Estimating Groundwater Flow through Fenner Gap 4-14
4.2.4 Discussion of Groundwater Flow Model Results 4-17

5.0 References Cited **5-1**

Tables

2-1 Summary of Precipitation Stations In the Area of Study

3-1 Cadiz Study Area Groundwater Storage Calculations

4-1 Monthly Atmospheric-Parameters Used in INFIL3.0 Simulations

4-2 Monthly Climate-Regression Models Coefficients used in INFIL3.0 Simulations

4-3 Soil Parameter Values Used in INFIL3.0 Simulations

4-4 Root-zone Porosity, Initial and Calibrated Saturated Hydraulic Conductivity for Bedrock and Deep Soil Used in INFIL3.0

4-5 Vegetation Properties Used in INFIL3.0 Simulations

4-6 Geologic Units In Fenner Gap Area

4-7 Summary of Aquifer Test Data – Fenner Gap Area

4-8 Summary of Survey Data and Groundwater Elevation Measurements – Fenner Gap Area

Figures

1-1 Overall Cadiz and Fenner Valleys Location Map

2-1 Overall Cadiz and Fenner Valleys Location Map

2-2 Topography

2-3 Drainage Map

2-4 Vegetation

2-4b Vegetation Coverage

2-5 Climate Stations

2-6 PRISM Isohyets for the 1971-2000 Period

2-7 Cumulative Departure from Mean Precipitation for Selected Precipitation Stations

2-8 Simplified Geologic Map

2-9 Geology of Fenner Gap Area

2-10 STATSCO Soil Map

2-11 Percentage of Grains Greater Than 2mm

2-12 Percentage of Clay from Fines

2-13 Conceptualization of Groundwater Occurrence and Movement in Area of Study

2-14 Schematic Cross Section showing Occurrence and Movement of Water

2-15 Wells and Springs Map

2-16 Groundwater Level

3-1 Base of Alluvial Aquifer Elevation

3-2 Storage Zone

4-1 Schematic of Water Balance Processes Simulated In INFIL3.0

4-2 INFIL3.0 Grid – Fenner Watershed

4-3 INFIL3.0 Grid – Orange Blossom Wash Area

4-4 INFIL3.0 Flow Accumulation/Routing – Fenner Watershed

4-5 INFIL3.0 Flow Accumulation/Routing – Orange Blossom Watershed

4-6 Climate Stations Used in INFIL3.0 for Fenner Watershed and Orange Blossom Wash Areas

4-7 Monthly Precipitation Versus elevation Regressions Used in INFIL3.0

4-8 Soil Depths Determined from STATSGO Database

4-9a INFIL3.0 Modeled Average Annual Precipitation for 1971-2000 Period Compared with PRISM – Fenner Watershed

4-9b INFIL3.0 Modeled Average Annual Precipitation for 1971-2000 Period Compared with PRISM – Orange Blossom Watershed

4-9c INFIL3.0 Modeled Average Annual Precipitation for 1958-2007 Period Compared with PRISM – Fenner Watershed

4-9d INFIL3.0 Modeled Average Annual Precipitation for 1958-2007 Period Compared with PRISM – Orange Blossom Watershed

4-10a INFIL3.0 Average Annual Infiltration for 1958-2007 – Fenner Watershed

4-10b INFIL3.0 Average Annual Infiltration for 1958-2007 – Orange Blossom Watershed

4-11 Fenner Watershed Recoverable Water INFIL3.0 Simulation Results

4-12 Orange Blossom Watershed Recoverable Water INFIL3.0 Simulation Results

4-13 Fenner Watershed Recoverable Water INFIL3.0 Versus GSSI High Estimate

4-14 Fenner Watershed Recoverable Water INFIL3.0 Versus GSSI Low Estimate

4-15 Orange Blossom Watershed Recoverable Water INFIL3.0 Versus GSSI High Estimate

4-16 Orange Blossom Watershed Recoverable Water INFIL3.0 Versus GSSI Low Estimate

4-17 NDVI for May 16, 1990

4-18 NDVI for March 16, 1991

4-19 NDVI for May 19, 1991

4-20 NDVI for March 10, 1992

4-21 NDVI for May 14, 1995

4-22 NDVI for August 13, 1995

4-23 Geology of Fenner Gap Area, Location of Cross Sections and Test Borings/Wells

4-24 Generalized Stratigraphic Column of Fenner Gap Area

4-25 Cross Section E-E'

4-26 Cross Section B1-B1′

4-27 Cross Section D1-D1′

4-28 Cross Section B-B′

4-29 Cross Section F-F′

4-30 Cross Section I-I′

4-31 Cross Section H-H′

4-32 Cross Section J-J′

4-33 Structure Contour Map of Base of Alluvium in the Fenner Gap Area

4-34 Isopach Map Saturated Alluvium

4-35 Estimated Extent of Consolidated Fanglomerates in the Fenner Gap Area

4-36 Isopach Map of Carbonate Rock Unit in the Fenner Gap Area

4-37 TO BE PROVIDED UNDER SEPARATE COVER

4-38 Groundwater Elevation Contour Map in the Fenner Gap Area

4-39 Groundwater Flow Model Extents, Grid and Boundary Conditions

4-40 PEST Pilot Points and Targets in Layer 1

4-41 PEST Pilot Points and Targets in Layer 3

4-42 PEST Simulated Groundwater Contours and Target Residuals – K Limit = 600 ft/d

4-43 PEST Computed Hydraulic Conductivity Distribution in Layer 1 with K Upper Limit = 600 ft/d

4-44 PEST Computed Hydraulic Conductivity Distribution in Layer 3 with K Upper Limit = 600 ft/d

4-45 PEST Simulated Groundwater Contours and Target Residuals – K Limit = 400 ft/d

4-46 PEST Computed Hydraulic Conductivity Distribution in Layer 1 with K Upper Limit = 400 ft/d

4-47 PEST Computed Hydraulic Conductivity Distribution in Layer 3 with K Upper Limit = 400 ft/d

4-48 Scatter Plot Showing Observed Versus Simulated Groundwater Levels from PEST Simulations

4-49 Hydrogeologic zones and Catchment Area of the Edwards Aquifer, San Antonio region Texas (from Lindgren et al., 2004)

4-50 Simulated distribution of horizontal hydraulic conductivity for calibrated Edwards Aquifer model, San Antonio region Texas (from Lindgren et al.., 2004)

Plates

1 Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle

2 Estimated Extent of Pediments and Adjacent Areas of Thin Alluvial Cover – East Mojave National Scenic Area

Appendixes

A Field Investigation Report (CD)

Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
ASP	aspect
BRGAP	USGS' Biological Resources National Gap Analysis Program
BLM	Bureau of Land Management
bgs	below ground surface
cm/d	centimeters per day
CPC	Climate Prediction Center
DEM	digital elevation model/map
ELEV	elevation
ft/yr	feet per year
GIS	geographic information system
gpm	gallons per minute
HUC	hydrologic unit codes
km	kilometers
km^2	square kilometers
LLNL	Lawrence Livermore National Laboratory
m	meters
mg/l	milligrams per liter
mi^2	square miles
MUID	map unit identifier
NED	National Elevation Dataset
NDVI	Normalized Difference Vegetation Index
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
PEST	parameter estimator
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
SL	slope

TDS	total dissolved solids
USGS	United States Geological Survey
UTM	Universe Transverse of Mercator
WESTVEG	western region vegetation map

Executive Summary

Executive Summary

Cadiz, Inc. owns 34,000 acres of largely contiguous land in the Cadiz and Fenner valleys, located in the eastern Mojave Desert, where they have farmed successfully for more than 15 years (Figure ES-1). Cadiz desires to develop a water conservation project that involves capturing natural recharge in the Fenner and northern Bristol valleys that would otherwise discharge to the Bristol and Cadiz dry lakes and then evaporate. In addition, Cadiz proposes to implement a groundwater storage component of the project that involves extraction of native groundwater from subsurface groundwater in storage. The company's intent is to develop storage conditions that would allow native water to be conserved and imported water to be transported, stored, and recaptured in the project area for beneficial uses, including environmental mitigation purposes.

Cadiz requested CH2M HILL to review previous studies and conduct additional studies to provide an updated assessment of 1) potential recoverable water that could be conserved over the long term (by intercepting water that would otherwise discharge by evapotranspiration from Bristol and Cadiz dry lakes) and 2) groundwater in storage in the Fenner Valley and northern Bristol Valley area. This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model, based on the USGS MODFLOW-2000 computer code, of the Fenner Gap area. The purpose of the update was to assess the quantity of groundwater flowing through the gap. The groundwater is expected to be a large part of the long-term average annual recharge to the Fenner Watershed, which is flowing toward the Bristol and Cadiz dry lakes. These assessments indicated that a reasonable estimate of potential recoverable water is 32,000 acre-feet per year and the volume of groundwater in storage is reasonably estimated to be between about 17 million to 34 million acre-feet in the alluvium of the Fenner Valley and northern Bristol Valley area.

Summary of Field Investigations

Field investigations were a part of this study and included the following activities:

- Geologic reconnaissance to directly observe geologic, hydrologic, and geomorphic features and conditions in the field
- Drilling of four boreholes to better delineate the subsurface geology and hydrogeology
- Three aquifer tests and one packer test to provide estimates of hydrogeologic properties
- Survey of wells and measurements of groundwater levels to define hydraulic gradients and groundwater level fluctuations
- Collection of water samples from new wells to assess groundwater quality

Figure ES-2 shows a geologic map of the Fenner Gap area and locations of wells, including new wells completed as a part of this study. Appendix A presents the details of the field investigations completed as part of this study. Following is a summary of findings from these field investigations.

The primary purpose of well TW-1 was to assess the hydrogeologic properties of the carbonate rock units in the Fenner Gap. A video log of the open borehole from 454 feet below ground surface (bgs) to about 1,000 feet bgs shows extensive fracturing, cavities, and dissolution features, resulting in significant secondary porosity and permeability. Approximately 500 feet of the carbonate rock unit was pumped for 3 days at 1,160 gallons per minute (gpm), which resulted in about 0.5 foot of drawdown (after an initial rise in groundwater level), demonstrating the substantial water transmitting properties of this hydrogeologic unit. This test indicated that hydraulic conductivity values of the carbonate rock units can be in excess of 1,000 feet per day.

The purpose of well TW-2 was to assess the thickness and hydrogeologic properties of the alluvium in its thicker section through the Fenner Gap. Wells TW-2 and TW-2B confirm a thickness of about 860 to 810 feet of alluvium, respectively. An aquifer test conducted for 3 days at 1,130 gpm on TW-2 indicated an average hydraulic conductivity value of about 600 feet per day, demonstrating substantial water transmitting capacity of the younger alluvium in the Fenner Gap.

Well TW-3 indicated that the eastern side of the Fenner Gap is underlain by older alluvium (fanglomerates) that are consolidated and less permeable than the younger alluvium. Packer tests in this hydrogeologic unit indicate an average hydraulic conductivity of 3.1×10^{-3} feet per day.

A recent well survey and groundwater-level measurements confirm a steep hydraulic gradient upstream of the Fenner Gap and a flattening of the gradient in and downstream of the gap, which is consistent with an increase in water transmitting properties of those hydrogologic units through and downstream of the gap.

Groundwater samples were collected from wells TW-1 and TW-2. Total dissolved solids (TDS) in groundwater samples collected from wells TW-1 and TW-2 screened in the alluvial aquifer range from 260 to 300 milligrams per liter (mg/l). The TDS of groundwater in the carbonate rock unit from well TW-1 is 220 mg/l. Overall, groundwater quality meets all primary and secondary maximum contaminant levels for those constituents analyzed in the samples collected as a part of this study (see Appendix A).

Summary of Groundwater in Storage

Estimates of the volume of groundwater in storage were updated from those developed previously by Geoscience Support Services Inc. (GSSI, 1999). These estimates were updated based on more recent field investigations conducted as a part of this study, as previously described, and recent studies conducted by the United States Geological Survey (USGS). As a part of their assessment of the geology and mineral resources of the East Mojave Scenic Area, the USGS (2006) developed estimates of the thickness of the alluvial sediments north of Interstate 40that were used in this study to refine the distribution of alluvial sediments in the Fenner Watershed. The volume of groundwater in storage is reasonably estimated to be about 17 million to 34 million acre-feet in the alluvium of the Fenner Valley and northern Bristol Valley area. Section 3 provides the details of the estimates of groundwater in storage.

Summary of Recoverable Water

Section 4 presents estimates of potentially recoverable water, water that would otherwise discharge to the Bristol and Cadiz dry lakes and then evaporate. The estimates were developed using the USGS INFIL3.0 watershed soil moisture budget model and then tested through application of the USGS MODFLOW-2000 model of groundwater flow through the Fenner Gap. Figure ES-3 conceptually illustrates groundwater occurrence and movement in the Fenner and Bristol valley areas. Groundwater originates as precipitation falling on the surrounding mountains. A portion of this precipitation infiltrates into the groundwater system as recharge, then flows, principally through alluvial and carbonate rock units and to a lesser extent through volcanic deposits, towards and through the Fenner Gap on its way to the Bristol and Cadiz dry lakes, where it ultimately evapotranspires, leaving behind salts that are carried with the groundwater.

Total recoverable water, therefore, is equal to the amount of recharge to the groundwater system in the Fenner Watershed, which is approximately equal to the amount of groundwater flow through Fenner Gap through the alluvial and carbonate rock units (flow through other rock units is expected to be substantially less than through these two hydrogeologic units). By intercepting this groundwater flow through the gap, a reduction of evapotranspiration from Bristol and Cadiz dry lakes is expected, but there would be no reduction in groundwater storage.

The USGS computer program INFIL3.0 was used to assess the quantity of recharge to the groundwater system and, therefore, recoverable water. The USGS released INFIL3.0 in 2008. INFIL3.0 is a grid-based, distributed–parameter, deterministic water-balance watershed model used to estimate the areal and temporal net infiltration below the root zone (USGS, 2008). The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone and is no longer affected by evapotranspiration and is capable of percolating to, and recharging, groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water runon (runoff and streamflow).

INFIL3.0 requires a number of inputs including (1) a grid (based on uniform squares over the watershed); (2) an estimate of the initial root-zone water contents; (3) a daily time-series input of total daily precipitation and maximum and minimum temperatures; and (4) a set of model input variables that define drainage basin characteristics, model coefficients for simulating evapotranspiration, drainage, and spatial distribution of daily precipitation and air temperature, average monthly atmospheric conditions, and user-defined runtime options. INFIL3.0 will compute daily, monthly, and annual average water-balance components for multi-year simulations.

Input required for INFIL3.0 was obtained from the following sources:

- National Elevation Dataset (NED) to define topography
- National Hydrologic Unit Codes (HUCs) to define watershed and sub-watershed boundaries

- San Bernardino County and the National Oceanic and Atmospheric Administration (NOAA) Climate Data Center to develop temporal and spatial distributions of daily precipitation and temperatures
- STATSGO soil database (STATSGO2, 2009) to define the distribution of soils and soil properties
- USGS and the state of California for geologic mapping, including the recent map, Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California (Bedford et al., 2006)
- WESTVEG GAP regional vegetation mapping to characterize vegetation in the area

The average annual recoverable water quantities for Fenner Watershed, Orange Blossom Wash area and combined (Fenner and Orange Blossom wash area) in total are: 30,191 acre-feet per year (AFY); 2,256 AFY; and 32,447 AFY, respectively, based on calendar years 1958 through 2007. The annual quantities vary with annual precipitation. In general, the period prior to about 1975 was much drier than the long-term average, while the period after 1975 was much wetter than average. So, the period 1958 through 2007 covers both a long-term dry and long-term wet periods.

Validation of Recoverable Water Estimate

Fenner Gap is the path of groundwater flow through alluvial and bedrock aquifers (such as carbonate units) from Fenner Valley into Bristol and Cadiz valleys. The long-term steady-state flow of groundwater through the gap is expected to be similar to long-term groundwater recharge in the Fenner Watershed. A three-dimensional groundwater flow model of the Fenner Gap area was developed for the purposes of validating the 30,000 AFY estimate of steady-state groundwater flow through Fenner Gap, previously described. The model is used to solve the inverse problem, that is, given a boundary inflow of groundwater at the north end of the gap of 30,000 AFY, and measured steady-state groundwater levels, what distribution of aquifer properties (specifically hydraulic conductivity) is required to allow for this flow and is this distribution likely given available information on aquifer properties?

The question was answered using a software program called PEST, which is often used in inverse modeling to aid in calibrating groundwater flow models. PEST is a model-independent parameter estimator (PEST) computer program that provides for nonlinear parameter estimation for use with almost any numerical model. PEST has been widely used and extensively tested since 1994 by scientists and engineers around the world working in many different fields, including biology, geophysics, geotechnical, mechanical, aeronautical and chemical engineering, ground and surface water hydrology, and other fields (Doherty, 2004). PEST is used to estimate groundwater model parameter values, such as hydraulic conductivity, where measurements of groundwater levels and stresses (such as pumping or recharge) are known. PEST calculates values of hydraulic conductivity that makes the groundwater flow model "calibrate" to the measured values. PEST makes many (often thousands) model simulation runs to find the best set of parameter values that minimizes the residuals (differences) in simulated and observed measurements (e.g., groundwater levels).

PEST was used in the Fenner Gap groundwater model to estimate hydraulic conductivity distributions for the alluvial aquifer and carbonate rock units in the Fenner Gap given the following constraints (1) areal and vertical distribution of alluvial and carbonate rock units as previously described, (2) constant head values (groundwater elevations) of 660 feet and 590 feet on the northern and west-southern boundaries, respectively, (3) a target flux across the northern boundary of 30,000 AFY, (4) target groundwater-level measurements from monitoring wells in the Fenner Gap area based on recent groundwater levels and, (5) estimates of hydraulic conductivity from aquifer tests from previous studies and as a part of this study. These PEST-estimated hydraulic conductivity values are evaluated in the context of the hydrogeology of the gap, including available aquifer test data, to determine if these parameter estimates are reasonable. If these hydraulic conductivity values are considered reasonable, then it is reasonable that groundwater flow through the Fenner Gap is 30,000 AFY.

PEST results produced two distributions of hydraulic conductivity that are both reasonable and consistent with observed data from aquifer tests, while maintaining 30,000 AFY of groundwater flow through the gap and matching observed groundwater levels in monitoring wells. Because of this match, it is reasonable to assume that 30,000 AFY is flowing through the gap and, therefore, that 30,000 AFY is a reasonable estimate of potentially recoverable water.

In total, data obtained from field investigations, INFIL3.0 watershed soil-moisture budget assessments, and Fenner Gap three-dimensional groundwater flow model simulations support a 32,000 AFY estimate of potentially recoverable water from the Fenner and northern Bristol Valley area. However, numerical models are based on simplified conceptual models of the more complex physical groundwater system and processes. Model construction and calibration results in non-unique models, which is demonstrated herein, in that two conceptual models provide a good fit to observed data (groundwater levels and range of hydraulic conductivity values). The Fenner Gap models suggest a large area of highly transmissive alluvium and carbonate rock units, especially along the eastern side of the gap, extending into the Bristol Valley. This area should be the focus of any additional field investigations as might be required for development of an operations plan and subsequent environmental impacts assessments, which also will provide further support of these potentially recoverable water estimates.

It is important to note that it was not the purpose, or within the scope, of the present study to develop an operations plan for development of the water resources or to provide an assessment of those environmental impacts associated with this development. Findings of this study are intended only to serve as a foundation for defining a groundwater conservation and storage project on lands owned by Cadiz, Inc. An operations plan that would include locations, quantities and timing of extractions, recharge, and storage and recovery operations would be the logical next step, followed by assessments of environmental impacts associated with the proposed operations. Those environmental assessments could include additional field investigations to further confirm the findings of this study and provide additional data as may be required to complete the environmental assessments.

Figures

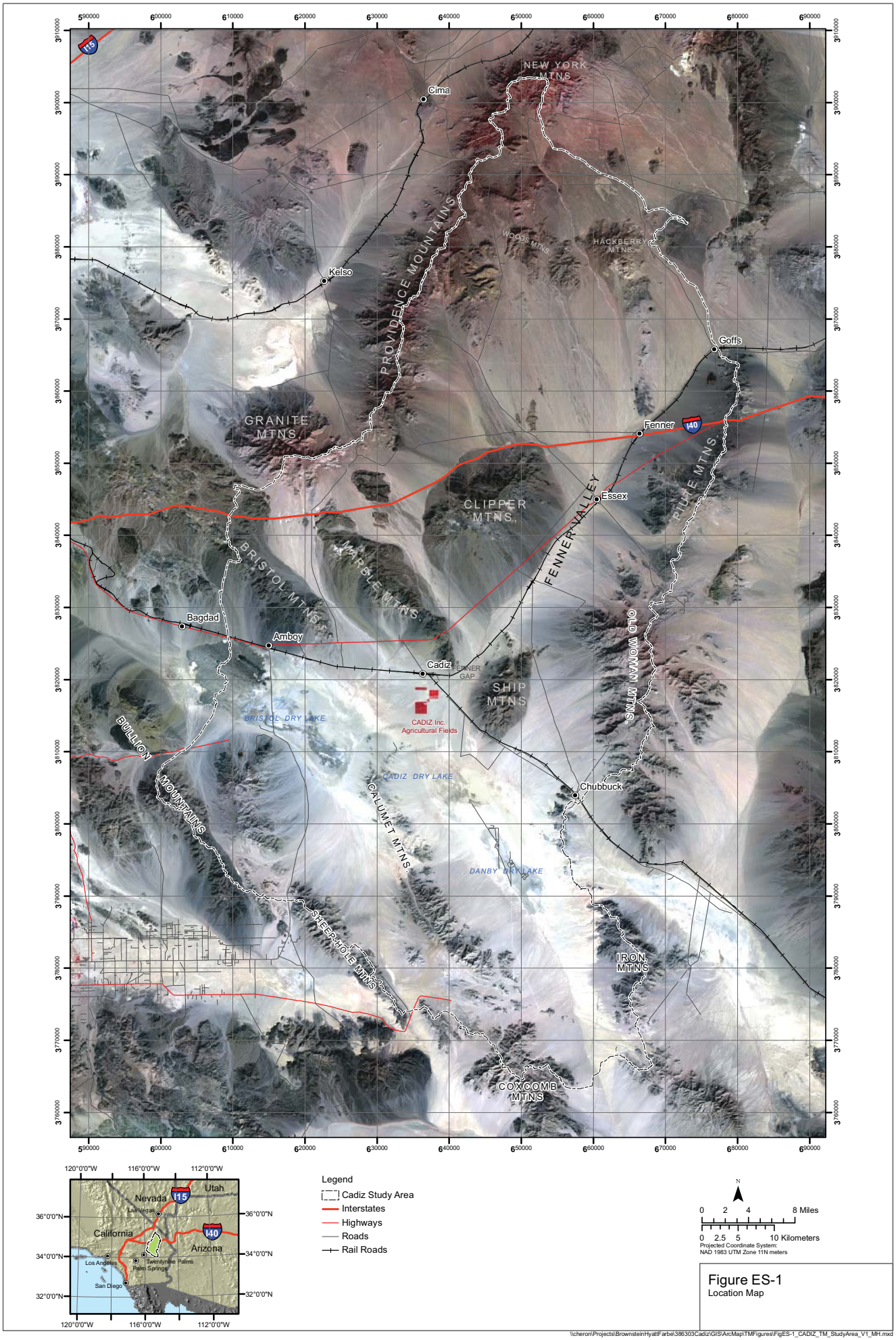
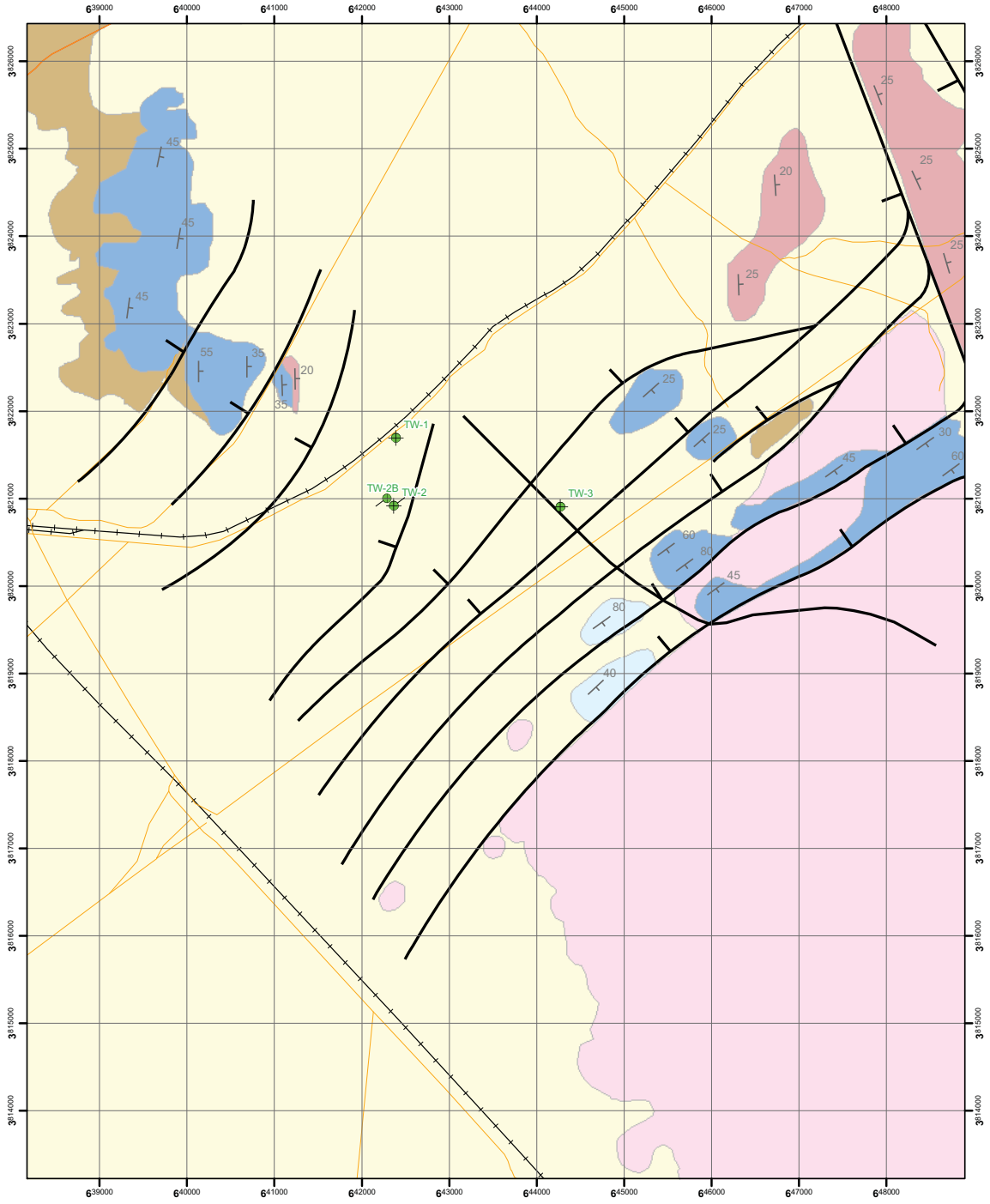


Figure ES-1
Location Map

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\FigES-1_CADIZ_TM_StudyArea_V1_MH.mxd



Legend

- Test Wells
- Test Borings
- Fault
- Interstates
- Roads
- Rail Roads

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

0 0.25 0.5 1 Miles

0 0.25 0.5 1 Kilometers

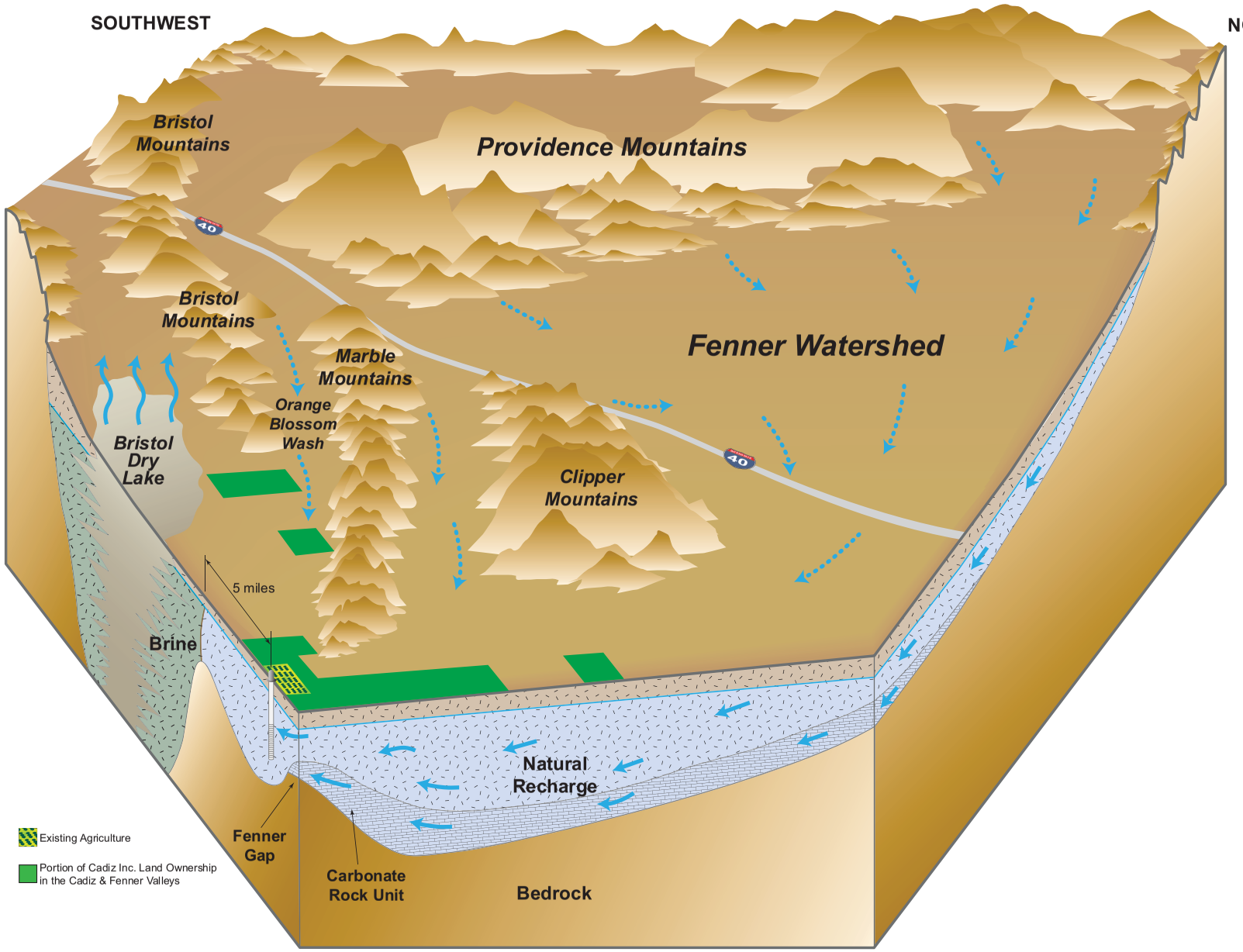
Projected Coordinate System:
NAD 1983 UTM Zone 11N meters
Vertical Datum NAVD88

N

Figure ES-2
Field Map of New Boreholes and Test Wells Locations

Modified from Liggett (2010) and Bishop (1963)

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\FigES-2_CADIZ_TM_Location_of_New_Boreholes_TestWells _V1_MH1.mxd



LOOKING NORTHWEST

FIGURE ES-3
Conceptualization of Groundwater Occurrence and Movement In the Area of Study

Section 1 - Introduction

1.0 Introduction

Cadiz, Inc. (Cadiz) owns 34,000 acres of largely contiguous land in the Cadiz and Fenner valleys, located in the eastern Mojave Desert (Figure 1-1). Under land use approvals issued by San Bernardino County, Cadiz has successfully farmed about 1,000 acres of land on the property for more than 15 years.

Cadiz recognized the potential for developing a water supply project on its properties in the early 1990s and reached out to partner with water supply agencies. Cadiz selected the Metropolitan Water District of Southern California (Metropolitan) to evaluate the feasibility of operating a groundwater storage and transfer project. The project would have involved transporting surplus Colorado River water to the project site, recharging it through a series of recharge basins, storing the water, and then extracting the stored water during times of drought. A pipeline would have been constructed from the Colorado River aqueduct to the project site to convey water across Bureau of Land Management (BLM) land to and from the project site. This project was referred to as the "Cadiz Groundwater Storage and Dry-Year Supply Program." The United States Department of Interior issued a right of entry for the pipeline after finding the proposed project would not cause any significant environmental harm. However, although the feasibility studies completed under the partnership demonstrated a significant potential for water supply development, Metropolitan decided not to pursue the project in 2001.

Cadiz continues to pursue partnerships to develop a water supply project in a different manner than the project previously contemplated with Metropolitan. In particular, Cadiz desires to emphasize water conservation that involves capturing natural recharge in the Fenner and northern Bristol valleys that would otherwise discharge to the Bristol and Cadiz dry lakes and then evaporate. The groundwater storage component involves extraction of native groundwater from groundwater in storage to develop storage conditions that would allow native water to be conserved and imported water to be transported, stored, and recaptured in the project area for beneficial uses, including environmental mitigation purposes.

Cadiz is a publicly traded renewable resources company founded in 1983. Between 1984 and 1994, Cadiz installed seven production wells to support irrigated agriculture that now extends to approximately 1,600 acres and includes table grapes, lemons, and various row crops. Currently, Cadiz is actively pursuing options to site utility-scale solar energy projects at their properties and to utilize renewable energy to power project-related facilities (such as well pumps and booster pump stations).

1.1 Purpose

The purpose of the current study is two-fold: (1) to develop an estimate of the recoverable water that can be prudently conserved over the long term (water that can be intercepted and that would otherwise flow to the Bristol and Cadiz dry lakes and evaporate) and (2) develop an estimate of groundwater in storage in the Fenner Valley and northern Bristol Valley area. This work is intended to complement and update the substantial earlier technical work

conducted in connection with the evaluation the proposed joint project with Metropolitan. These recoverable water and storage estimates are a refinement on earlier work and also provide an independent basis for the ultimate development of a scope of a water supply project that includes water supply and storage components. It is not the scope of the current study to assess potential environmental impacts associated with development of a water supply project. The analysis of potential environmental impacts will be the subject of subsequent studies, based on the definition of a specific water supply project.

1.2 Scope

The scope of this study includes review of a substantial body of existing technical information developed in connection with the joint Cadiz/Metropolitan project, access to recent published reliable information from federal databases, including the United States Geological Service (USGS), the development of new data, including new field investigations, to assess recoverable water and groundwater in storage that can be used to establish the basis for defining a groundwater conservation project in the Cadiz area.

A large body of information, including data from project-specific field investigations was compiled as part of the Cadiz Groundwater Storage and Dry-Year Supply Program feasibility study. The feasibility study is presented in a report entitled *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources*, prepared by Geoscience Support Services, Inc. (GSSI) in November 1999. GSSI included an evaluation of recoverable water and groundwater in storage as a part of their study. GSSI estimated the range of groundwater recharge to the Fenner, Bristol, and Cadiz watershed areas to be 20,000 to 58,000 acre-feet per year (AFY) and the amount of groundwater available to the project area to be 30,000 AFY. The volume of groundwater in storage within aquifers of the Fenner Watershed was estimated by GSSI to range from 13 to 23 million acre-feet (AF) and the volume of groundwater in storage in the aquifers of the project area ranges from 4 to 7 million acre-feet. Although thorough, GSSI's 1999 report was subject to review and evaluation by third parties.

The current study is focused on providing a new independent assessment of recoverable water and groundwater storage estimates presented by GSSI (1999), including their responses to critiques of their 1999 report. The specific scope of work of this study includes the following elements:

1. Review of previous studies on hydrology, geology, hydrogeology, groundwater conditions, vegetation, and land use in the Fenner, Bristol and Cadiz valleys, including the third-party reviews of the GSSI 1999 report.
2. Compilation of information regarding climate data (e.g., precipitation and temperature data), geologic investigations, data on wells, springs and groundwater conditions, soils mapping and characterization, and vegetation studies since the publishing of the earlier 1999 GSSI study.
3. Revisions to the depth to bedrock contour map and groundwater-level contour map to update estimates to groundwater in storage.

4. Application of a soil-moisture budget model, specifically INFIL3.0 published by the USGS (2008), to estimate net infiltration of water below the root zone and recoverable water in the Fenner Watershed and Orange Blossom Wash areas.
5. Survey of monitoring wells in the Fenner Gap area and measurement of groundwater levels.
6. Drilling of four deep boreholes and installation and testing of three deep wells in the Fenner Gap to further assess hydrogeologic properties and groundwater conditions in the gap, including characterization of the alluvial aquifer unit and carbonate units underlying the alluvial aquifer.
7. Preparation of detailed geologic cross-sections through the Fenner Gap based on previously published work and field investigation conducted as a part of this study.
8. Development of a local three-dimensional groundwater flow model of the Fenner Gap to estimate the likely flow of groundwater through the gap.
9. Comparison and discussion of recoverable water estimates, groundwater flow through Fenner Gap, and evaporation of water from Bristol and Cadiz dry lakes.
10. Preparation of a report to summarize information and present findings and conclusions of this study.

It is important to note that it was not the purpose or within the scope of the present study to develop an operations plan for development of the water resources or to provide and assessment of those environmental impacts associated with this development. Findings of this study are intended only to serve as a foundation for defining a groundwater conservation and storage project on lands owned by Cadiz. An operations plan that would include locations, quantities, and timing of extractions, recharge, and storage and recovery operations would be the logical next step, followed by assessments of environmental impacts associated with the proposed operations. Those environmental assessments could include additional field investigations to further confirm the findings of this study and provide additional data as may be required to complete the environmental assessments.

Figures

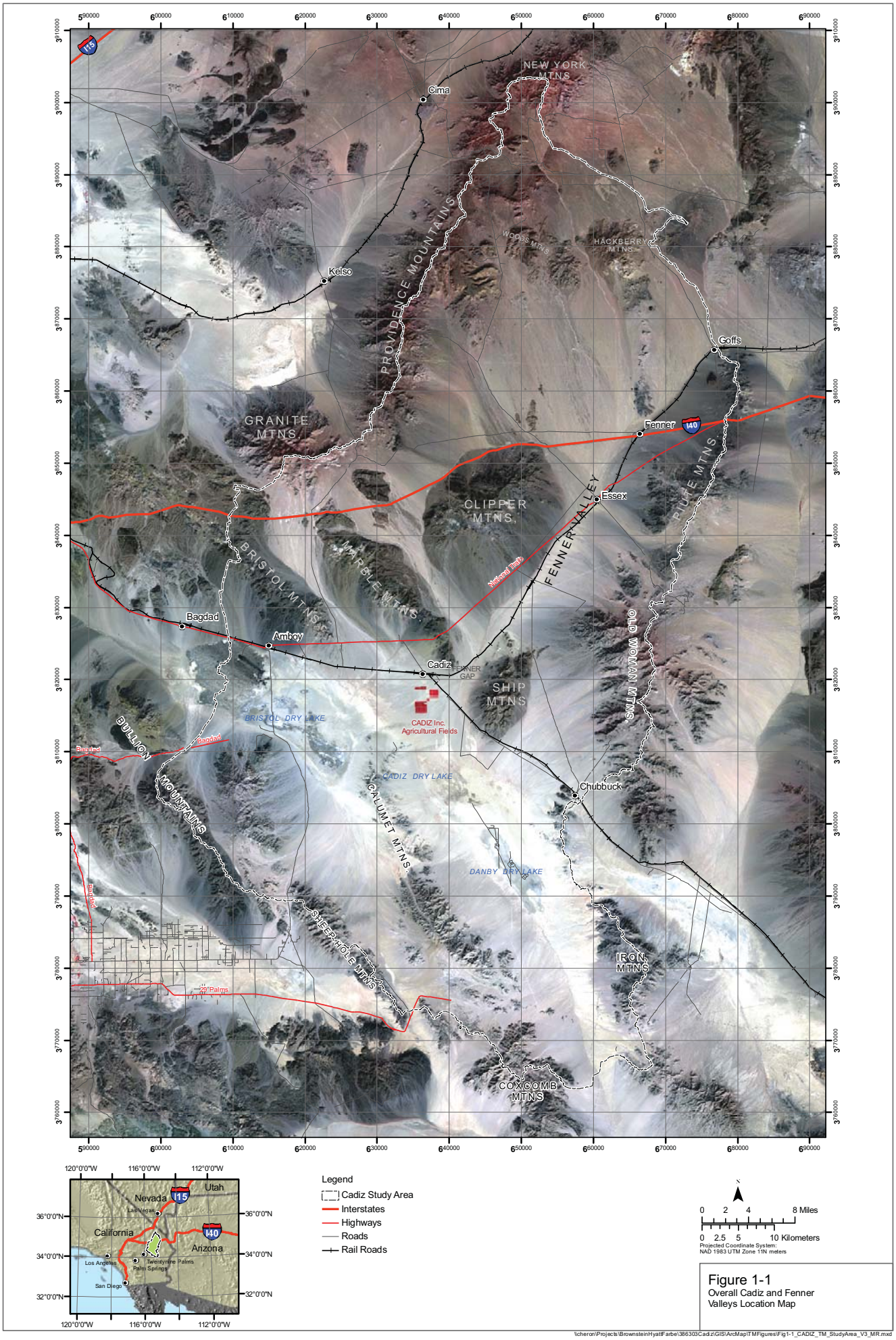


Figure 1-1
Overall Cadiz and Fenner Valleys Location Map

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig1-1_CADIZ_TM_StudyArea_V3_MR.mxd

Section 2 - Setting

2.0 Setting

This section presents an overview of the setting of the larger area of study that includes the Fenner, Bristol, and Cadiz watersheds, and the focused area of study, which includes the Fenner Watershed, Orange Blossom Wash, and northwestern Cadiz Valley areas. Following is a brief overview of the physiography, climate, geology, and hydrogeology of the larger area of study. More comprehensive discussions of each of these topics can be found in GSSI's 1999 report and references cited therein, as well as references listed in each section below.

2.1 Physiography

2.1.1 Overview of Setting

Figure 2-1 shows the location of the larger area of study that includes the Fenner, Bristol, and Cadiz watersheds. These watersheds are located in the Eastern Mojave Desert, which is a part of the Basin and Range Province of the western United States. The Basin and Range Province is characterized by a series of northwest/southeast trending mountain and valleys formed largely by faulting (Burchfiel et al., 1980). One of the prominent features of the area is the Bristol Trough, a major structural depression caused by faulting (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). The Bristol Trough encompasses the Bristol and Cadiz watersheds that together form a relatively low land area that extends from just south of Ludlow, California, on the northwest to a topographic and surface drainage divide between the Coxcomb and Iron mountains on the southwest. The Bristol and Cadiz valleys are bounded on the southwest by the Bullion, Sheep Hole, Calumet, and Coxcomb mountains and on the northeast by the Bristol, Marble, Ship, Old Woman, and Iron mountains. The Cadiz and Bristol dry lakes are separated by a low topographic and surface drainage divide.

The Fenner Watershed is located north of the Bristol Trough. This watershed encompasses approximately 1,100 square miles (mi^2). It is bounded by the Granite, Providence, and New York mountains on the west and north and the Piute, Ship, and Marble mountains on the east and south. Fenner Gap occurs between the Marble and Ship mountains, where the surface drainage exits Fenner Watershed and enters the Bristol and Cadiz watersheds. The Clipper Mountains rise from the southern portion of the watershed, just northwest of Fenner Gap.

2.1.2 Topography

Figure 2-2 shows a topographic map of the larger area of study based on the National Elevation Dataset (NED) (USGS, 2006). Figure 2-3 shows drainage areas within the Fenner, Bristol, and Cadiz watersheds based on the National Hydrologic Unit Codes (HUC) (NRCS, 2009).

The New York Mountains rise to elevations of approximately 7,532 feet above the National Geodetic Vertical Datum of 1988 (NGVD). The Granite and Providence mountains range from 6,786 feet to 7,178 feet above NVGD, respectively. The Piute Mountains range up to 4,165 feet above NVGD. The Clipper Mountains rise to an elevation of more than 4,600 feet

above NVGD. Finally, the Marble and Ship mountains range up to 3,842 and 3,239 feet above NGVD, respectively. Generally, the Fenner Valley slopes southward toward the Fenner Gap, which is the surface water outlet from the valley, at an elevation of about 900 feet above NGVD.

Mountain ranges surrounding the Bristol and Cadiz watersheds are lower in elevation than those mountain ranges surrounding the Fenner Watershed. Peak elevations for these mountains include the following: Bristol, 3,422 feet above NGVD; Iron, 3,296 feet above NGVD; Bullion, 4,187 feet above NGVD; Sheep Hole, 4,685 feet above NGVD; Calumet, 1,751 feet above NGVD; and Coxcomb, 4,416 feet above NGVD.

The Bristol and Cadiz dry lakes represent the lowest elevations at 595 and 545 feet above NGVD, respectively.

2.1.3 Vegetation

Figures 2-4 and 2-4b show the distribution of vegetation in the larger area of study based on a western region vegetation map (WESTVEG) compiled as a part of the USGS's Biological Resources National Gap Analysis Program (BRGAP, 2009). The BRGAP digital vegetation maps are developed using satellite imagery and other records based on the National Vegetation Classification System (Hevesi, 2003). The WESTVEG plant associations in the larger area of study include the following: blackbush scrub, desert dry wash woodland, desert saltbrush scrub, Mojave creosote bush scrub, Mojave mixed steppe, Mojave mixed woodland and succulent scrub, Mojave mixed woody scrub, Mojavean pinyon and juniper woodland, semi-desert chaparral, and Sonoran creosote bush scrub. The Mojave creosote bush shrub is the most prevalent plant association and covers most of the valley floors; however, it is relatively sparse even in these areas. The Pinyon and juniper woodlands vegetation association occurs at higher elevations where precipitation is higher and temperatures are cooler.

2.1.4 Dry Lakes (Playas)

The Bristol and Cadiz dry lake playas are located at the lowest elevations in the larger area of study. The Bristol and Cadiz watersheds are closed, so the only natural outlets for surface water and groundwater are evaporation from the dry lake surfaces. The lake surfaces are normally dry but flash flooding from sudden spring snow thaws and/or late summer thunderstorms of high intensity can result in standing water (Bassett et al., 1959; Koehler, 1983; GSSI, 1999; Liggett, 2009).

The playas are made up of a variety of surface types, including salt crust and soft puffy porous surfaces and are largely devoid of vegetation. Clay and silts are the predominant soil types beneath the surface. Puffy surfaces are believed to be formed from capillary groundwater movement causing salts to precipitate and clays to swell on the surface, resulting in a network of polygons and hummocky relief (Czarnecki, 1997). This puffy surface is reported to cover more than 60 percent of Bristol Dry Lake (Kupfur and Basset, 1962).

2.2 Climate

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and

summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower temperatures and higher precipitation at higher altitudes.

2.2.1 Precipitation

Davisson and Rose (2000) describe environmental factors that complicate the distribution of precipitation through southeastern California and western Nevada. These factors include the rain-shadow effect of the Sierra Nevada, San Gabriel, and San Bernardino mountains, and storms moving up from the Gulf of California that create more precipitation in the eastern Mojave Desert than in the western Mojave Desert. The rain-shadow effect of the Sierra Nevada Mountains has its greatest impact on precipitation just east of the Sierra Nevadas and decreases eastward into Nevada. In general, Davisson and Rose (2000) show that precipitation versus elevation is higher east of the 116° W longitude than west of it. The Fenner Watershed lies to the east of this demarcation, so this watershed is expected to have higher precipitation with increases in elevation as compared to watersheds in the western Mojave Desert.

Figure 2-5 shows precipitation and temperature stations in the study area. Those stations with relatively long and complete records in the immediate area of study include Mitchell Caverns and Amboy stations. Stations with short and less complete records in the area and vicinity include the San Bernardino County stations of Goffs, Essex, and Kelso. Table 2-1 summarizes the records available for these stations. The long-term annual average precipitation at Mitchell Caverns, located at an altitude of 4,350 feet, is 10.47 inches. Amboy is represented by two stations, Amboy – Saltus Number 1, with an elevation of 624 feet and a long-term annual average precipitation of 3.28 inches (from 1967 through 1988) and Amboy – Saltus Number 2, with an elevation of 595 feet and long-term annual average precipitation of 2.71 inches (1972 through 1992)

Figure 2-6 shows isohyets of average annual precipitation for the larger area of study based on the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) map for the period 1971 through 2000. PRISM was developed by Dr. Christopher Daly of Oregon State University starting in 1991. PRISM uses point estimates of climate data and a digital elevation model (DEM) to generate estimates of climate elements, such as average annual, monthly, and event-based precipitation among other elements (www.prism.oregonstate.edu). This isohyet map shows average annual precipitation that varies from about 4 inches in Bristol Valley to more than 12 inches in the New York Mountains.

Figure 2-7 shows the cumulative departure from mean precipitation for the Mitchell Caverns and Amboy stations. The trend of relatively dry conditions prior to the mid-1970s (overall declining trend in the cumulative departure curve) and relatively wet conditions (overall rising trend in the cumulative departure curve) since the mid-1970s is typical of much of southern California.

2.2.2 Temperature

Air temperature in the eastern Mojave Desert reaches highs in the summer and lows in the winter. The average winter temperature is between 50°F and 55 °F, with average daily maximum near 65 °F and average daily minimum near 40° F. Average daily temperature in the summer months is over 85°F, with maximum temperatures hovering around 100°F and

occasionally exceeding 120 °F. Average daily minimum temperatures in the summer are around 70 °F, so the range of daily temperatures may exceed 20 °F to 30°F.

The two weather stations in the area, Amboy and Mitchell Caverns, record air temperature. The minimum monthly temperature at Amboy is reported to be 50.7 °F in December and the maximum monthly temperature is 94.7 °F in July. The minimum monthly temperature at Mitchell Caverns is reported to be 46.3 °F in January and the maximum monthly temperature is 82.1 °F in July. The average annual temperatures at Amboy and Mitchell Caverns are 71.8 °F and 62.6 °F, respectively.

2.3 Geology

Information on the regional geology and structure is excerpted largely from the *Final Environmental Impact Report/Environmental Impact Statement on the Cadiz Groundwater Storage and Dry-Year Supply Program* ("Final EIR/EIS," Metropolitan, 2001) and summarized below. A recent report published by the USGS entitled: *Geology and Mineral Resources of the East Mojave National Scenic Area, San Bernardino County, California, U.S. Geological Survey Bulletin 2160* (USGS, 2006) provides additional detail on the geology and geologic structure of the northern part of the larger area of study. This report also provides additional information on the vertical extents of alluvial deposits in northern Fenner Valley that was not available during the GSSI study. In 2002, the USGS published the *Sheep Hole Mountains 30x60 Minute Quadrangle, Riverside and San Bernardino County, California* (Howard, 2002), which provides geologic details through the Bristol and Cadiz troughs, for most of the southern portion of the larger area of study. In addition, the USGS published a surficial geologic map entitled: *Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California* (Bedford et al., 2006), which covers a large portion of the area of study. This map is reproduced as Plate 1, provided in the pocket attached to this report. This later map provides valuable information on the surficial geology in the area of study.

2.3.1 Regional Geology

The larger area of study is located within the Basin and Range province of North America. Figure 2-8 is a simplified geologic map of the larger area of study showing the distribution of bedrock and alluvial/dune/lacustrine deposits. Bedrock includes igneous, metamorphic, and consolidated sedimentary rocks (including carbonates). Alluvial/dune/lacustrine deposits are unconsolidated sediments deposited by streams, wind, or in playa lakes for the purposes of this map. In general, bedrock forms the perimeter of the major watersheds. Large bedrock masses occur within watersheds, such as Clipper Mountains, which are located in the Fenner Watershed.

The Bristol and Cadiz watersheds form a broad depression that is referred to as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). This depression is thought to be six to ten million years old (Rosen, 1989), having formed as a result of regional movement along faults.

The crystalline basement rocks exposed in the mountain ranges of the project area consist primarily of Precambrian granitic and metamorphic rocks that are locally overlain by a sequence of Paleozoic sedimentary rocks. The Paleozoic rocks consist of sandstones, shales, slates, limestones and dolomites. These Paleozoic sediments and the underlying basement rocks have been faulted and folded by numerous periods of regional tectonism.

The crystalline basement rocks are generally much less permeable than alluvium and typically yield only small quantities of water to wells (Freiwald, 1984). Some of the Paleozoic sedimentary sections, particularly those limestone and dolomites sections that are fractured or contain solution cavities, can and do yield large quantities of water to wells, as further described in Section 4.2. Mictchell Caverns, located on the eastern side of the Providence Mountains, occur in karstic limestone of this section. The widespread distribution of these carbonate units can be seen by the distribution of other outcrops that can be found on the eastern slope of the New York Mountains, in Lanfair Valley, just north of Clipper Mountains, in the Marble Mountains, in the Ship Mountains, in the southeast end of Bristol Mountains, the Kilbeck Hills on the south, and the Old Woman Mountains on the east (see USGS, 2006; Howard, 2002; and Bedford et al., 2006, Hazzard, 1956) for locations of these carbonate units). These carbonate units are expected to be significant aquifers where dissolution features are present in the subsurface.

The basement complex and the overlying Paleozoic section were locally metamorphosed and intruded by granitic plutons during Mesozoic time. In the Old Woman Mountains, the Precambrian and Paleozoic section was also intensely deformed by ductile thrusting that accompanied the Mesozoic plutonism (Karlstrom et al., 1993). Throughout the project area, mostly fractured crystalline basement rocks form the boundaries of the groundwater aquifer system.

In the Fenner Valley, the Paleozoic section is unconformably overlain by clastic sediments and interbedded volcanic rocks of mid- to late-Tertiary age. The Tertiary volcanic rocks consist of lava flows of basaltic to andesitic composition, and pyroclastic tuffs of rhyolitic to dacitic composition. The USGS (2006) reports that a shallow trap-door caldera roughly 10 kilometers (km) in diameter is centered in the eastern Woods Mountains, based on gravity and aeromagnetic anomalies, and was formed from a major eruption 15.8 million years ago, with resurgent eruptions filling the caldera with rhyolitic flows and tuffs. Dikes of similar composition are exposed in the Marble and Ship mountains. The Tertiary sediments consist of conglomerate, fanglomerate, sandstone, siltstone, water-laid tuff, and lake sediments, which form a composite section more than 7,000 feet thick (Dibblee, 1980). The Tertiary sediments and interlayered volcanic rocks are gently dipping, due to extensional normal faulting of late-Tertiary age.

The Quaternary and late-Tertiary alluvial fill in the basins is largely derived from the Precambrian basement rocks, Paleozoic sediments, and Tertiary volcanic rocks. The USGS (2006) mapped alluvial deposits exceeding 300 meters (m) in thickness in the northern Fenner Valley (see Plate 2 provided in the pocket attached to this report and reproduced from USGS, 2006). Geophysical evidence indicates this alluvial fill locally exceeds 3,500 feet in thickness beneath a portion of the southern Fenner Valley (Maas, 1994) and even greater under Bristol Valley; a depth-to-bedrock map is shown in Section 3. These alluvial sediments form one of the principal aquifers in the study area.

The playa sediments underlying the Bristol, Cadiz and Danby dry lakes consist of brine-saturated clay, silt, fine-grained sand, and evaporite deposits. The clastic sediments were deposited when stream flow and sheet flow from the surrounding alluvial fans spread onto the playas during major storm events (Gale, 1951). The evaporite deposits formed from evaporation of both surface water and groundwater that seeps into the playa sediments from the adjacent alluvial fans (Rosen, 1989).

Bristol, Cadiz and Danby dry lakes have static groundwater levels at or near the playa surfaces (Moyle, 1967; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on all three of these playas. Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) concur that the principal recharge to the playas occurs as diffuse seepage of groundwater onto the playas from the adjacent alluvial fans.

Cadiz and Bristol dry lakes are locally bordered by active dunes formed by fine to medium-grained windblown sand. These Holocene deposits overlie older playa deposits of differentiated Quaternary age (Moyle, 1967).

Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lava field believed to be as young as 6,000 years (Parker, 1963; Hazlett, 1992).

2.3.2 Structural Geology

The larger area of study is located at the eastern margin of the eastern California shear zone, a broad seismically active region dominated by northwest-trending right-lateral strike-slip faulting (Dokka and Travis, 1990). Roughly a dozen fault zones showing evidence of Quarternary movement (during the last 1.6 million years) have been identified in and adjacent to Bristol, Cadiz, and Fenner valleys (Howard and Miller, 1992).

Cadiz Valley is underlain by two major northwest-trending faults, inferred on the basis of gravity and magnetic data (Simpson et al., 1984). These fault zones have strike lengths of at least 25 miles, and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones (Howard and Miller, 1992; see the Final EIR/EIS for locations).

Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated on the basis of correlation of a distinctive Precambrian gneiss unit across the zone (Howard and Miller, 1992). Slickenside surfaces produced by fault movement and steeply dipping sediments recovered from cored drill holes beneath Cadiz Dry Lake suggest the fault zone displaces sediments of Pleistocene age (Bassett et al., 1959).

Bristol Dry Lake is bordered by probable extensions of the Cadiz Valley and South Bristol Mountains fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west (Howard and Miller, 1992). Geophysical data indicate this structural depression may exceed 6,000 feet in depth (Simpson et al., 1984; Maas, 1994). Drill cores recovered from depths of more than 1,000 feet beneath Bristol Dry Lake suggest that subsidence of this basin began by Pliocene time and continues to the present (Rosen, 1989), and therefore may be tectonically active.

Fenner Gap appears to be a structural half-graben, formed by a system of northeast-trending, northwest-dipping normal faults, some of which are exposed in outcrops of the bedrock that flank the gap, as shown in Figure 2-9. The presence of these northeast-trending faults beneath the alluvial deposits that underlay the gap can be inferred from surface geology mapping, gravity surveys, a seismic reflection survey conducted across the gap by NORCAL Geophysical Consultants, Inc. (1997), and recent test wells drilled as a part of the this current study (see Section 4.2).

The system of normal faults that formed the half-graben of Fenner Gap displace and tilt volcanic rocks of mid- to late- Tertiary age, as shown in Figure 2-9. However, these faults do not displace Quarternary sediments and are, therefore, not considered to be either active nor potentially active.

2.3.3 Surficial Geology and Soils

This section summarizes information on surficial geology and soils in the study area.

2.3.3.1 Surficial Geology

Traditional geologic mapping often does not provide details on erosional surfaces and surface hillslope deposits. These deposits can serve as important conduits of precipitation for enhancing infiltration and groundwater recharge. Bedford et al. (2006) present a surficial geologic map of the Amboy 30x60 minute quadrangle, California. This map covers significant portions of the area of study (Plate 1 in attached pocket). Bedford et al. (2006) map two types of erosional and hillslope type deposits: abundant hillslope deposits (Holocene and Pleistocene) and Sparse hillslope deposits (Holoecene and Pleistocene). Definitions of these deposits are as follows:

- Abundant hillslope deposits - Hillslope materials such as colluvium, talus, weathering products, and landslide deposits; disaggregated cover greater than rock exposure. Generally less than 2 meters thick or patchy distribution with a small fraction of the area covered by deposits thicker than 2 meters.
- Sparse hillslope deposits – Hillslope materials such as colluvium, talus, weathering products, and landslide deposits; disaggregated cover less than rock exposure. Generally less than 2 meters thick and patchy distribution.

As shown on Plate 1 most bedrock in the area of study is mapped as abundant hillslope deposits.

2.3.3.2 Soils

The Soil Conservation Service has developed a geographical database of soils for each state called STATSGO. STATSGO provides information on soil types by a single map unit identifier (MUID). Each MUID represents a group of similar soil types. Figure 2-10 shows the distribution of MUIDs in the larger area of study from the STATSGO database.

There are 19 unique soil MUIDs in the larger area of study. Figures 2-11 and 2-12 show the percentage of grain sizes larger than 2 mm and percentage of clay for that grain size fraction less than 2 mm, respectively. In general, the soils in the area contain high percentages of coarse-grained materials and little clay in the fines (based on the fraction of materials that are less than 2 mm), based on averages using the combined weight of layer thickness and area for the soil components in each MUID. Additional soil moisture characteristics are given in Section 4.1.

2.4 Hydrogeology

The primary sources of replenishment to the groundwater system in the project area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes,

particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the regional watershed occurs in the higher elevations (Metropolitan, 2001; USGS, 2000; Davisson and Rose, 2000).

Figure 2-13 presents a conceptualization of groundwater occurrence and movement in the area of study. Figure 2-14 presents a schematic cross-section showing occurrence of groundwater in fractured bedrock that is recharged by precipitation. Precipitation infiltrates and moves downward to the water table. In some cases, the infiltrating water may be diverted to the land surface or groundwater may intersect land surface creating a spring. Otherwise, this infiltrating water moves vertically downward where it ultimately reaches the regional groundwater system and continues to flow downgradient through principal aquifer systems.

Groundwater occurrence in fractured bedrock of the watershed-perimeter mountains has been known since before the turn of the twentieth century (Mendenhall, 1909). The USGS documented the occurrence of wells and springs (referred to as "some desert watering places") throughout southeastern California and southwestern Nevada for the benefit of travelers and prospectors (Mendenhall, 1909). The USGS documented at least 10 wells and springs in the mountains and hills around the Fenner Watershed and a number of wells drilled into the alluvium by the Santa Fe Railroad. Another USGS study by Thompson (1929) provided additional information on more wells and springs in the study area i to survey, mark, and provide protection of watering places. Additional wells and springs were identified in the area of study and described by Thompson (1929). A more recent USGS survey of wells and springs in the area of study was conducted by Freiwald (1984). Figure 2-15 includes the distribution of wells and springs inventoried as a part of that study (USGS, 2009). These studies provide evidence of the fractured nature of the surrounding bedrock and the continuous infiltration of precipitation and movement of water through these perimeter rocks.

Although some groundwater is tapped by vegetation near the range fronts, the remainder moves slowly downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to Bristol and Cadiz dry lakes. Evaporation of groundwater and surface water from the dry lakes over the past several million years has resulted in thick deposits of salt (primarily calcium chloride and sodium chloride) and brine-saturated sediments (Rosen, 1989).

Bristol, Cadiz, and Danby dry lakes have static groundwater levels at or near the playa surfaces (Moyle, 1967; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on all three of these playas. Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) concur that the principal source of groundwater recharge to the playas occurs as diffuse seepage of groundwater into the playa sediments from the adjacent alluvial fans.

The mountain ranges that define the boundaries of the regional watersheds are comprised predominantly of granitic and metamorphic basement rock, as described previously. This less permeable basement complex forms the margins and bottoms of the aquifer systems (Freiwald, 1984). More permeable carbonate bedrock of Paleozoic age occurs locally within the boundaries of these watersheds (see previous discussion for general distribution and Section 4.2 for details in the Fenner Gap).

2.4.1 Hydrogeologic Units

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater (aquifers) have been divided into three general units: an upper (younger) alluvial aquifer; a lower (older) alluvial aquifer; and a carbonate rock unit aquifer (principally carbonate units are aquifers, but the unit contains interbedded quartzite and shale, see Section 4.2).

The younger alluvial aquifer consists of Quaternary and late-Tertiary alluvial sediments, including stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967; GSSI, 1999). The thickness of the upper alluvial sediments ranges to approximately 1,000 feet (GSSI, 1999; Section 4.2 of this report). The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of mid- to late-Tertiary age. Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments (Moyle, 1967; GSSI, 1999; Appendix A of this report). Production well PW-1, located in Fenner Gap, draws water primarily from the upper and lower aquifers and yields 3,000 gallons per minute (gpm) with less than 20 feet of drawdown (GSSI, 1999). The Cadiz, Inc. agricultural wells draw water from the alluvial aquifers and typically yield 1,000 to more than 2,000 gpm.

Based on findings from recent drilling in Fenner Gap, carbonate bedrock of Paleozoic age, located beneath the alluvial aquifers, contains groundwater and is considered a significant aquifer (GSSI, 1999; findings of this study as described in Section 4.2). Groundwater movement and storage in this carbonate bedrock aquifer primarily occurs in secondary porosity features (i.e., joints, faults, and dissolution cavities that have developed over time). The full extent, potential yield, and storage capacity of this carbonate aquifer have not been quantified at this time.

As previously noted, granite and metamorphic basement rock form the subsurface margins of the aquifer system. This basement rock is generally less permeable and typically yields smaller quantities of water to wells (Freiwald, 1984).

2.4.2 Groundwater Movement

In general, groundwater within the watersheds flows in the same direction as the slope of the land surface. In the Fenner Valley, groundwater generally flows southward and discharges through Fenner Gap toward Bristol and Cadiz dry lakes.

In Orange Blossom Wash, located between the Marble and Bristol mountains, groundwater flows generally southward from the Granite Mountains into Bristol Dry Lake.

Figure 2-16 presents a generalized contour map of groundwater elevations and horizontal flow directions in the area of study. The contours in this figure are based on water levels measured in more than 80 wells (GSSI, 1999). In some cases, published water level elevations have been adjusted to reflect more accurate reference elevations, obtained from updated topographic maps of the area (GSSI, 1999).

Tables

TABLE 2-1
Summary of Precipitation Stations in the Area of Study

STA #	Station Name	Elevation (ft)	Established	Discontinued
6048A	Twentynine Palms	1975	05/01/1935	Active
6179	Goffs	2587	05/17/1962	10/01/1968
6193	Kelso (Soda Lake Valley)	2148	05/16/1962	10/01/1991
6215	Mitchell Caverns	4330	03/01/1948	02/01/2004
6223	Ivanpah County Yard	2927	07/01/1961	10/01/1987
6245	Dale Dry Lake - Barnett's Trading Post	1220	12/10/1964	10/01/1978
6298	Amboy - Saltus #1	625	10/02/1966	10/01/1989
6300	Amboy - Saltus #2	595	06/27/1972	10/01/1993
6336	Dale Lake - Craine	1315	05/01/1975	10/01/1995
6375	Ludlow	1740	08/02/1982	10/01/1985
6397	Shadow Mountain	1360	10/02/1989	10/01/1993
6398	New York Mountains	4620	05/01/1990	12/01/2003
6401	Wonder Valley	1250	05/20/1991	10/01/1994
6402	Twentynine Palms U.S.M.C.	2004	10/02/1977	06/01/2001
7114	Iron Mountain	938	10/02/1940	10/01/1990
9004	Twentynine Palms County Yard	1895	12/01/1960	Active
9016	Wonder Valley F.S. - East	1224	08/28/1999	Active
9020	Essex Cal Trans Yard	1720	10/31/1994	Active

Figures

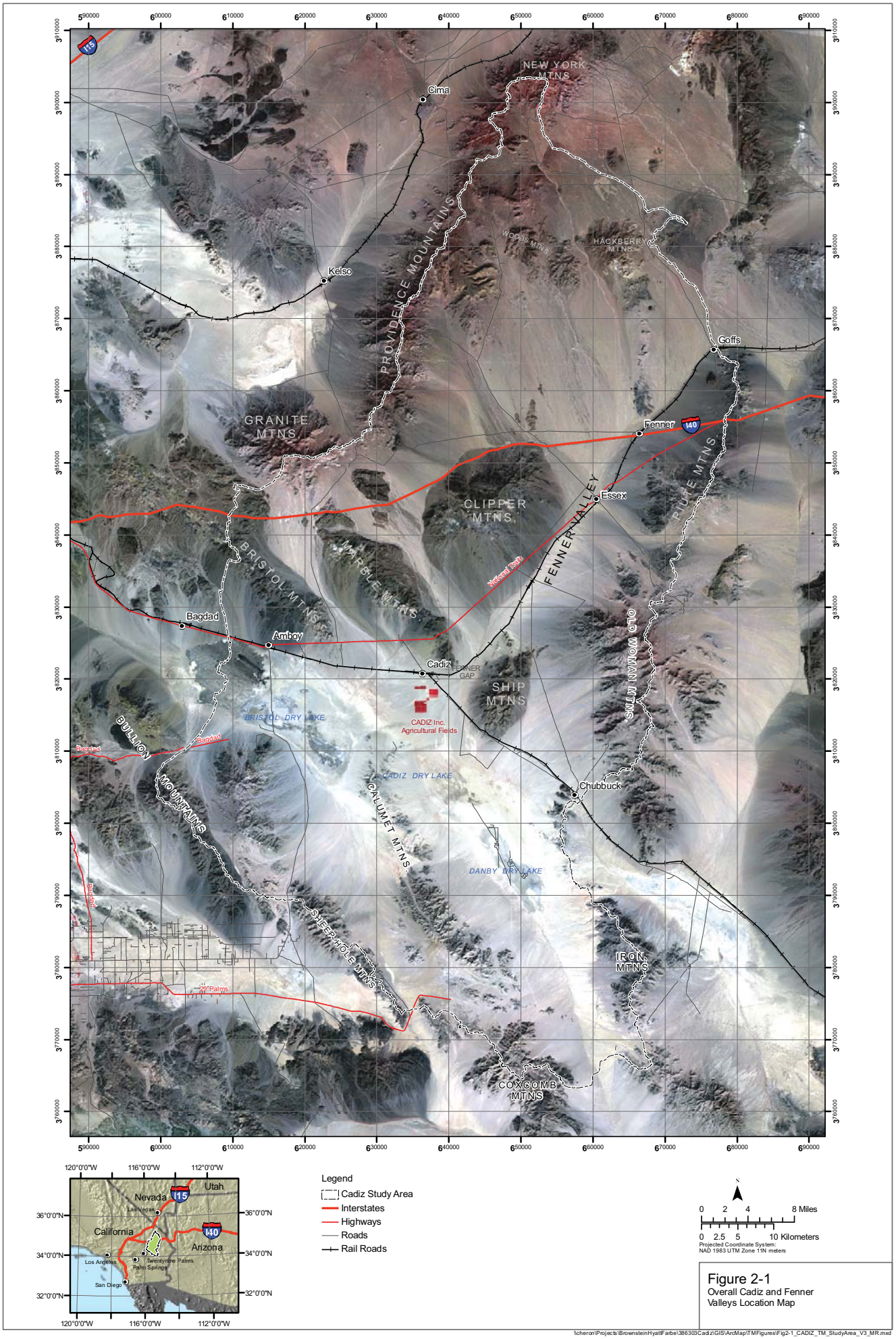
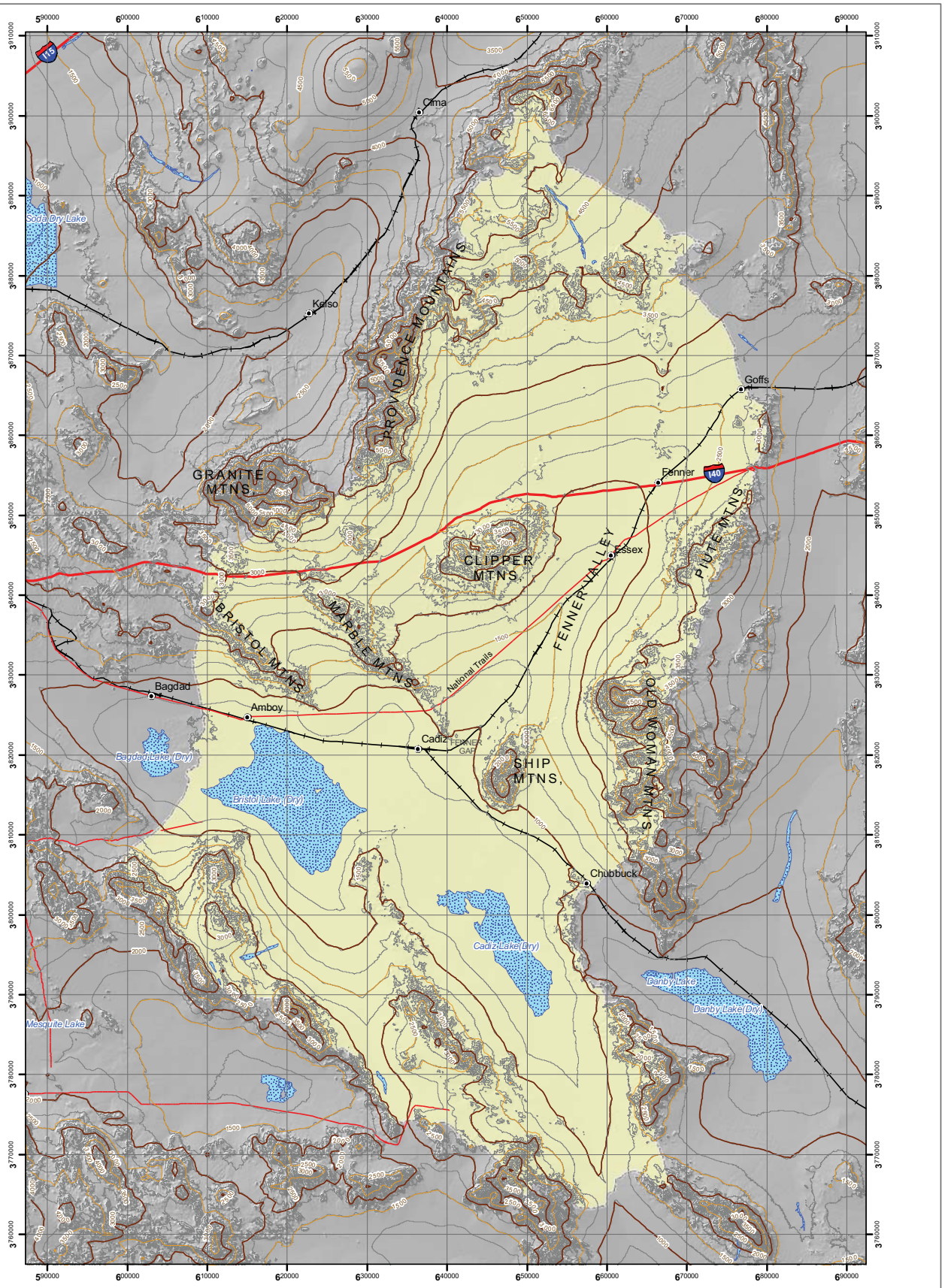


Figure 2-1
Overall Cadiz and Fenner Valleys Location Map

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-1_CADIZ_TM_StudyArea_V3_MR.mxd



Legend

- Cities/Communities
- Elevation
  - 1000 ft interval
  - 500 ft interval
  - 250 ft interval
- Interstates
- WaterBodies
- Rail Roads
- Cadiz Study Area

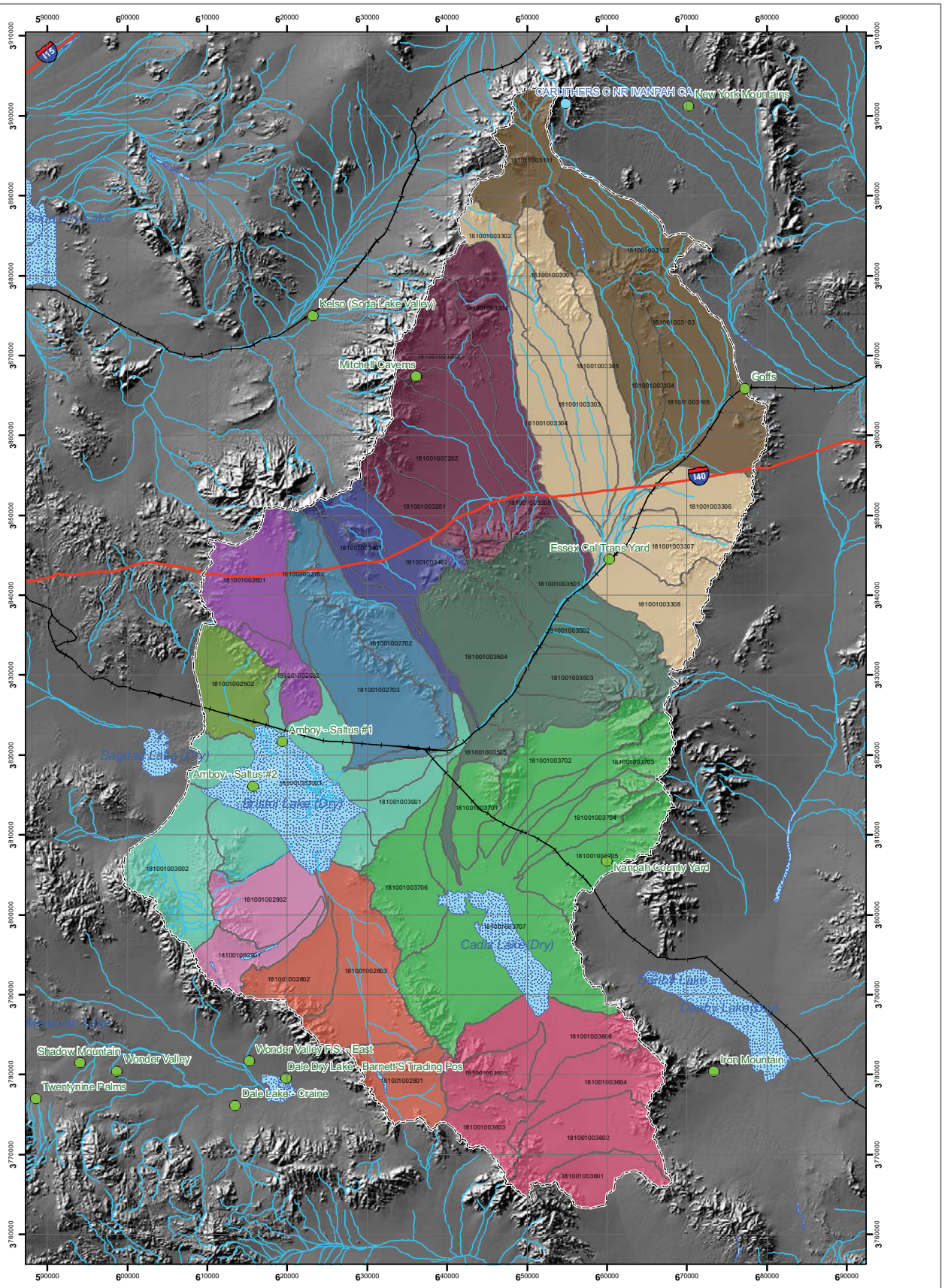
0 2 4 8 Miles

0 2 4 8 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-2
Topography

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-2_CADIZ_TM_ElevationContourMap_V3_MR.mxd



Legend

Watershed Boundaries
HUC10
1810010025
1810010026
1810010027
1810010028
1810010029
1810010030
1810010031
1810010032
1810010033
1810010034
1810010035
1810010036
1810010037
Climate Stations
USGS CA Flow Gages
Cadiz Study Area
Interstates
Rail Roads
WaterBodies
Drainage

N

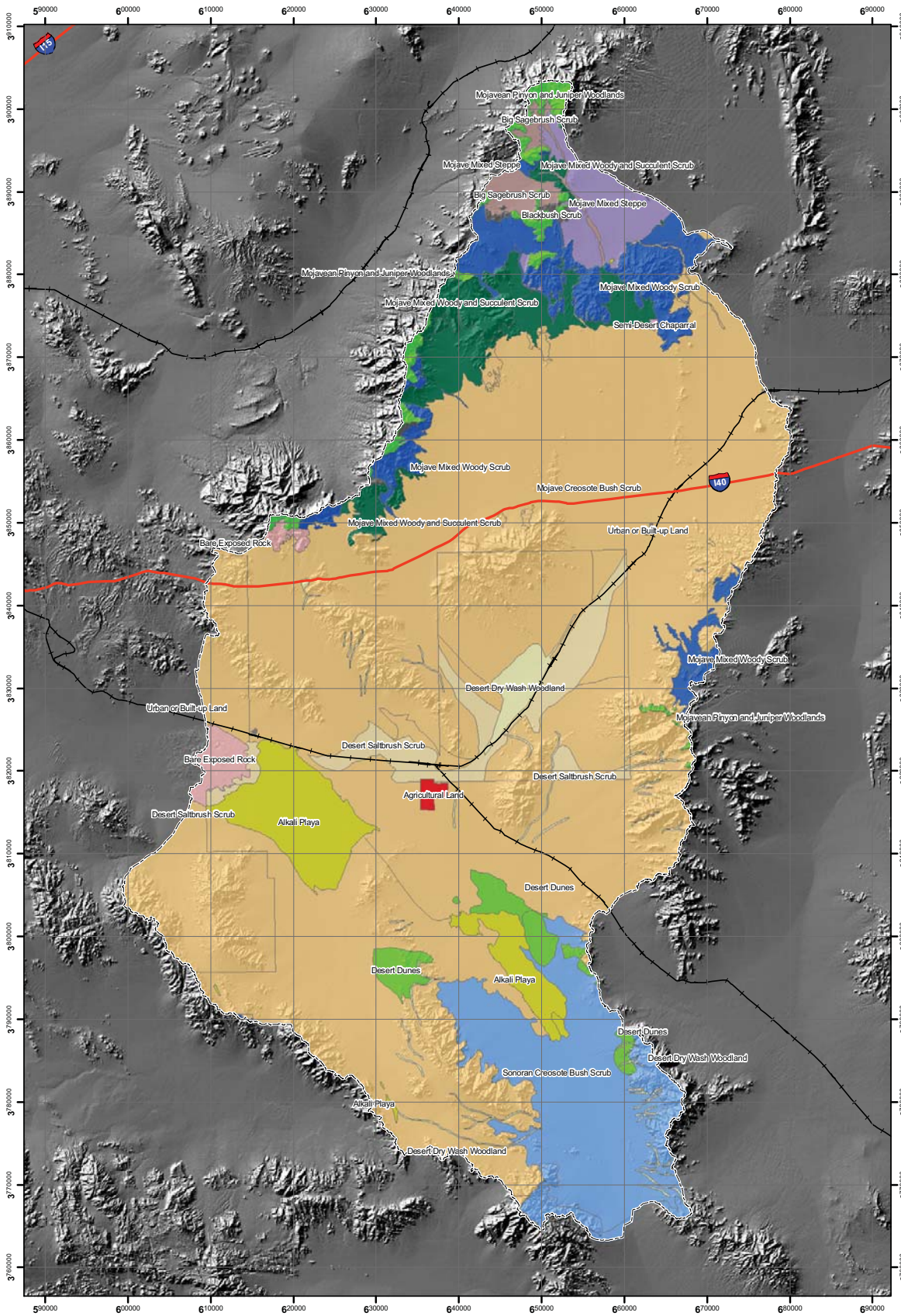
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-3
Drainage Map

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-3_CADIZ_TM_WatershedBoundaries_V4_MR.mxd



Legend

Cadiz Study Area
Interstates
Rail Roads

Vegetation

Common Name

- Agricultural Land
- Alkali Playa
- Bare Exposed Rock
- Big Sagebrush Scrub
- Blackbush Scrub
- Desert Dry Wash Woodland
- Desert Dunes
- Desert Saltbrush Scrub
- Mojave Creosote Bush Scrub
- Mojave Mixed Steppe
- Mojave Mixed Woody Scrub
- Mojave Mixed Woody and Succulent Scrub
- Mojavean Pinyon and Juniper Woodlands
- Semi-Desert Chaparral
- Sonoran Creosote Bush Scrub
- Urban or Built-up Land

N

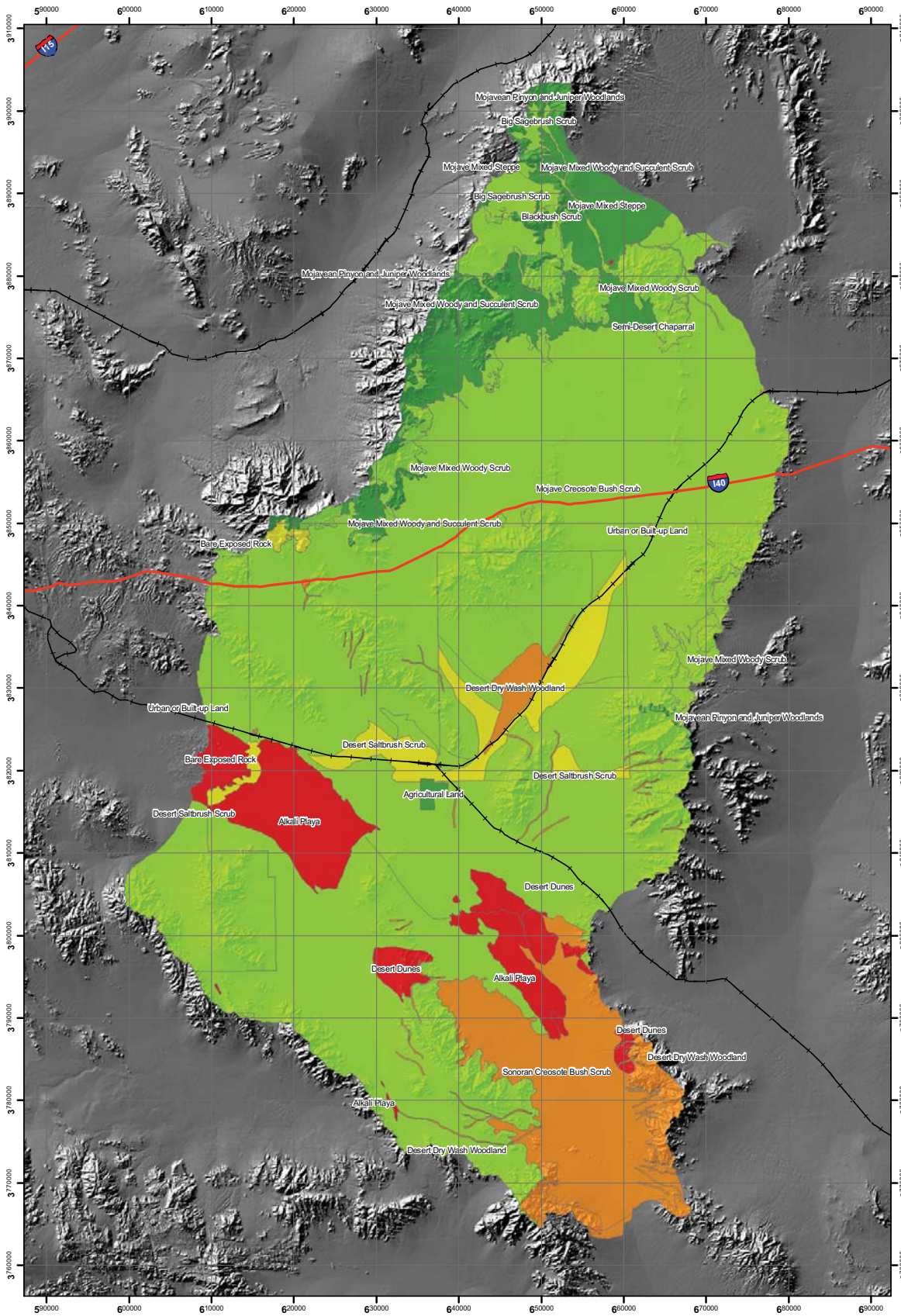
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-4
Vegetation

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-4_CADIZ_TM_VegetationMap_V3_MR.mxd



Legend

Interstates
Rail Roads

Vegetation Percentage Cover

- 0
- 1 - 5
- 6 - 25
- 26 - 35
- 36 - 50

N

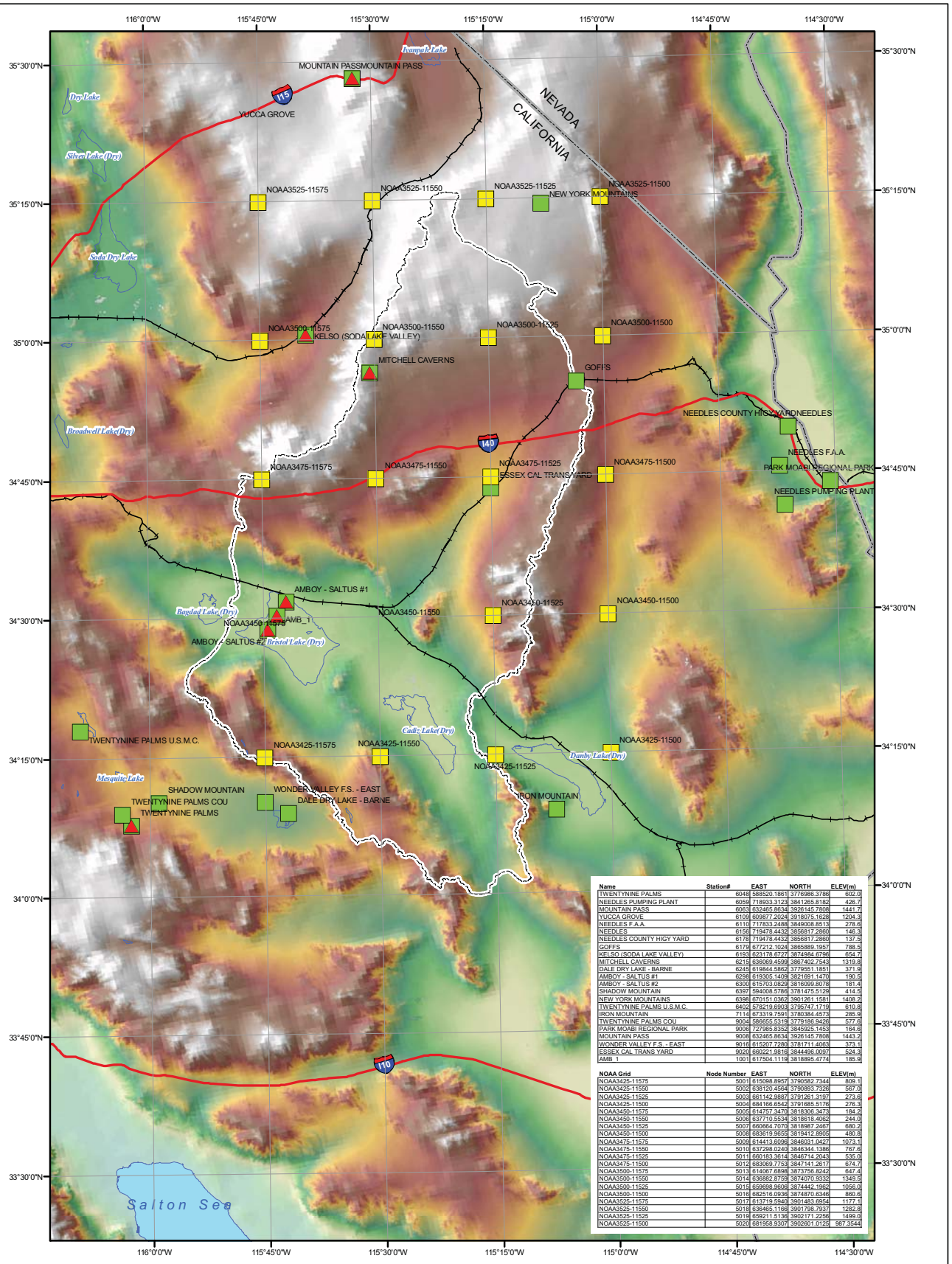
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-4b
Vegetation Coverage

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-4b_CADIZ_TM_VegetationMap_V3_MR.mxd



Name	Station#	EAST	NORTH	ELEV(m)
TWENTYNINE PALMS	6048	588520.1861	3776986.3786	602.0
NEEDLES PUMPING PLANT	6059	718933.3123	3841265.8182	426.7
MOUNTAIN PASS	6063	632465.8634	3926145.7808	1441.7
YUCCA GROVE	6109	609877.2024	3918075.1628	1204.3
NEEDLES F.A.A.	6110	717833.2488	3849008.8513	278.6
NEEDLES	6156	719478.4432	3856817.2860	146.3
NEEDLES COUNTY HIGY YARD	6178	719478.4432	3856817.2860	137.5
GOFFS	6179	677212.1024	3865889.1957	788.5
KELSO (SODA LAKE VALLEY)	6193	623178.6727	3874984.6796	654.7
MITCHELL CAVERNS	6215	636069.4599	3867402.7543	1319.8
DALE DRY LAKE - BARNE	6245	619844.5862	3779551.1851	371.9
AMBOY - SALTUS #1	6298	619305.1409	3821691.1470	190.5
AMBOY - SALTUS #2	6300	615703.0829	3816099.8078	181.4
SHADOW MOUNTAIN	6397	594008.5786	3781475.5129	414.5
NEW YORK MOUNTAINS	6398	670151.0362	3901261.1581	1408.2
TWENTYNINE PALMS U.S.M.C.	6402	578219.6903	3795747.1719	610.8
IRON MOUNTAIN	7114	673319.7591	3780384.4573	285.9
TWENTYNINE PALMS COU	9004	586655.5319	3779186.9426	577.6
PARK MOABI REGIONAL PARK	9006	727985.8352	3845925.1453	164.6
MOUNTAIN PASS	9008	632465.8634	3926145.7808	1443.2
WONDER VALLEY F.S. - EAST	9016	615207.7280	3781711.4063	373.1
ESSEX CAL TRANS YARD	9020	660221.9816	3844496.0097	524.3
AMB_1	1001	617504.1119	3818895.4774	185.9

NOAA Grid	Node Number	EAST	NORTH	ELEV(m)
NOAA3425-11575	5001	615098.8957	3790582.7344	809.1
NOAA3425-11550	5002	638120.4564	3790893.7328	567.0
NOAA3425-11525	5003	661142.9887	3791261.3197	273.6
NOAA3425-11500	5004	684166.6542	3791685.5176	276.3
NOAA3450-11575	5005	614757.3470	3818306.3473	184.2
NOAA3450-11550	5006	637710.5534	3818618.4062	244.0
NOAA3450-11525	5007	660664.7070	3818987.2467	680.2
NOAA3450-11500	5008	683619.9655	3819412.8905	480.8
NOAA3475-11575	5009	614413.6096	3846031.0427	1073.1
NOAA3475-11550	5010	637298.0240	3846344.1386	767.6
NOAA3475-11525	5011	660183.3614	3846714.2043	535.0
NOAA3475-11500	5012	683069.7753	3847141.2617	674.7
NOAA3500-11575	5013	614067.6898	3873756.8242	647.4
NOAA3500-11550	5014	636882.8759	3874070.9332	1349.5
NOAA3500-11525	5015	659698.9608	3874442.1962	1056.0
NOAA3500-11500	5016	682516.0936	3874870.6346	860.6
NOAA3525-11575	5017	613719.5940	3901483.6954	1177.1
NOAA3525-11550	5018	636465.1166	3901798.7937	1282.8
NOAA3525-11525	5019	659211.5136	3902171.2256	1499.0
NOAA3525-11500	5020	681958.9307	3902601.0125	987.3544

Legend

- Temperature Data
- NOAA Grid Precipitation
- San Bernardino County Precipitation
- interstates
- states
- Rail Roads
- Dry Lake Beds
- Cadiz Study Area

Elevation
metes
High : 2394
Low : -87

N

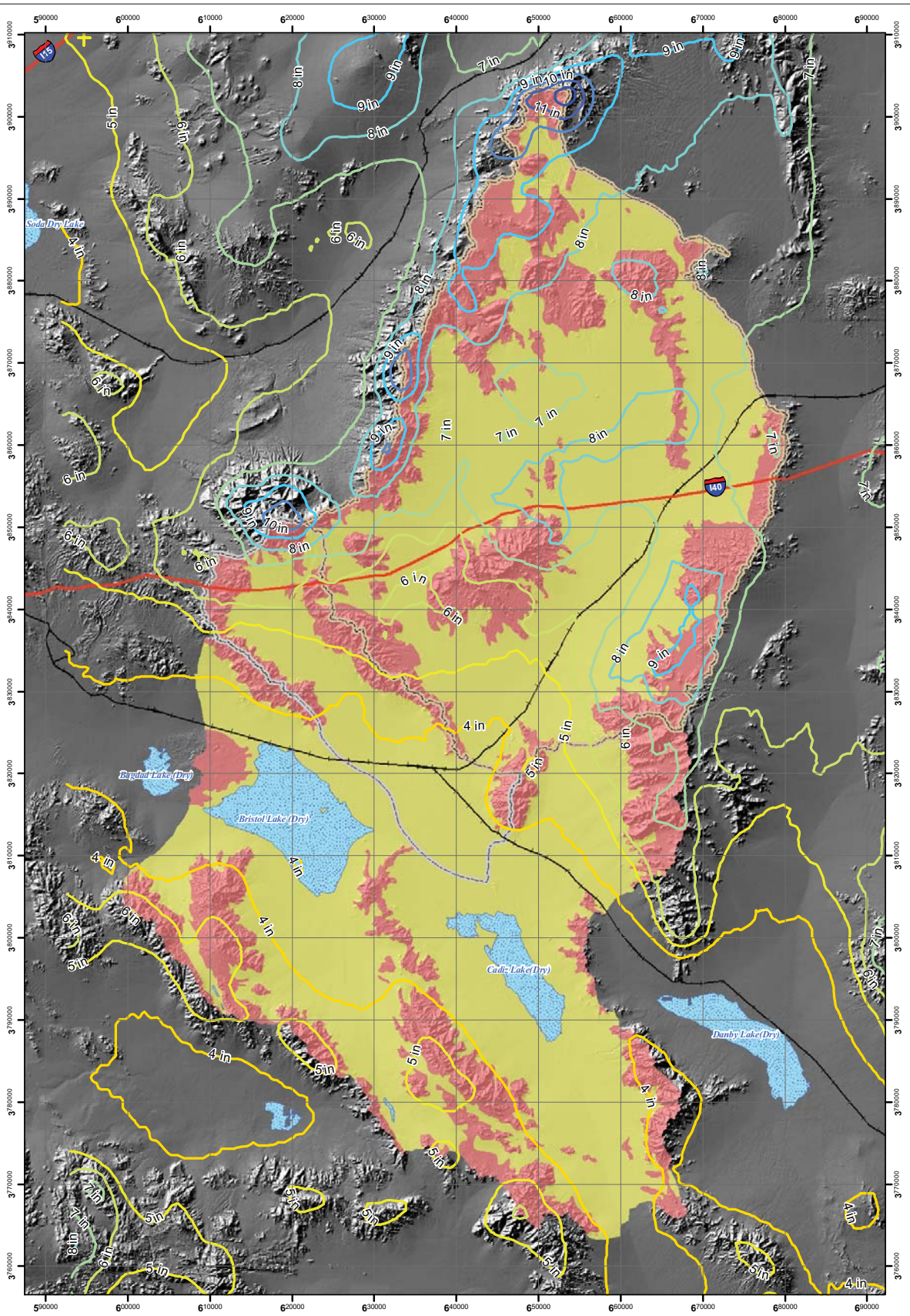
0 2 4 8 Miles

0 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-5
Climate Stations

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-5_CADIZ_TM_ClimateStations_V4_MR.mxd



Legend

- Interstates
- Rail Roads
- Fenner Valley Model Boundary
- Orange Blossom Model Boundary
- Dry Lake Beds

Geology

- Rock
- dune sand; Alluvium

PRISM Annual Average Precipitation from 1971-2000
Inches

1 2 3 4 5 6 7 8 9 10 11 12

Isohyets created from PRISM data
PRISM Climate Group, Oregon State University, http://www.prismclimate.org, created 4 Feb 2004.

0 2 4 8 Miles

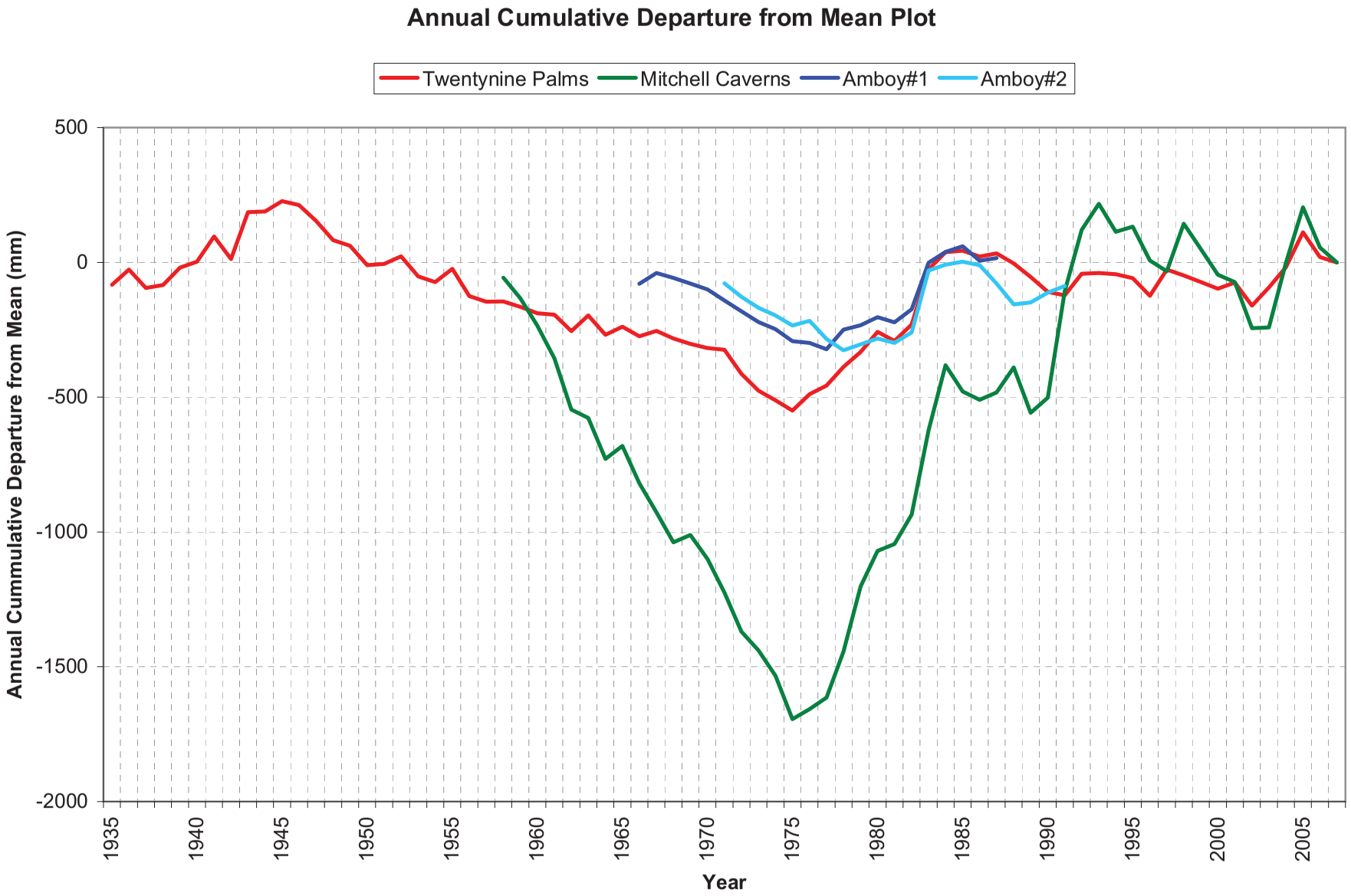
0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-6
PRISM Isohyets for the 1971-2000 period

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TM\Figures\Fig2-6_CADIZ_TM_PRISM_IsohyetMap_V5_MR.mxd

Figure 2-7
Cumulative Departure From Mean Precipitation For Selected Precipitation Stations



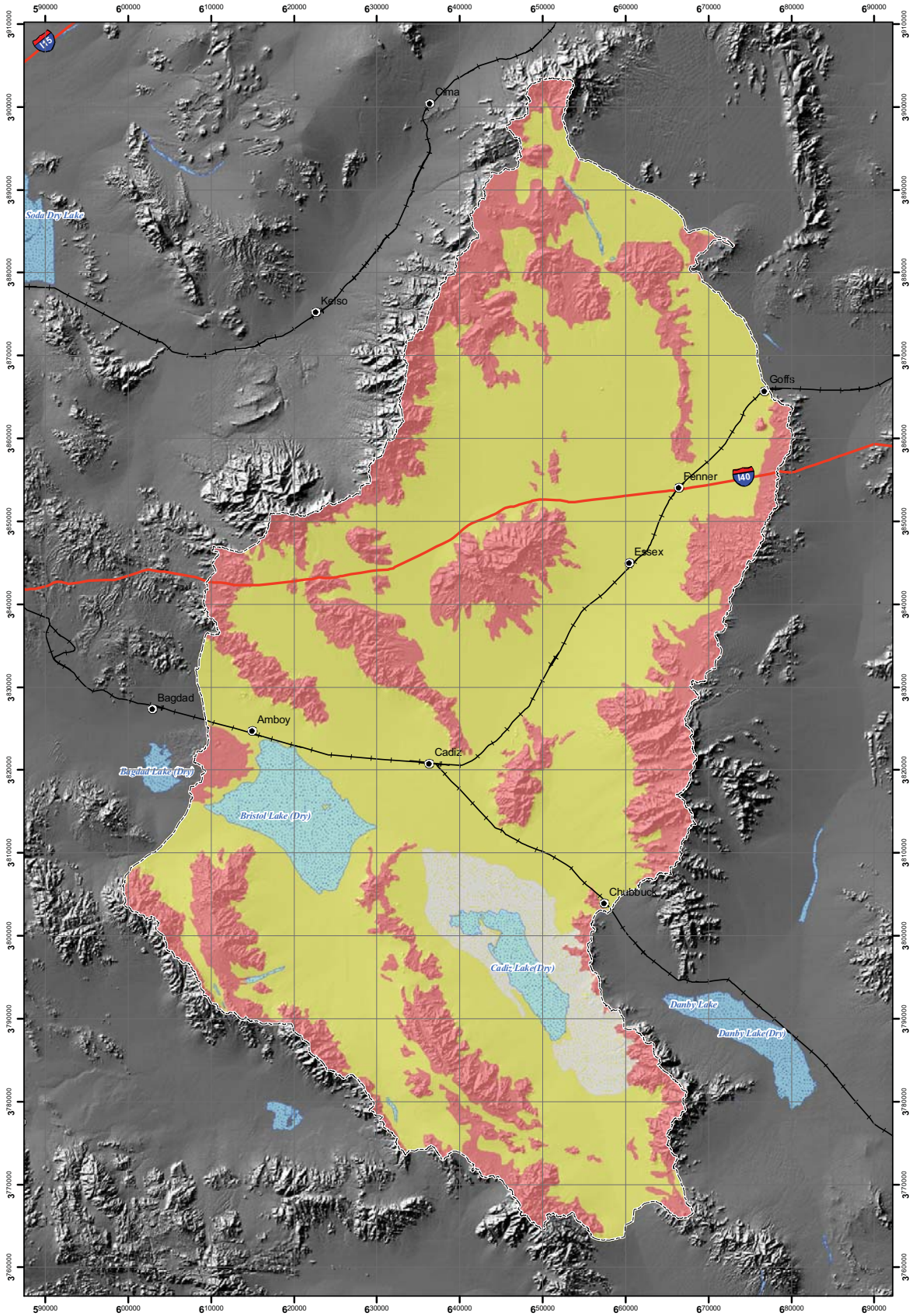
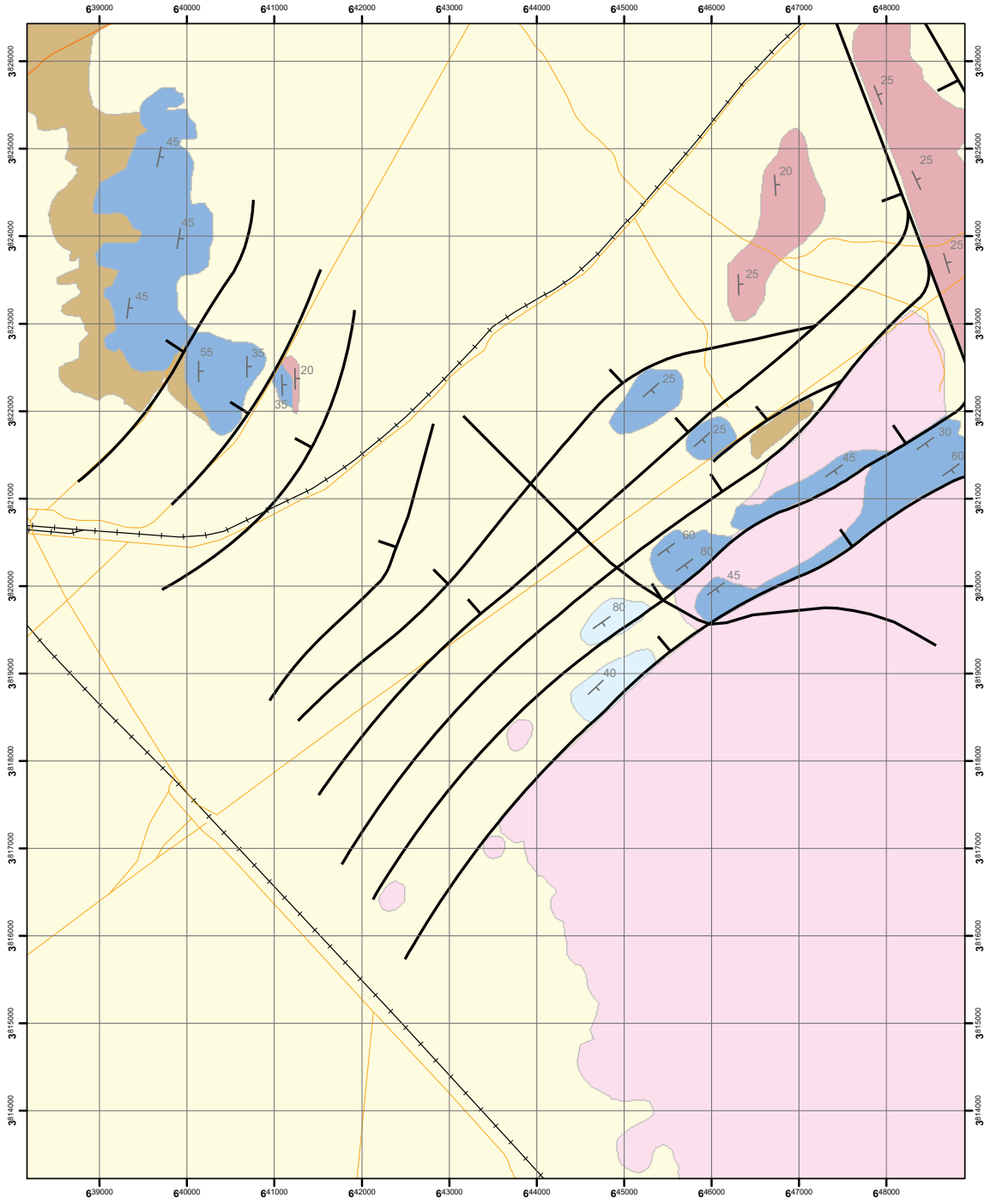


Figure 2-8
Simplified Geologic Map

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TM\Figures\Fig2-8_CADIZ_TM_AluviumBedrockMap_V3_MR.mxd



Legend

- Fault
- Interstates
- Roads
- Rail Roads

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

0 0.25 0.5 1 Miles

0 0.25 0.5 1 Kilometers

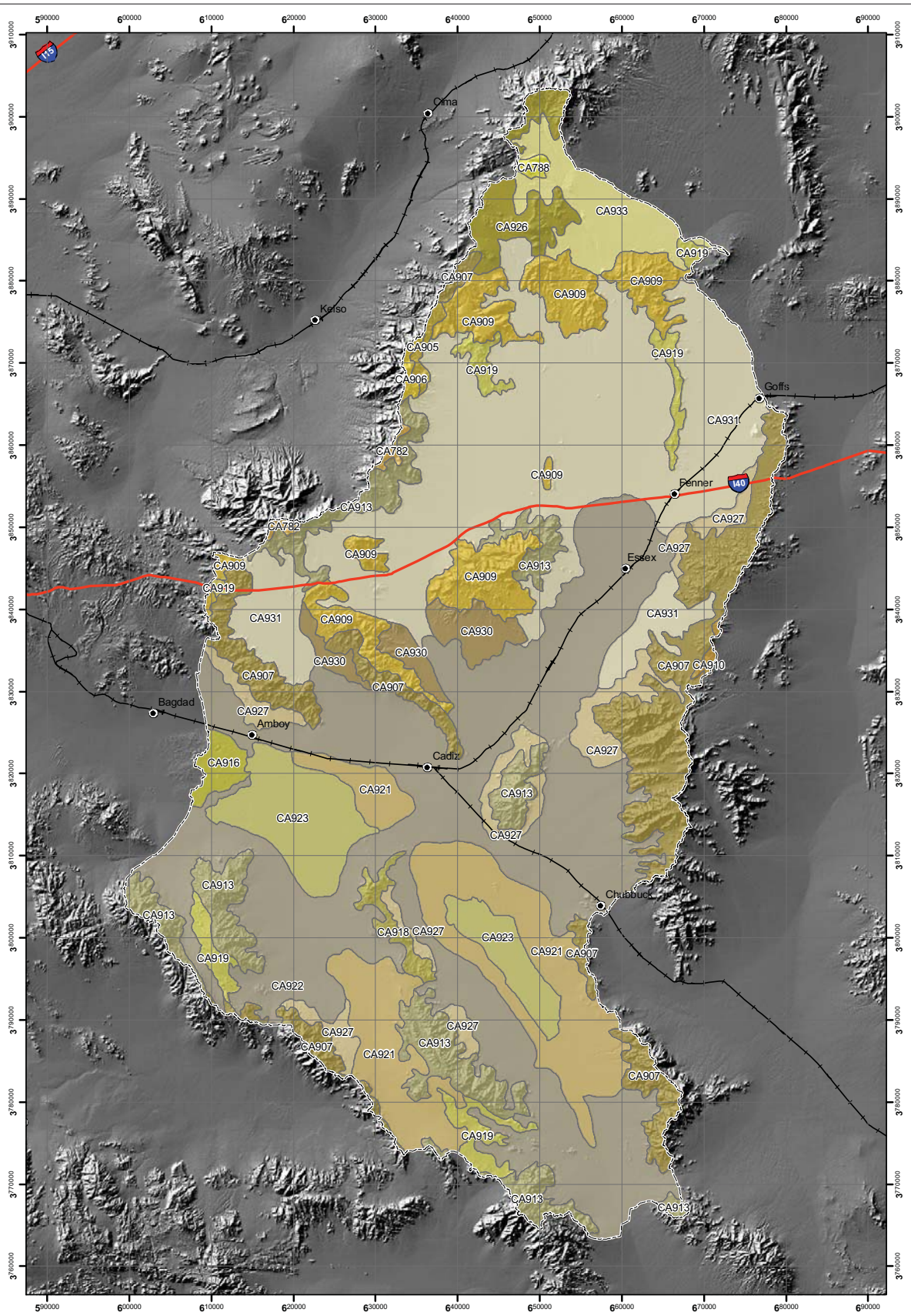
Projected Coordinate System:
NAD 1983 UTM Zone 11N meters
Vertical Datum NAVD88

N

Modified from Liggett (2010) and Bishop (1963)

Figure 2-9
Geology of Fenner Gap Area

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-9_CADIZ_TM_GeologyofFennerGap_V1_MH.mxd



Legend

STATSGO Soil Types

MUNAME

- ARMOINE-LOMOINE-PETSPRING (CA782)
- BADLAND-BITTERWATER-CAJON (CA910)
- BLACKTOP-DOWNEYVILLE-ROCK OUTCROP (CA788)
- CAJON-ARIZO-VICTORVILLE VARIANT (CA931)
- CALVISTA-ROCK OUTCROP-TRIGGER (CA919)
- CARRIZO-ROSITAS-GUNSIGHT (CA922)
- GUNSIGHT-RILLITO-CHUCKAWALLA (CA927)
- MCCULLOUGH-RILLITO-BLUEPOINT (CA933)
- NICKEL-ARIZO-BITTER (CA930)
- PENELAS-UBEHEBE-RODAD (CA906)
- PLAYAS-ROSITAS-MELOLAND (CA923)
- ROCK OUTCROP-HYDER-LOMITAS (CA916)
- ROCK OUTCROP-LAPOSA-QUILOTOSA (CA918)
- ROCK OUTCROP-LITHIC TORRIORTHENTS-CALVISTA (CA913)
- ROCK OUTCROP-LOMOINE-ARMOINE (CA926)
- ROCK OUTCROP-ST. THOMAS-TECOPA (CA905)
- ROCK OUTCROP-TECOPA-LITHIC TORRIORTHENTS (CA907)
- ROCK OUTCROP-UPSPRING-SPARKHULE (CA909)
- ROSITAS-CARSITAS-DUNE LAND (CA921)

- Cadiz Study Area
- Interstates
- Rail Roads
- Cities/Communities

N

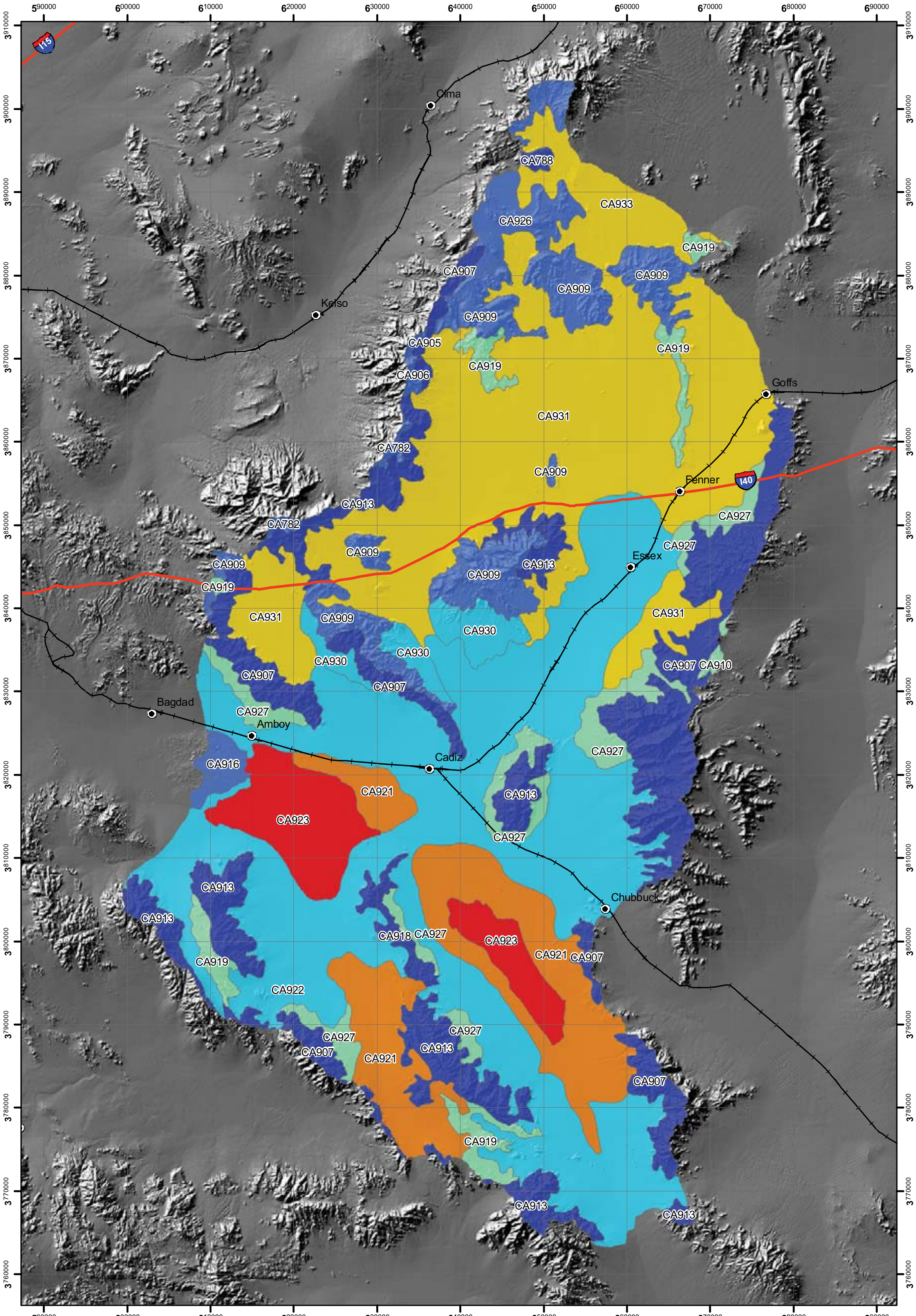
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-10
STATSGO Soil Map

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-10_CADIZ_TM_SoilsMap_SoilTypes_V3_MR.mxd



Legend

- Cities/Communities
- Interstates
- Rail Roads

STATSGO Soil Types
Percentage of grains >2mm

- 0.0 - 10.0
- 10.1 - 20.0
- 20.1 - 30.0
- 30.1 - 40.0
- 40.1 - 50.0
- 50.1 - 60.0
- 60.1 - 70.0
- 70.1 - 80.0

N

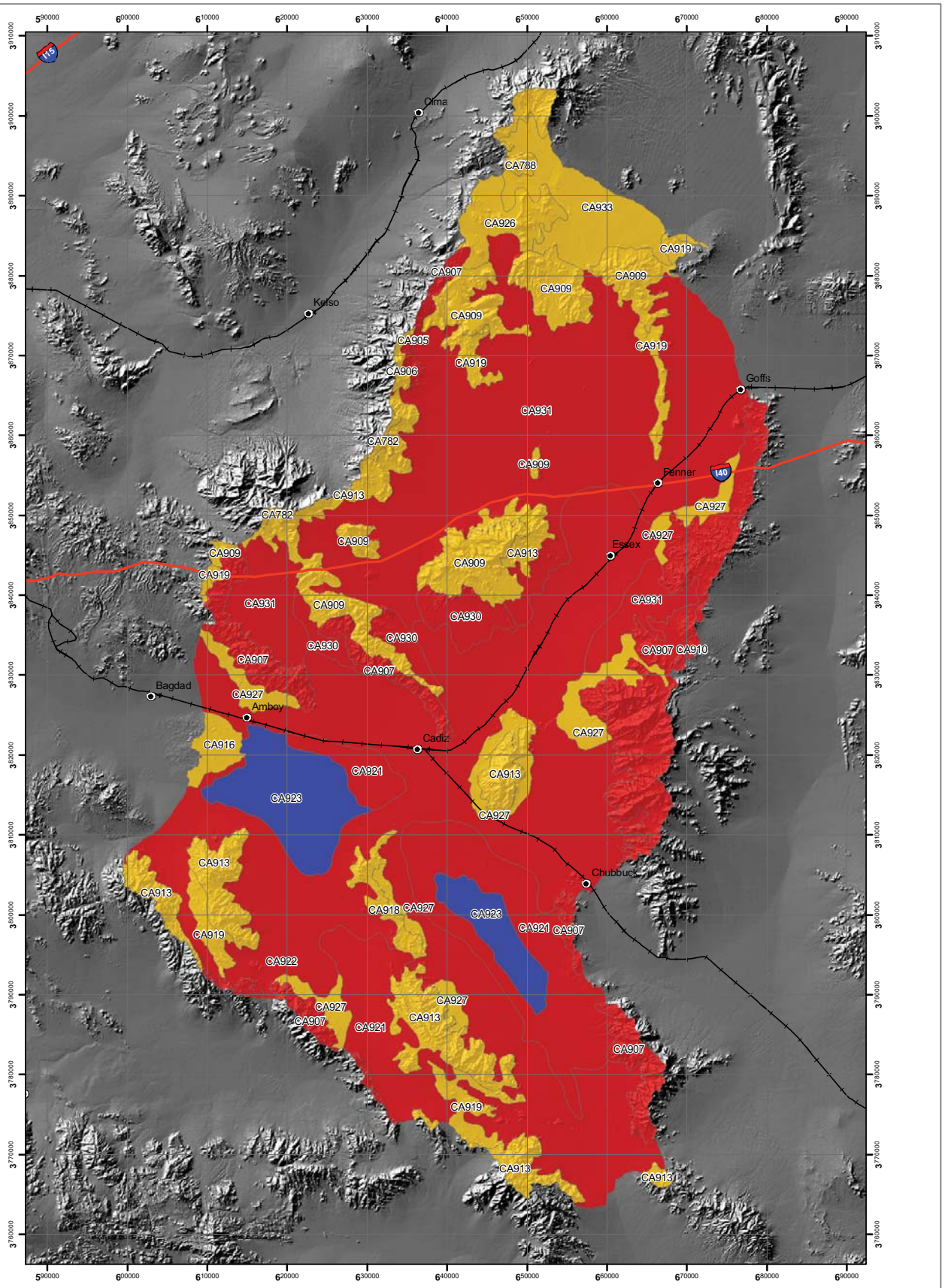
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-11
Percentage of grains greater than 2mm

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-11_CADIZ_TM_SoilsMap_SoilTypes_V3_MR.mxd



Legend

- Cities/Communities
- Interstates
- Rail Roads

Percentage of Clay from grains<2mm

- 3.8 - 10.0
- 10.1 - 20.0
- 20.1 - 30.0
- 30.1 - 40.0
- 40.1 - 50.0

STATSGO Soil Types

N

0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-12
Percentage of Clay from Fines

\\cheron\Projects\BrownsteinHyatt\Farbe\386303Cadiz\GIS\ArcMap\TM\Figures\Fig2-12_CADIZ_TM_SoilsMap_SoilTypes_V3_MR.mxd

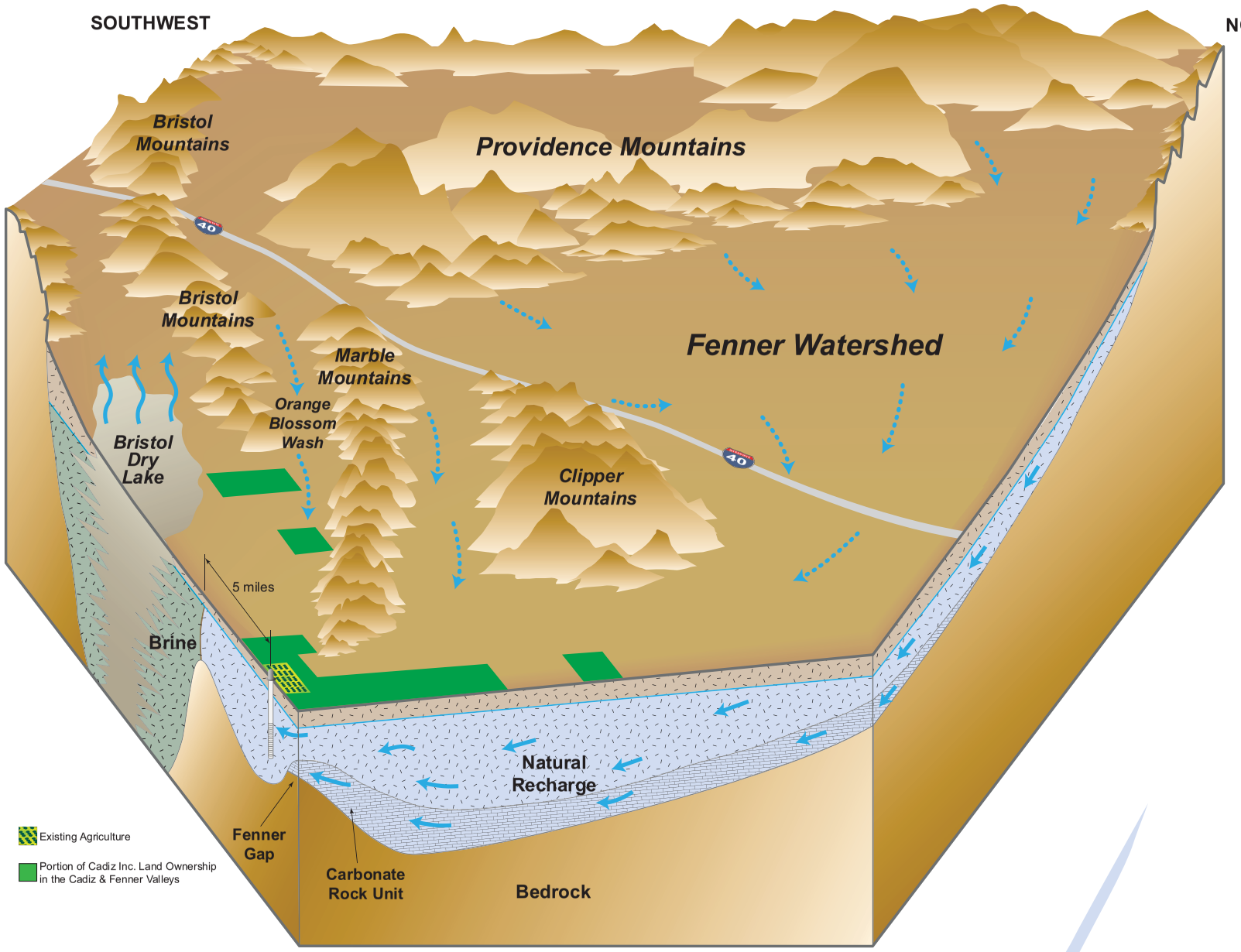


FIGURE 2-13
Conceptualization of Groundwater Occurrence and Movement In the Area of Study

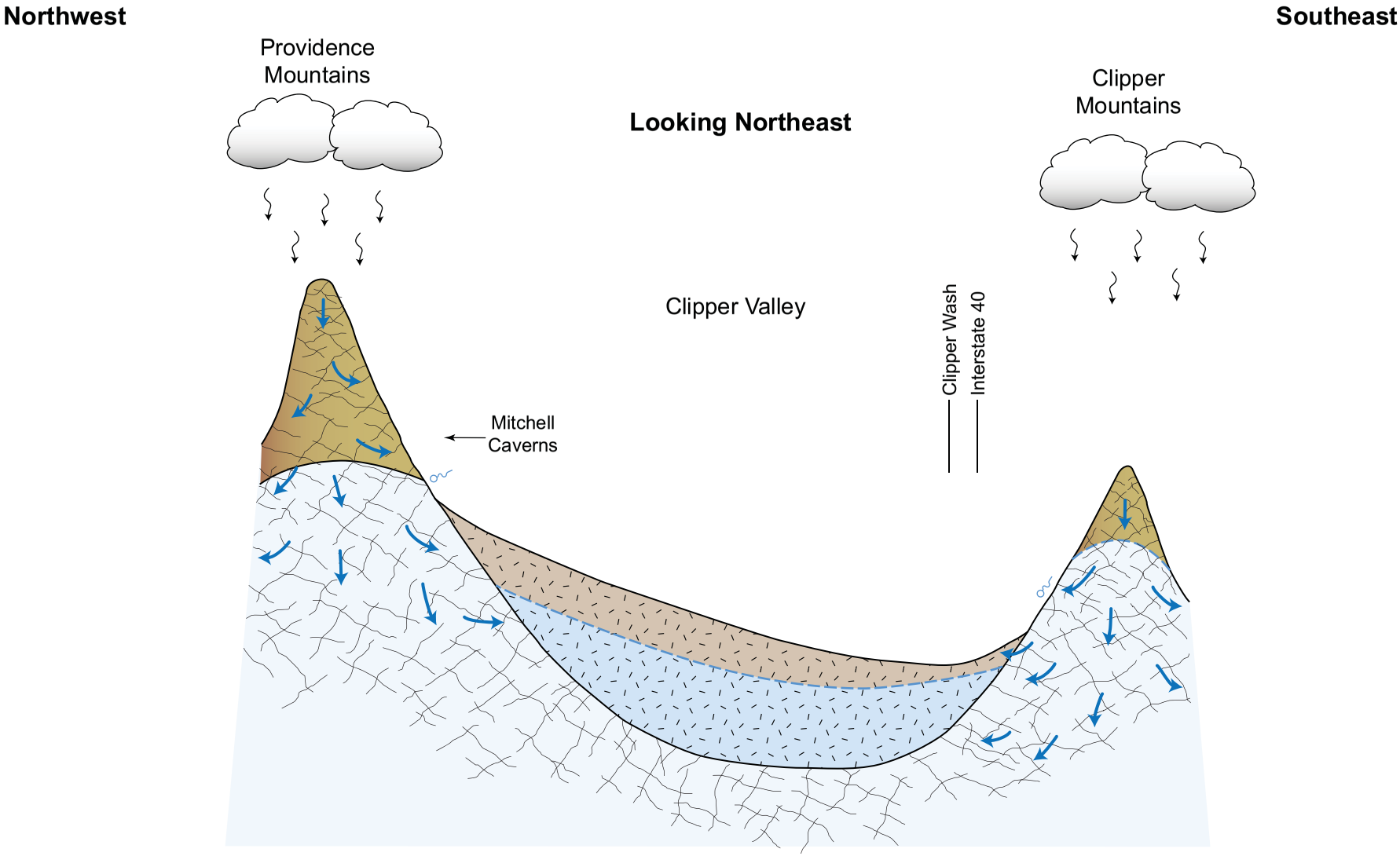
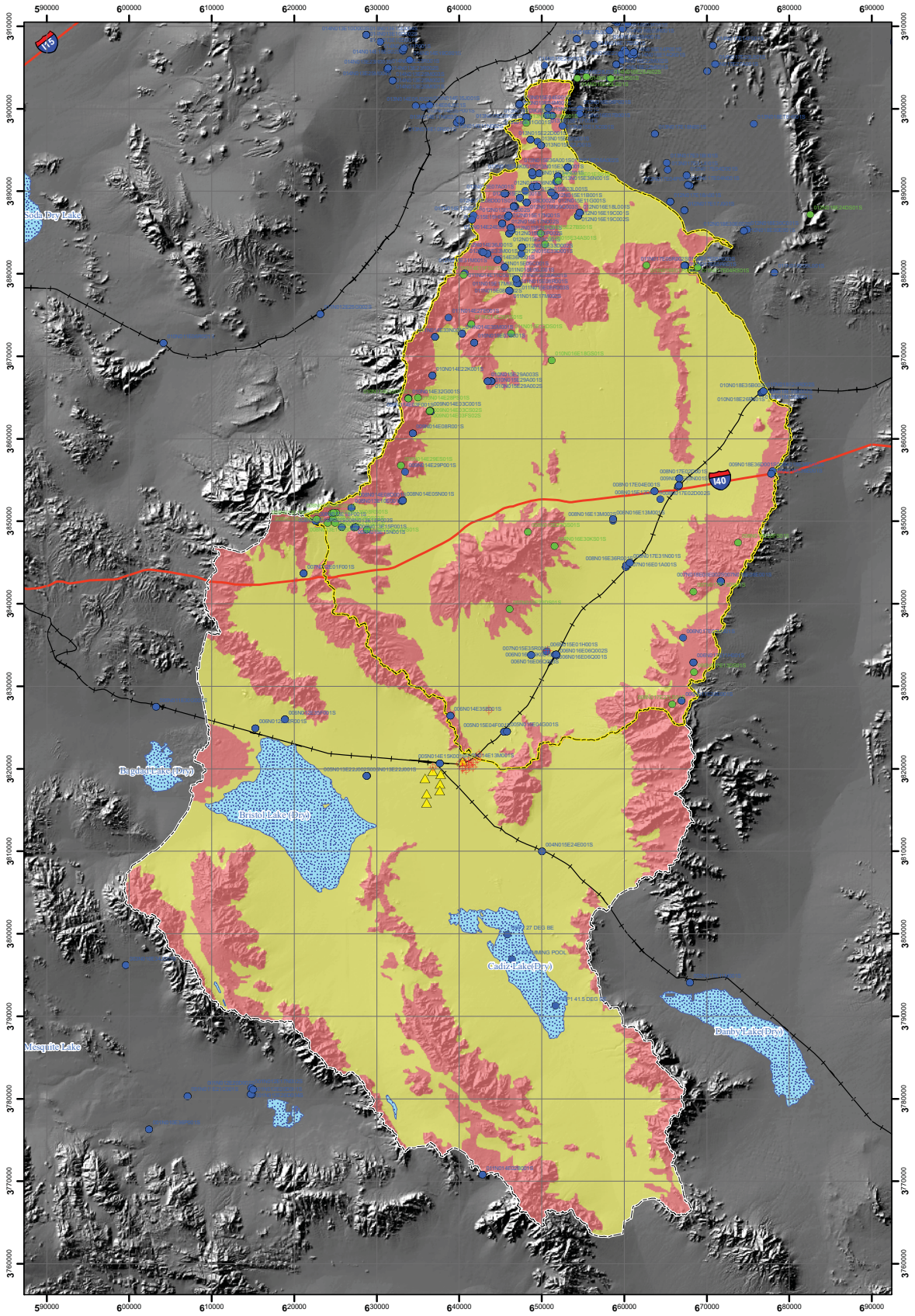


FIGURE 2-14
Schematic Cross Section Showing Occurrence and Movement of Water



Legend

- CADIZ Wells
- CADIZ AG Wells
- Springs
- Wells
- Cadiz Study Area
- Interstates
- Water Bodies (Dry/Wet)
- Rail Roads
- Rock
- Dune Sand; Alluvium

N

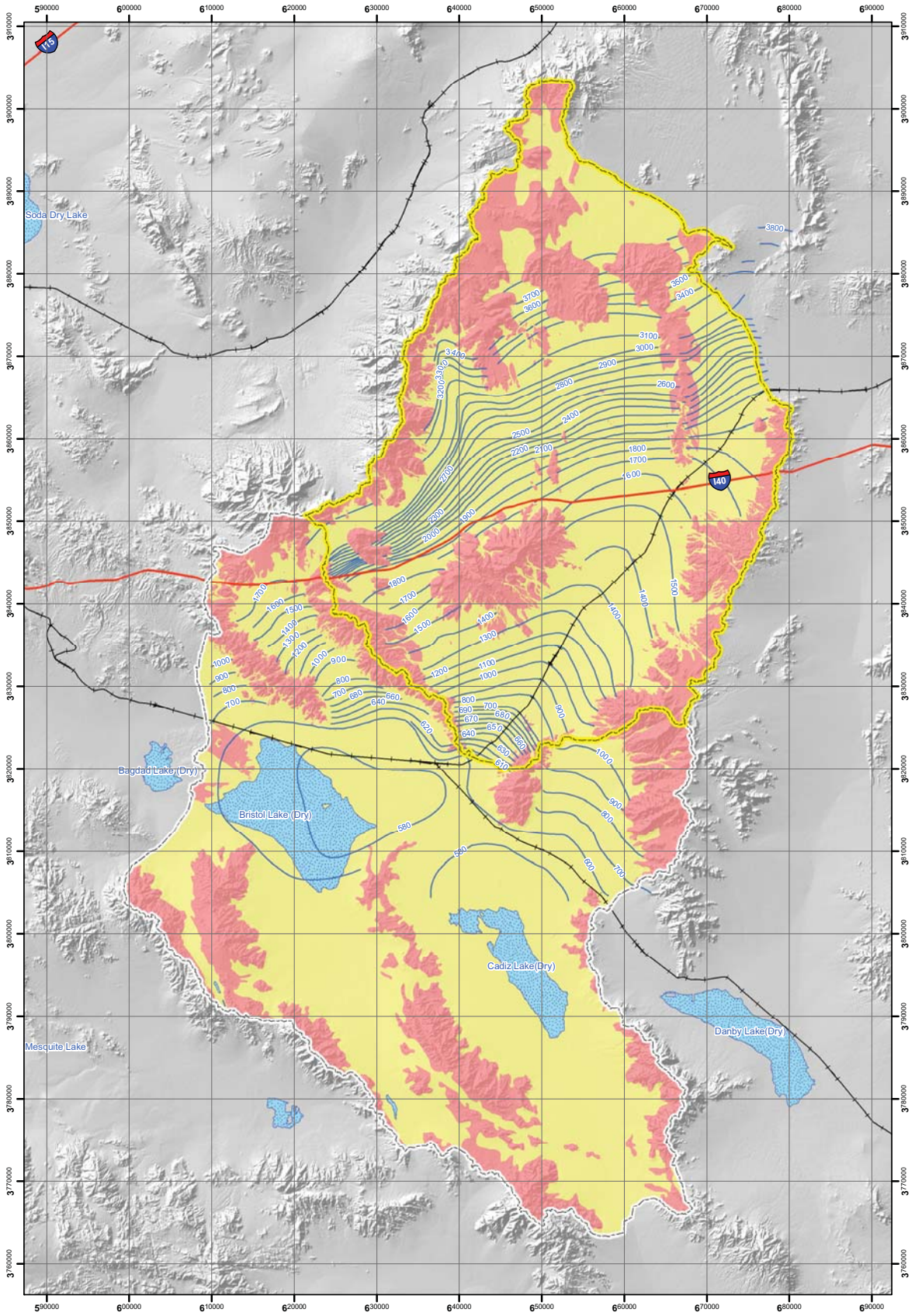
0 1.5 3 6 Miles

0 1.5 3 6 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 2-15
Wells and Springs Map

\\cheron\Projects\BrownsteinHyattFarber\386303CadizGIS\ArcMap\TMFigures\Fig2-15_CADIZ_TM_WellLocationMap_V5_MH.mxd



Legend

- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads
- Groundwater Level ft
- WaterBodies

Simplified Geology

- Alluvium/SandDunes
- Rock

N

0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 2-16
Groundwater Level

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig2-16_CADIZ_TM_GroundwaterLevel_V3_MH.mxd

Section 3 - Groundwater in Storage

3.0 Groundwater in Storage

This section presents estimated volumes of groundwater in storage in the focused area of study: Fenner Valley and in the fresh (approximately less than 1,000 milligrams per liter [mg/l] of total dissolved solids) groundwater portion of the Orange Blossom Wash and northern Bristol Dry Lake area. GSSI (1999) estimated groundwater in storage for the alluvium of these approximate areas. Their estimate of groundwater in storage for the Fenner Valley ranges from 12,762,000 AF to 23,340,000 AF and in the area described as the "area of influence of proposed program operations," it ranges from 3,646,000 AF to 6,689,509 AF. Approximately 432,596 AF are for the carbonate unit.

Updated estimates of groundwater in storage are provided in Table 3-1. These estimates are for groundwater in storage in the alluvial aquifers and should not be taken as a total volume that could be pumped out of these alluvial aquifers. These estimates are based on independent mapping of groundwater levels and depth to bedrock as a part of this study. Groundwater-level contours were drawn from available groundwater-level data for the study area. Groundwater levels are generally consistent with GSSI (1999) groundwater-level contour maps in the southern part of Fenner Valley, Orange Blossom Wash, and northern Bristol Dry Lake area. Figure 2-16 presents this updated groundwater-level contour map. Figure 3-1 is a structure contour map on top of bedrock (or on the base of alluvial aquifers) based on geophysical surveys of Maas (1994), USGS (2006), and NORCAL (1997), and drill intercepts in the Fenner Gap (GSSI, 1999; Section 4.2.1 of this study). In addition, detailed cross-sections prepared of the Fenner Gap subsurface geology were used to develop detailed bedrock contours in the Fenner Gap area (see Section 4.2).

Figure 3-2 shows the storage zones used in the calculations of groundwater in storage. Table 3-1 also includes estimates of the following variables: volume of aquifer, determined as the volume between the groundwater table and the base of the alluvium (saturated thickness), percent of aquifer saturated thickness that is expected to be an aquifer (to exclude clay and silt intervals that do not yield water readily), and estimated specific yield. Low and high ranges are provided for each of these variables based on GSSI's (1999) previous estimates. The range of groundwater in storage in the focus area of study ranges from 16,981,600 AF to 34,415,000 AF. Approximately 12,533,800 AF to 24,407,400 AF of groundwater is in storage in the Fenner Watershed, which is comparable to those estimates provided by GSSI (1999).

These estimates of groundwater in storage are very conservative because (1) this estimate does not include the northernmost area of the Fenner Watershed due to the paucity of groundwater-level data for completing a groundwater-level contour map and (2) it does not include any storage in the carbonate aquifer or other bedrock units. Storage of groundwater in these latter units is likely to be very large. As a simple example calculation, if one assumes 500 feet of geologic materials with an effective porosity of 0.02 (2 percent) over the approximate 1,100 mi^2 watershed, the volume of groundwater in these materials would be more than 7 million AF. Again, this is not groundwater that could be completely dewatered, but it provides an indication of the vast quantities of groundwater in the watershed.

The quantities of groundwater in the area of study can be put into perspective by comparison to volumes of groundwater in storage in some of the larger groundwater basins in Southern California. Following are estimated volumes of groundwater in storage for a few basins in Southern California (Metropolitan, 2007) and for the Mojave Desert (CDWR, 2010).

Basin	Area of Basin mi^2	Groundwater Storage Capacity (AF)
Main San Gabriel	167	8,600,000
Los Angeles Coastal Plain	435	21,800,000
Orange County Basin	350	66,000,000
Chino Basin	240	6,000,000
Ventura County Basins	177	3 to >6 million
Upper Los Angeles River Area	226	3,670,000
Upper, Middle, and Lower Mojave	1,422	23,850,000

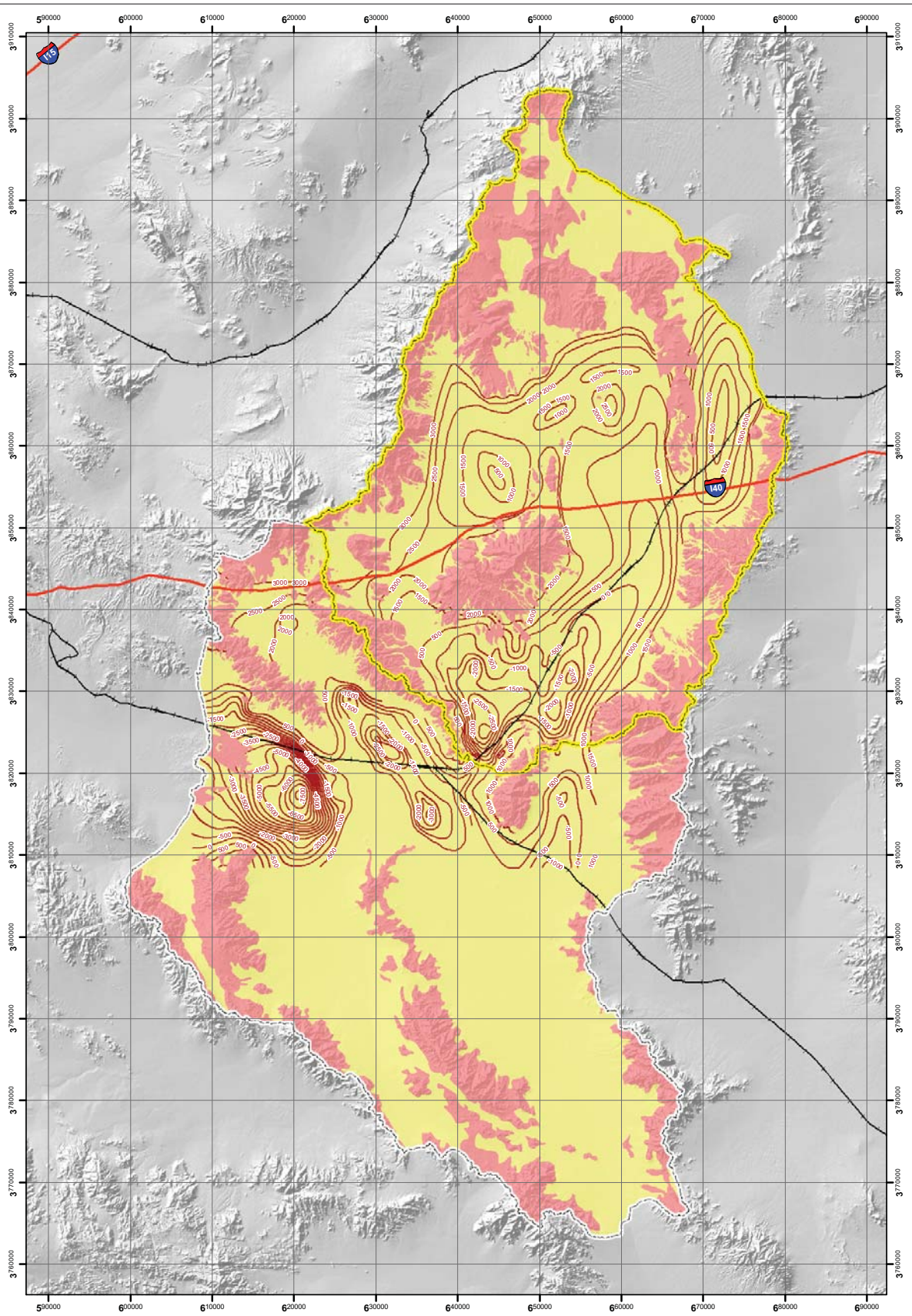
Tables

TABLE 3-1

Cadiz Study Area Groundwater Storage Calculations

Low Estimate					High Estimate				
Zones	**Saturated Thickness Volume (ac-ft)**	**% of Saturated Thickness which is Aquifer**	**Specific Yield**	**Groundwater in Storage (ac-ft)**	**Zones**	**Saturated Thickness Volume (ac-ft)**	**% of Saturated Thickness which is Aquifer**	**Specific Yield**	**Groundwater in Storage (ac-ft)**
Zone 1	11,251,515	75%	0.15	1,265,795	Zone 1	11,251,515	85%	0.20	1,912,758
Zone 2a	63,758,585	50%	0.10	3,187,929	Zone 2a	63,758,585	60%	0.15	5,738,273
Zone 2	93,083,800	50%	0.10	4,654,190	Zone 2	93,083,800	60%	0.15	8,377,542
Zone 3	13,052,800	20%	0.10	261,056	Zone 3	13,052,800	40%	0.15	783,168
Zone 4	489,237	50%	0.10	24,462	Zone 4	489,237	75%	0.15	55,039
Zone 5	88,466,500	50%	0.10	4,423,325	Zone 5	88,466,500	75%	0.15	9,952,481
Fenner	93,676,400	50%	0.05	2,341,910	Fenner	93,676,400	60%	0.10	5,620,584
Goffs	32,917,900	50%	0.05	822,948	Goffs	32,917,000	60%	0.10	1,975,074
				16,981,615					**34,414,919**

Figures



Legend

- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads
- 500 ft interval Base of Alluvium

Simplified Geology

- Alluvium/SandDunes
- Rock

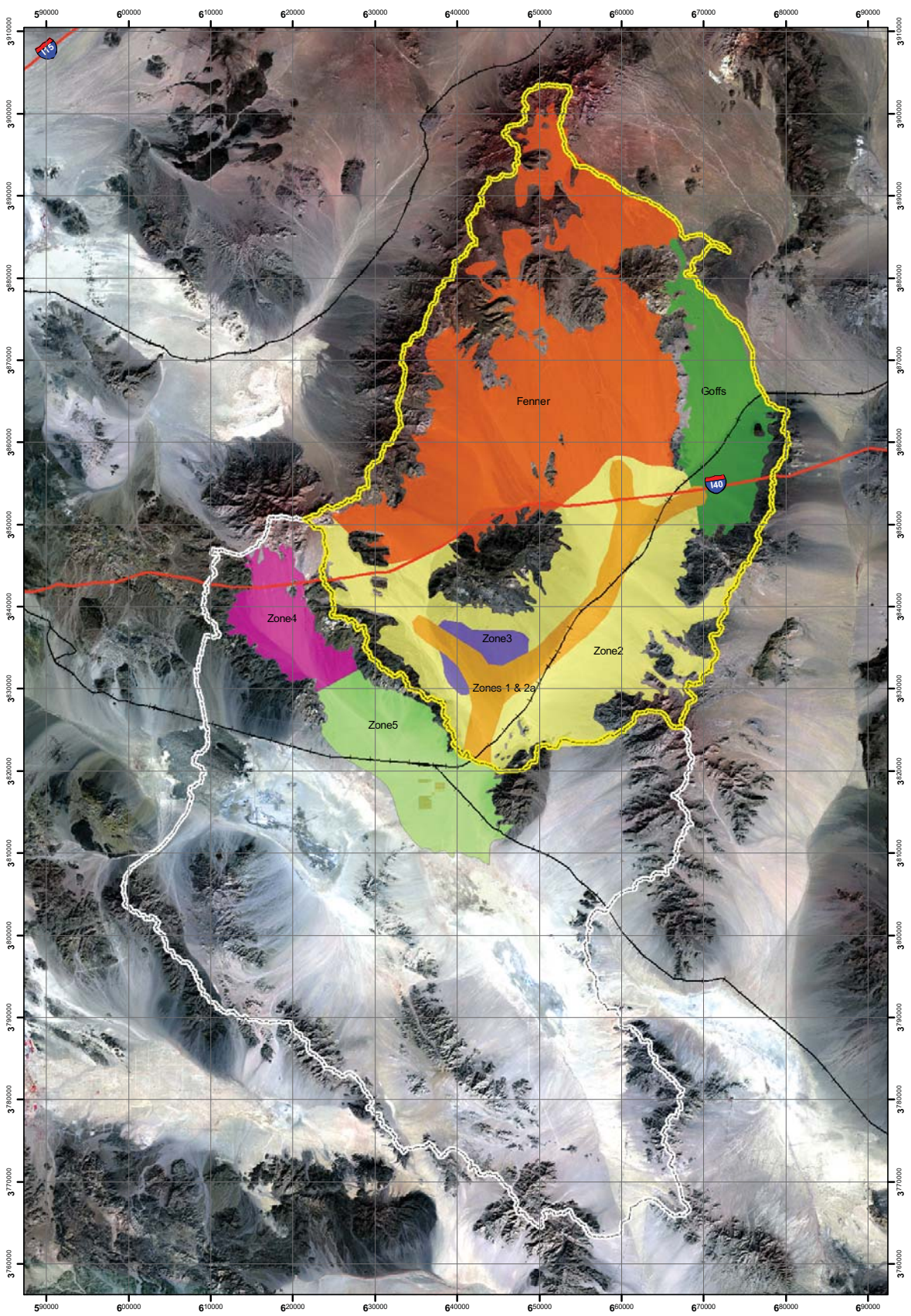
0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 3-1
Base of Alluvial Aquifer Elevation

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig3-1_CADIZ_TM_StructureContourBAlluv_V2_MR



Legend

Fenner_BND
Cadiz Study Area
Interstates
Rail Roads

Fenner Valley Storage Zones **CadizValley_Zones**

Fenner
Goffs
Zones 1 & 2a
Zone2
Zone3
Zone4
Zone5

0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 3-2
Storage Zones

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig3-2_CADIZ_TM_GroundwaterStorageZones_V1_MR.mxd

Section 4 - Recoverable Water

4.0 Recoverable Water

A number of attempts have been made to estimate recoverable water in the area of study. The most recent estimates are presented by GSSI (1999), USGS (2000), and Davisson and Rose (2000). GSSI (1999) based their estimates of recoverable water on a watershed model that accounts for variables affecting the daily water balance of the watershed, including precipitation, runoff, vegetation interception, infiltration, evapotranspiration, soil moisture, and percolation. GSSI estimated recoverable water for the entire Bristol, Cadiz, and Fenner watersheds to range between 19,886 to 58,268 AFY. Their estimate for the Fenner Watershed ranges from 14,646 to 37,254 AFY and for the Orange Blossom Wash area, they give a range of 1,193 to 4,285 AFY, for a combined total (Fenner and Orange Blossom) of 15,839 to 41,539 AFY.

The USGS (2000) developed a preliminary modified Maxey-Eakin model of the entire Bristol, Cadiz, and Fenner watersheds and estimated a median recharge rate of 2,550 to 11,800 AFY (2,070 to 10,343 AFY for the Fenner Watershed only). The modified model is based on a continuous exponential curve fitted to the original Maxey-Eakin step function, which is used to estimate recharge as a percentage of average annual precipitation within discrete elevation-precipitation-recharge zones.

Davisson and Rose (2000) of the Lawrence Livermore National Laboratory (LLNL) reviewed the USGS (2000) Maxey-Eakin estimates and concluded that the USGS (2000) underestimated recharge to the Fenner Watershed due to lack of geographic scale and context in their analysis of precipitation-elevation data, use of an uncalibrated Maxey-Eakin model, and lack of observational experience in the Fenner Watershed. Davisson and Rose (2000) developed a separate new Maxey-Eakin model of the Fenner Watershed. They estimated a recharge rate of 29,815 AFY based on local precipitation, but noted a worse-case scenario lower limit of 7,864 AFY, which they state is unlikely, but provided this lower number as a risk-based lower limit for use in analyses of potential environmental impacts.

Presented below is an updated estimate of recoverable water for the Fenner Watershed and Orange Blossom Wash area based on the recently released USGS (2008) INFIL3.0 model. This analysis is followed by an evaluation of groundwater flow through the Fenner Gap, which is the outlet for groundwater flow from the Fenner Watershed into the Bristol and Cadiz valleys. The analysis of groundwater flow through the Fenner Gap is used to substantiate the likely long-term quantity of recoverable water generated in the Fenner Watershed.

4.1 Application of INFIL3.0 - Watershed Soil Moisture Budget Model

INFIL3.0 is a grid-based, distributed–parameter, deterministic water-balance watershed model, released for public use by the USGS in 2008, and used to estimate the areal and temporal net infiltration below the root zone (USGS, 2008). The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the

Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone and is no longer affected by evapotranspiration and is capable of percolating to and recharging groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water run-on (runoff and streamflow).

Figure 4-1 shows a schematic of the water balance processes controlling net infiltration in the INFIL3.0 model. These processes can be described in mathematical terms as follows:

$$NI_d^i = SM_d^i + RAIN_d^i + RI_d^i - D_d^i - \sum_{j=1}^{6}(\Delta w_d^i) - \sum_{j=1}^{6}(ET_d^i)_j$$

Where:

d is day

i is the cell number, grid location for the computation

NI is the total net infiltration from the bottom of the root zone

SM is snowmelt

RAIN is precipitation occurring as rain

RI is water that infiltrated the root zone from surface-water runon

D is surface-water discharge (outflow)

Δw is the change in the root-zone water storage for layer j (up to 6 layers)

ET is the evapotranspiration from layer j

INFIL3.0 computes a daily water balance on a grid overlay of a given watershed. There are several other second-level equations in the model that calculate each one of the components of Equation 1. A more detailed description of all model equations is presented in the INFIL3.0 documentation (USGS, 2008).

INFIL3.0 requires a number of inputs including (1) a grid (based on uniform squares over the watershed), (2) an estimate of the initial root-zone water contents, (3) a daily time-series input of total daily precipitation and maximum and minimum temperatures, and (4) a set of model input variables that define drainage basin characteristics, model coefficients for simulating evapotranspiration, drainage, and spatial distribution of daily precipitation and air temperature, average monthly atmospheric conditions, and user-defined runtime options. INFIL3.0 will compute daily, monthly, and annual average water-balance components for multi-year simulations.

The following section provides a summary of key inputs to INFIL3.0 for the Fenner Watershed and Orange Blossom Wash areas, used to compute recoverable water for these specific areas.

4.1.1 Model Geometry and Grid

Two model grids are used to cover the Fenner Watershed and Orange Blossom Wash areas. The model area of the Fenner Watershed is defined based on the watershed area contributing to the Fenner Gap, that is, the surface water discharge area of the Fenner Watershed. The watershed boundaries are based on the National HUCs that are extensively used throughout the United States and that were extensively reviewed to match, to a minimum, the USGS topographical 7.5 minute quads. The Fenner Watershed modeled area comprises part of the 8-digit national HUC drainage area 18100100, all the 10-digit HUC watersheds 1810010031, 1810010032, 1810010033, 1810010034, and subwatersheds located within the 1810010027 and 181001003135 watersheds. The total Fenner Watershed modeled area equals 2,816 square kilometers (km^2) or 695,845 acres.

The Orange Blossom Wash area is a much smaller area. The total Orange Blossom Wash area equals 412.75 km^2 or 101,992 acres, approximately 15 percent of the Fenner Watershed area.

Initially, the model grid resolution was defined based on the total number of cells that would have to be modeled. INFIL3.0 allows a maximum of 60,005 cells. A very fine terrain resolution is available (10-m resolution). A 500 m by 500 m grid cell resolution is selected as the input grid for the INFIL3.0 model simulations. This resolution is small enough to spatially represent all the soil, vegetation, and climate data, without major generalization of their boundaries, and large enough to provide reasonable runtimes for simulations. Figures 4-2 and 4-3 show the grid overlays used in the INFIL3.0 model simulations.

4.1.2 Topography

Topography is used in INFIL3.0 for the following purposes: estimate evapotranspiration as a function of location in the watershed (see INFIL3.0 documentation for detailed discussion of simulated evapotranspiration processes), estimate precipitation as a function of elevation (see additional details on precipitation versus elevation, below), and route runoff through the watershed.

Topography of the Fenner Watershed and Orange Blossom Wash areas, represented by a digital elevation map (DEM) file, was obtained from the National Elevation Dataset (NED) at a horizontal resolution of 10 m times 10 m. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. NED data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are in meters and, over the conterminous United States, are referenced to the North American Vertical Datum of 1988 (NAVD 88)(USGS, 2006a). NED data set coordinates where projected into the Universe Transverse of Mercator (UTM) Zone 11 projection, so these data could be used in INFIL3.0.

The DEM for both areas had to be converted into a x,y,z file format to be used in INFIL3.0. The Geospatial Watershed-Characteristics (GWC) file is one of the main files of the INFIL3.0 model. The GWC file requires the following parameters: CELLCODE, EASTING and NORTHING; LAT and LONG; ROW and COL; ELEV; SL; ASP; LOCID; IWAT; UPCELLS; SOILTYPE; DEPTH; ROCKTYPE; VEGTYPE: SKYVIEW RIDGE (36). Following is a brief

explanation of each of these parameters. A more detailed discussion can be found in Hevesi (2008).

CELLCODE, EASTING, NORTHING, LAT, LON, grid ROW and COL are all location input parameters that are extracted from the DEM file.

Elevation (ELEV), slope (SL) (in degrees) and aspect(ASP) are all parameters derived from the DEM file and geographic information system (GIS) processing.

LOCID, is an ID number for each cell given that the DEM is sorted in descending order; therefore, the highest cell will have LOCID value 1. IWAT represents the LOCID ID of the cell that will be receiving flows from the current watershed simulation (cell at the lowest point in the watershed). UPCELLS represents the number of cells upstream from that location. All these three variable values are obtained from the DEM file using GIS processing techniques. The grid cell numbering is accomplished using a GIS flow accumulation/routing routine to ensure that INFIL3.0 routes runoff downstream through the watershed domain. Figures 4-4 and 4-5 show the flow accumulation/routing for Fenner Watershed and Orange Blossom Wash areas, respectively.

SOILTYPE is an integer code number that represents a soil type with unique properties that can be assigned to different cells in the grid. The code is linked to a soils table with specific soil parameters for each soil type within the model boundaries. DEPTH refers to soil depth in meters. Soil parameters are discussed further in Section 4.1.4.

ROCK is an integer code number that represents a unique rock type (which are geologic materials below the soil zone, so these are not necessarily rocks, but may include alluvium or other unconsolidated deposits). Each rock type code is linked to a rock type file with unique parameters of porosity, unsaturated and saturated vertical hydraulic conductivity. Rock parameters are discussed in Section 4.1.5.

VEG is an integer representing a vegetation code with unique vegetation characteristics. Vegetation parameters are discussed further below in Section 4.1.6.

SKYVIEW is total fraction of viewable sky, as fraction of hemisphere (dimensionless) (see Hevesi, 2008), which affects evapotranspiration.

RIDGE(36) are the 36 blocking ridge angles related to the SKYVIEW parameter (see Hevesi, 2008), which affects evapotranspiration.

Both SKYVIEW and RIDGE parameters are derived from a FORTRAN program that was obtained from USGS INFIL3.0 authors (Flint, 2009).

4.1.3 Climate Parameters

Two sets of climate parameters are required for INFIL3.0: monthly atmospheric conditions and daily precipitation and air temperatures (daily pairs of maximum and minimum temperature).

4.1.3.1 Monthly Atmospheric Conditions

Monthly atmospheric conditions are needed in INFIL3.0 and include monthly values of ozone layer thickness in centimeters, precipitable atmospheric water in centimeters, mean atmospheric turbidity, circumsolar radiation, and surface reflectivity. These conditions are

assumed to be the same as those conditions used in previous USGS studies realized for the Death Valley, Yucca Mountain, and Joshua Tree areas in San Bernardino County (Hevesi et al., 2003; Hevesi et al., 2002; Nishikawa et al., 2004; and Rewis et al, 2006). Table 4-1 shows the model input values for each of these atmospheric conditions.

4.1.3.2 Precipitation and Air Temperature

Data sources for precipitation and air temperature include San Bernardino County, PRISM, and the National Oceanic and Atmospheric Administration (NOAA). Figure 4-6 shows all the stations, including NOAA grid locations, for which precipitation and temperature data and estimates are available and used in INFIL3.0 simulations, as described below.

San Bernardino County has six stations with precipitation and minimum and maximum temperature data. A summary of the date ranges of available data from these stations is given in Table 2-1. As indicated in Section 2, there are only a few stations in the larger area of study with long-term precipitation records.

A second source of precipitation data accessed for this study is NOAA Climate Prediction Center (CPC) .25 x .25 Daily US UNIFIED Precipitation data. The data description can be obtained from the CPC website (CPC, 2009). The CDC of NOAA dataset is derived from 3 sources: NCDC daily co-op stations (1948 through 1998), CPC dataset (River Forecast Centers data + 1st order stations - 1992 through 1998), and daily accumulations from hourly precipitation dataset (1948 through 1998). There are about 13,000 station reports each day for 1992 through 1998, and about 8,000 reports before that yielding about three times the reports of any existing historic and operational analyses as of 2000. The data were reviewed to eliminate duplicates and overlapping stations, and standard deviation and buddy checks were applied. Then they were gridded into 0.25 x 0.25, 140W-60W, 20N-60N using a Cressman Scheme. A grid of points was created in a 0.25 x 0.25 degree interval to cover areas that did not have any historical climate data and to provide interpolated values within the area of study.

CDC data were not available after 1998. Data sets after 1998 (1998 through 2008) were extrapolated by comparing annual precipitation values for Mitchell Caverns with annual precipitation values from the CDC data set. Those years from the CDC data set corresponding to comparable precipitation to Mitchell Caverns were selected as a surrogate time series and then multiplied by a scale factor so that the year average matches the true year average observed at Mitchell Caverns.

Figure 4-6 shows all the stations, including NOAA grid locations, for which precipitation and temperature data and estimates are available.

INFIL3.0 also requires monthly regression model for precipitation and air temperature to calculate daily values at each grid cell of the model. INFIL3.0 has an internal subroutine that takes into consideration grid cell elevation and the surrounding monthly precipitation from available stations when computing precipitation for a specific cell. The precipitation as a function of elevation can be estimated by a linear or quadratic function.

Average monthly precipitation and average minimum and maximum temperatures were calculated for available climate stations in the region. These monthly average data were used to develop linear equations that estimate precipitation and minimum and maximum temperature as a function of elevation for each month. Regression coefficients are derived

for each month and entered into INFIL3.0's monthmod file. The equation used by INFIL3.0 is as follows:

$$E_m^i - A_m (ELEV^i) + C_m$$

where,

E_m^i is the estimated monthly climate parameter (daily precipitation or air temperature for grid location, i, and month, m

A_m and C_m are regression coefficients for each month, m

$ELEV^i$ is the elevation for grid location, i

Figure 4-7 shows the linear regression of monthly precipitation values in the area of study.

Table 4-2 shows the regression coefficients used in the monthmod table of INFIL3.0 for this study.

4.1.4 Soil Parameters

Soil data used in INFIL3.0 model simulations are obtained from the STATSGO soil database (STATSGO2, 2009) as described in Section 2. The STATSGO soil database has two components: a spatial map with polygons representing soil units (also called map units), and a database containing several tables that link to soil polygon map units. Each individual soil map polygon, or map unit, can have multiple soil components with multiple layers.

A FORTRAN program referred to as STATSGO36 (Hevesi, 2009) was used to process the STATSGO soils data and obtain soil parameters in the study area for use in INFIL3.0. STATSGO36 computes the necessary soil parameters for INFIL3.0 including, soil thickness, soil porosity, wilting-point water content, field capacity, saturated hydraulic conductivity, and drainage curve coefficient from the STATSGO database and those map units found in the modeled area. The soil thickness computed by the STATSGO36 procedure was checked against a second source that also computed weighted average soil thickness for the entire U.S. The second soils data source is available online and uses the STATSGO database to compute soil parameters that are commonly used in environmental modeling (Miller and White, 1998). The two results compare favorably for soil thicknesses of the various soil units in the study area.

There are a total of 15 different map units for the Fenner Watershed and nine for the Orange Blossom Wash area. Figure 2-10 shows the distribution of soil types in the area of study. Figure 4-8 shows the thickness of each soil map unit in the study area. Soil porosity is estimated in STATSGO36 using bulk density data from STATSGO and modified for coarse fractions (Maidment, 1993). Soil texture data are used with equations from Campbell (1985) to estimate the drainage coefficient, wilting point and field capacity. Saturated hydraulic conductivity is the layer-weighted average of the high and low values provided in the STATSGO database (Hevesi, 2009). Table 4-3 lists the soil parameter values for each soil map unit.

4.1.5 Hydrogeologic Parameters

Available geologic mapping is used to define the spatial distribution of different rock types (those geologic materials below the soil zone) in the area of study. These maps include the

geologic map of California for the northernmost portion of the area and the Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California (Bedford et al., 2006). The spatial distribution of geologic units determines the values for saturated hydraulic conductivity and root zone storage capacities assigned to the bottom root zone (layer 6 in INFIL3.0) for all model grid cells.

Site-specific values of hydraulic conductivity and porosity values are not available for each lithology occurring in the area of study, except for the percolation testing in the alluvium that was completed as a part of the Cadiz Groundwater Storage and Dry-Year Supply Program (GSSI, 1999). Hydraulic conductivity and porosity values assigned to various rock types are based on a field reconnaissance and literature values for similar rock types. Bedinger et al. (1989) present hydraulic properties of rocks in the Basin and Range Province and a later study by Belcher et al., (2002) provides additional data on hydraulic conductivity distributions for comparable rocks in Death Valley as part of a regional groundwater system assessment. These studies, as well as the GSSI (1999) percolation test in the alluvium, are used as guides to defining the parameters for Table 4-4, which presents estimates of porosity and hydraulic conductivity for rock types in the area of study. In general, the saturated hydraulic conductivity is assumed to be one order of magnitude higher than the unsaturated hydraulic conductivity.

In addition to the basic rock types, the surficial geologic map of Bedford et al. (2006) discussed in Section 2.3.3 shows extensive hillslope deposits, including colluvium, talus, and other coarse-grained porous deposits throughout the area of study. These hillslope deposits are anticipated to provide conduits for precipitation to reach bedrock and infiltrate more readily than for bare exposed rocks. Therefore, those parameters given in Table 4-4 are likely to be generally more conservative than compared to parameter values that more directly accounts for these deposits.

4.1.6 Vegetation and Root Zone Parameters

The WESTVEG GAP regional vegetation map (Figure 2-4) of vegetation types is used to define estimates of vegetation cover and root zone density. Vegetation types were grouped into estimated vegetation associations that have similar root-zone depths and densities, comparable to those used by Hevesi et al., (2003) for the Death Valley region. Vegetation cover was estimated from the GAP vegetation types, using the higher values for cover. INFIL3.0 parameters for vegetation include percentage of land covered by a given type of vegetation, root density of each vegetation type for six layers, root-zone depth from land surface for Layers 1 through 5, and root-zone thickness for Layer 6. Table 4-5 shows the vegetation root zone parameters for each vegetation type in the area of study.

4.1.7 INFIL3.0 Simulation Results

Figures 4-9a through 4-9d show modeled average annual precipitation over the area of study for two time periods: 1971 through 2000 and 1958 through 2007. The first time period allows for comparison with PRISM average annual isohyets. The second time period is for the period over which recoverable water is estimated for the area of study. As shown in Figure 4-9a and 4-9b, the distribution of precipitation compares favorably with the more regional PRISM isohyets. INFIL3.0 shows slightly higher values of precipitation over the Clipper Mountains compared to PRISM. INFIL3.0 uses local elevation and precipitation relations to refine the distribution of precipitation over mountainous areas, such as the

Clipper Mountains. INFIL3.0 simulated precipitation over the Clipper Mountains is consistent with PRISM precipitation over the Old Woman Mountains, which are comparable in altitude. INFIL3.0 simulated precipitation in the Providence Mountains is also slightly higher than PRISM values, which are also due to the refinement in precipitation versus elevation modeling at this local scale and are consistent with the findings of the Davisson and Rose (2000) analysis of local precipitation compared to more regional analyses of precipitation. In general, INFIL3.0 modeled precipitation has overall lower annual average precipitation for the period 1958 through 2007, compared with the period 1971 through 2000, which is consistent with the cumulative departure from mean analysis discussed in Section 2.2.1.

INFIL3.0 simulation results for Fenner Watershed and Orange Blossom Wash Area are shown in Figures 4-10a and 4-10b, respectively. As expected, the majority of recharge occurs at higher altitudes in the mountains, where precipitation is highest and temperatures are lowest (thus lower evapotranspiration). This trend, highest infiltration at higher altitudes, is consistent for other INFIL3.0 simulations in the Basin and Range Province and southern California (e.g., Hevesi et al., 2003; Hevesi et al., 2002; Nishikawa et al., 2004; and Rewis et al, 2006).

Figures 4-11 and 4-12 show estimated annual recoverable water quantities for each area. The average annual recoverable water quantities for Fenner Watershed, Orange Blossom Wash area, and in total are 30,191 AFY, 2,256 AFY, and 32,447 AFY, respectively, based on calendar years 1958 through 2007.

4.1.8 Discussion of Recoverable Water Results

Simulation results of recoverable water using INFIL3.0 are compared to those most recent estimates of GSSI (1999), USGS (2000), and Davisson and Rose (2000) and to estimates of groundwater discharge from Bristol and Cadiz dry lakes.

4.1.8.1 Comparison to Most Recent Recoverable Water Estimates

INFIL3.0 simulation results compare favorably to GSSI (1999) watershed water balance modeling results and the Davisson and Rose (2000) Maxey-Eakin recoverable water estimate of 29,815 AFY, and are much higher than the USGS (2000) Maxey-Eakin model estimates of 2,070 to 10,343 AFY (for the Fenner Watershed only).

Figures 4-13 through 4-16 compare the INFIL3.0 simulation results against GSSI (1999) high and low estimates of recoverable water for the Fenner Watershed and Orange Blossom Wash areas. GSSI (1999) presented estimates of recoverable water for a range of model input parameters, with field capacity and soil thickness showing the greatest impacts on their estimates. GSSI (1999) changed parameters over the entire watershed to observe sensitivities, when in actuality, those changes would not likely change from the mean values over the entire watershed, but likely vary lower and higher around the mean value across the watershed, which is why GSSI (1999) selected the middle or mean value as the expected value of recoverable water. In general, INFIL3.0 results, which also uses expected values (or means) for input parameters, tracks between these two recoverable water estimates as expected, even though results are based on a completely different set of numerical algorithms. However, INFIL3.0 simulation results show significantly less spiking in infiltration during wet years as compared to GSSI's (1999) high infiltration case. The

INFIL3.0 annual spikes (highest infiltration rates) compare more closely to the highest spikes (highest infiltration) of GSSI's low-estimate case. This is true for both the Fenner Watershed and Orange Blossom Wash area.

The INFIL3.0 simulation results are based on setting IROUT equal to 1 (see USGS, 2008, for full discussion of model input options). By setting IROUT equal to 1, INFIL3.0 will route daily runoff to downstream cells as surface water runon. Runon can infiltrate back to the root zone and contribute to net infiltration. The INFIL3.0 simulation, with IROUT equal to 1, results in no surface water outflow from the watershed; that is, all runoff generated at model cells is infiltrated downstream before it can leave the watershed. INFIL3.0 simulations were conducted using IROUT equal to 0 for both the Fenner and Orange Blossom Wash watersheds. For the case with IROUT equal to 0, INFIL3.0 routes all generated runoff downstream and out of the watershed so it is not allowed to infiltrate at downstream grid cells. These INFIL3.0 simulations generated 28,380 AFY and 2,060 AFY of net infiltration and runoff out of the watershed, respectively, for the Fenner Watershed and 2,170 AFY and 90 AFY of net infiltration and runoff out of the watershed, respectively, for the Orange Blossom Wash area. Field observations after rainfall events indicate generation of runoff in washes in the Fenner Gap area, as reported in previous studies and observed during this study. Therefore, the division of total recoverable water is likely to lie between these two extremes of runoff conditions.

As stated in the introduction to this section, the USGS (2000) used precipitation data from a very large regional area, including data from precipitation stations west of the 116° W longitude to compute an elevation-precipitation relation for their Maxey-Eakin model. As demonstrated by Davisson and Rose (2000), the USGS (2000) estimates are too low due to lack of geographic scale and context in their analysis of precipitation-elevation data, use of an uncalibrated Maxey-Eakin model, and lack of observational experience in the Fenner Watershed. The Davisson and Rose (2000) estimate of 29,815 AFY of recoverable water is similar to the estimate developed in this and GSSI (1999) studies.

4.1.8.2 Groundwater Discharge at Dry Lakes

Bristol and Cadiz dry lake playas are areas of groundwater discharge in the larger area of study. Groundwater flow from the Fenner Watershed is expected to be the most significant source of groundwater that is evapotranspired at these dry lake playas. The relative significance is shown by GSSI (1999), who estimated that Fenner and Orange Blossom wash areas contributed approximately 74 percent of the recoverable water in the larger area of study.

A qualitative assessment was undertaken to assess the occurrence of moist soils at Bristol and Cadiz dry lake. This assessment was made using a Normalized Difference Vegetation Index (NDVI). NDVI gives a measure of vegetation cover on the land surface over wide areas. Dense vegetation shows up very strongly in the imagery and areas with little or no vegetation are also clearly identified. Negative NDVI values indicate the presence of water, snow, or clouds.

Vegetation differs from other land surfaces because it tends to strongly absorb the red wavelengths of sunlight and reflect in the near-infrared wavelengths. Water and moist soils have more reflectance in the red wavelengths than the near infrared, while the difference is almost zero for rock and bare soil. NDVI takes values between -1 and 1, with vegetation

NDVI values typically from 0.1 up to 0.6, with higher values associated with greater density and greenness of the plant canopy. Surrounding soil and rock values are close to zero while the differential for water bodies such as rivers and lakes have the opposite trend to vegetation and the index is negative.

The NDVI formula is given by the equation (NIR-RED/NIR+RED), where RED and NIR correspond to Channels 3 and 4, respectively, for Landsat TM Satellite images.

In this study, we have used six Landsat TM satellite images to produce NDVIs. A classification system was designed using the unsupervised classification method and ERDAS software to differentiate between the land cover types within the larger area of study. Four NDVI classes were created for each subset image. Class 1 NDVI values range between -1 to -0.2 and indicate the presence of water; Class 2 values (-0.2 to 0) indicate the presence of moist and humid soils. Class 3 (0 to 0.1) is a combination of bare soil and rocks. NDVI values higher than 0.1 were combined in Class 4 and classified as vegetation. Figures 4-17 through 4-22 present the results of this analysis for Landsat TM Satellite images, including: May 16, 1990, March 16, 1991, May 19, 1991, March 10, 1992, May 14, 2005, and August 13, 2005. In all of these images, Bristol and Cadiz dry lakes stand out as having the lowest NDVI values (indicating very moist soils or water near the surface).

GSSI (2000) developed a range of estimates of evapotranspiration from Bristol and Cadiz dry lakes, using three different methods. They estimate a range of 11,665 AFY to 105,436 AFY. The upper range of values are based on evapotranspiration estimates at Franklin Dry Lake playa by Czarnecki (1997), who used energy-balance eddy-correlation techniques to estimate evapotranspiration from the playa lake surface, which resulted in evapotranspiration rates of 0.1 to 0.3 centimeters per day (cm/d) (approximately 1.2 to 3.6 feet per year [ft/yr]).

The USGS (Laczniak et al., 2001) has estimated evapotranspiration for a number of areas in the Death Valley regional flow system, which includes estimates for open playas similar to the Bristol and Cadiz dry lakes. The USGS estimated evapotranspiration rates range from 0.1 to 0.7 ft/yr . They adjust these evapotranspiration rates by the estimated long-term average annual precipitation rate (by subtracting the precipitation rate) to get evapotranspiration rates ranging from 0.15 to 0.21 ft/yr. However, Laczniak et al. (2001) state that the contribution of precipitation to evapotranspiration is uncertain. Given the high rate of evaporation in these arid environments, precipitation may not effect the evapotranspiration rates as estimated from micrometerological measurements. Using a range of 0.1 to 0.7 ft/yr (which are those estimated evapotranspiration rates from measured micrometeorological parameters) gives a range of evapotranspiration rates of 5,965 to 41,755 AFY for the Bristol and Cadiz dry lakes. Actual evapotranspiration rates are determined by site-specific conditions; however, it seems plausible that groundwater discharge from the Bristol and Cadiz dry lakes exceeds the recoverable water estimates for Fenner Watershed and Orange Blossom Wash area.

4.2 Groundwater Flow through Fenner Gap

Fenner Gap is the path of groundwater flow through alluvial and bedrock aquifers (such as carbonate rock units) from Fenner Valley into the Bristol and Cadiz valleys. The long-term steady-state flow of groundwater through the gap is expected to be similar to, and represent

long-term groundwater recharge in the Fenner Watershed. A three-dimensional groundwater flow model of the Fenner Gap area was developed for the purposes of validating the 30,000 AFY estimate of steady-state groundwater flow through Fenner Gap, as previously described. The following sections provide a brief description of the local hydrogeology of the Fenner Gap, development of a three-dimensional groundwater flow model, and inverse modeling to assess the potential groundwater flow through the gap.

4.2.1 Local Hydrogeology of the Fenner Gap Area

The Fenner Gap occurs between the Marble Mountains on the west and the Ship Mountains on the east, with an alluvial plain in between these mountains as shown in Figure 4-23. Available geologic maps (e.g., GSSI, 1999; Liggett, 2010; Bishop, 1963), surface geophysical surveys (GSSI, 1999), field mapping done as part of this study, previous drilling and aquifer test data, and drilling and aquifer testing as a part of this study were synthesized to develop a conceptual model of the hydrogeology of the Fenner Gap area.

The following formations are present in the Fenner Gap area (Hall, 2007; Hazzard, 1933; Murbach and Baldwin, 1994; and Bishop, 1963): Precambrian granitic rocks in the southern Marble Mountains; Lower Cambrian rocks, including Zabriskie quartzite, Latham shale, and Chambless limestone; Middle Cambrian rocks, including the Cadiz Formation and Bonanza King Formation; Upper Paleozoic (Pennsylvanian and Permian(?)) carbonate rocks (Goodsprings Formation(?) (Hazzard, 1933, and Bishop, 1963); Mesozoic granitic rocks (Ship Mountains); Tertiary volcanics, Plio-Peistocene older alluvium, and Holocene alluvium. Figure 4-24 provides a generalized stratigraphic column of geologic units in the Fenner Gap area, and Table 4-6 summarizes the characteristics of these units, including their range of thickness.

In general, those geologic units considered most important for transmitting and storing groundwater in the Fenner Gap are the younger alluvium (referred to as "alluvium" herein) and those carbonate rocks (limestone and dolomite) within the Paleozoic sequence. Carbonate rocks in this region have been subjected to dissolution and karstification, which is evidenced by the Mitchell Caverns in the nearby Providence Mountains (Hall, 2007) and in field and well video log observations made as a part of this study (see Appendix A). Field testing, as done in previous studies and as a part of this study, demonstrate substantial water transmitting and storage properties of these units (see Appendix A). Those granitic rocks, Cambrian shales and metamorphic rocks, Tertiary volcanics and older alluvium are not expected to transmit or store water in significant quantities as compared to these other geologic units; however, there could be significant flow along fracture zones, possibly associated with faulting. For purposes of this study, the younger alluvium and carbonates rocks (limestones and dolomites) are considered aquifers. The Paleozoic sequence includes a series of carbonate units, quartzites, and shales, however, it is not practical to differentiate the various lithologic units into multiple hydrogeologic units, so the whole sequence is treated as one hydrogeologic unit and referred to as the Carbonate Rock unit. In addition, Younger Alluvium transitions to a more complex sequence of younger alluvium, older alluvium, interbedded volcanics, and possibly lacustrine deposits to the north and south of the Fenner Gap area. However, for purposes of this assessment, these finer details are not considered significant for assessing groundwater flow through the Fenner Gap as discussed in Subsection 4.2.4 below.

A series of normal faults underlie the Fenner Gap area (see Figure 4-23) and have a significant effect on the distribution of the Carbonate Rock units. Figures 4-25 through 4-32 are cross-sections through the Fenner Gap, showing the distribution of hydrogeologic units in the subsurface. These cross-sections illustrate the significant occurrence of Carbonate Rock units in the southern Marble Mountains and along the western flank of Ship Mountain. Thick sections of Carbonate Rock units dip easterly off of the northern and eastern flanks of the Marble Mountains, extending northward under the Fenner Watershed. Similarly, Carbonate Rock units dip easterly (steeply in most cases), with significant fault offsets (as much as 2,500 feet) beneath Fenner Gap. In some cases, faulting has resulted in basement rock being in direct contact with the Alluvial aquifer unit. For example, granitic rocks were encountered below about 860 feet below ground surface (bgs) in test well TW-2 and exploratory borehole TW-2B (see Appendix A). These Carbonate Rock units are projected to terminate just south of the Fenner Gap due to down-cutting and erosion by an ancestral stream through the gap. Cross-sections I-I′ and J-J′ show our projection of a few remaining remnants of the Carbonate Rock units at these section lines.

The Alluvium unit extends north-south through the gap. The Alluvial aquifer unit is thicker to the north, in the Fenner Watershed, and south of the gap, in the Bristol and Cadiz valleys. Cross-section D-D′ appears to be located along the apparent crest of the bedrock high across the gap. Older alluvium is shown in Cross-sections E-E′, B1-B1′, and D-D′ on the Ship Mountain side. Highly consolidated fanglomerates were encountered during drilling of TW-3 as a part of this study. These fanglomerates are interpreted to be Plio-Pliestocene alluvial deposits that have undergone consolidation over time. Core from TW-3 show fractures that extend through the matrix and even across individual cobbles. As shown in the cross-sections, it is interpreted that these fanglomerates were likely removed by down-cutting and erosion from an ancestral stream; younger alluvium was then deposited across the gap. The deepest part of the Alluvial aquifer unit appears to be somewhat coincident with the current Schulyler Wash.

Figures 4-33 through 4-37 show contour maps of the base of the Alluvial aquifer unit, saturated thickness of the Alluvial aquifer unit, base of older alluvium, thickness of the Carbonate Rock unit, and base of Carbonate Rock unit, respectively. As shown in Figures 4-33 and 4-34, the Alluvial aquifer unit is deepest (and thicker) along an axis that roughly parallels the Schulyler Wash though the gap. Figure 4-35 shows the extent of the old alluvium, but more specifically the projected extents of the consolidated fanglomerates encountered in TW-3. Figure 4-36 and 4-37 shows the extent of the Carbonate Rock unit and its variation in thickness in the Fenner Gap area, which is largely controlled by the series of normal faults across the gap. The absence of the Carbonate Rock units extending southwesterly from TW-2 is likely due to faulting of basement rocks upward along normal faults and down-cutting and erosion along an ancestral stream(s) in this deepest part of the gap.

Aquifer tests have been completed in the Alluvium, Carbonate Rock, and Older Alluvium units. GSSI (1995, 1999, and 2000) summarizes available aquifer test information, including aquifer testing they preformed as a part of the Cadiz Groundwater Storage and Dry-Year Supply Program. Additional aquifer tests were conducted as a part of this current study and described in detail in Appendix A. The aquifer test completed at TW-1, in the carbonate rock unit, demonstrates the highly permeable nature of this unit, which is consistent with

significant dissolution and karstification of those carbonate rock units in the area. An aquifer test completed at TW-2 also demonstrates the highly transmissive nature of the Alluvial aquifer unit. TW-2 is completed in what is thought to be the axis of the deeper part of the Alluvial aquifer unit, which is likely the coarser part of the Alluvium unit. Table 4-7 summarizes aquifer test data for wells in the vicinity of the Fenner Gap.

4.2.2 Numerical Model Development

The Fenner Gap three-dimensional groundwater flow model described herein is based on the USGS MODFLOW-2000 numerical model. MODFLOW-2000 is a computer program that numerically solves the three-dimensional groundwater flow equation for a porous medium by using a finite-difference method (Harbaugh et al., 2000). MODFLOW-2000 is an enhancement to the previous MODFLOW numerical model originally documented by the USGS in 1984. MODFLOW-2000 requires that a conceptual model be developed of the groundwater system to be simulated, including, lateral and vertical extents of the system, definition of top and bottom of aquifers and confining units, boundary conditions (such as no-flow rock, specified inflows and outflows, constant heads where groundwater levels are maintained as constant, or some combination of these), hydrogeologic properties of aquifers, and observations to calibrate against (e.g., measured groundwater levels).

The purpose of the Fenner Gap groundwater flow model in this study is to assess whether it is likely that 30,000 AFY of groundwater is flowing through Fenner Gap, which is the expected long-term average recoverable water estimated to occur in the Fenner Watershed. Therefore, the numerical model is being used to test the hypothesis that 30,000 AFY is flowing through the gap. The model is used to solve the inverse problem, that is, given a boundary inflow of groundwater at the north end of the gap of 30,000 AFY, and measured steady-state groundwater levels, what distribution of aquifer properties (specifically hydraulic conductivity) is required to allow for this flow and is this distribution likely given available information on aquifer properties?

The conceptual model of the hydrogeology of the Fenner Gap described in Section 4.2.1 provides the basis for defining the lateral and vertical distribution of hydrogeologic units in the Fenner Gap and for use in mapping the distribution of these units in the numerical groundwater flow model.

Figure 4-38, a groundwater-level contour map, and historical groundwater-level data are used to define the lateral extents of the Fenner Gap groundwater flow model. Existing monitoring wells were surveyed for location and elevation and groundwater levels in wells were measured to obtain accurate groundwater levels in the gap. Table 4-8 shows survey results and groundwater levels for monitoring wells in the Fenner Gap, as obtained during this study. These groundwater levels, along with available groundwater-level data from the area, were used to construct the groundwater-level contour map shown in Figure 4-38. Historical groundwater-level data were reviewed to assess changes in groundwater levels in the area, in order to establish a steady-state groundwater-level condition through the Fenner Gap.

Figure 4-39 shows the lateral extents and grid selected for the Fenner Gap groundwater flow model. The lateral extents are defined by the 660-foot elevation groundwater contour on the north. This contour appears to be a stable groundwater level north of the Fenner Gap based

on review of historical groundwater levels. The southern and western boundary is taken as a 590-foot elevation groundwater-level contour, that is a hybrid between the map presented in Figure 4-38 and a groundwater-level contour map provided by GSSI (1999). This hybrid map takes into account more recent survey data and historical groundwater levels that are possibly more representative of historical steady-state conditions. Given the distance of this boundary from Fenner Gap, the model simulations are not expected to be sensitive to the actual delineation of this boundary. Outcrops of bedrock (granitic rocks or unsaturated carbonate rocks) define the extents of the model on the northern and eastern boundaries of the model. Outside of these boundaries, the model assumes there is no groundwater flow (no-flow boundary) into or out of these no-flow areas.

The model grid is divided into square cells of 200 feet by 200 feet. Three layers are represented: Alluvial aquifer unit, Old Alluvium unit, and Carbonate Rock unit. PEST is used to estimate the hydraulic conductivity distribution of the Alluvial aquifer and Carbonate Rock units. The hydraulic conductivity of the Old Alluvium unit is set at 1×10^{-3} ft/d. The Carbonate Rock unit is represented as a single unit made up of variable rock types, as previously described. In actuality, those carbonate rocks are the principal water-transmitting units; however, for modeling purposes, these variable units are lumped together and average water transmitting properties are averaged in the model across the whole layer. Groundwater levels are simulated in the model at the center of each cell. This grid-cell resolution allows for good approximation of boundaries, both vertically and laterally, and for good resolution of variations in hydrogeologic properties and at the same time providing for reasonable simulation run times.

As indicated above, the purpose of the Fenner Gap groundwater flow model is to assess the likelihood that 30,000 AFY of groundwater is flowing through the gap. Therefore, the following boundary conditions are imposed on the north and west-southern boundaries. Groundwater levels along the 660-foot groundwater elevation contour are assumed to be constant at the 660-foot level. In addition, 30,000 AFY of groundwater inflow is assumed to occur through this boundary into the gap from Fenner Watershed, which is the long-term average annual recharge in the watershed, as previously described. Groundwater levels along the 590-foot groundwater-level contour are expected to be constant and steady at this 590-foot level. Also, there are no other sources of recharge or discharge within the Fenner Gap model domain area.

4.2.3 Application of PEST to Estimating Groundwater Flow through Fenner Gap

PEST is a model-independent parameter estimator (PEST) computer program that provides nonlinear parameter estimation for use with almost any numerical model. PEST has been widely used and extensively tested since 1994 by scientists and engineers all over the world working in many different fields, including biology, geophysics, geotechnical, mechanical, aeronautical and chemical engineering, ground and surface water hydrology and other fields (Doherty, 2004). PEST is often used in inverse modeling to aid in calibrating groundwater flow models. That is, PEST is used to estimate groundwater model parameter values, such as hydraulic conductivity, where measurements of groundwater levels and stresses (such as pumping or recharge) are known, so PEST calculates values of hydraulic conductivity that makes the groundwater flow model "calibrate" to the measured values. PEST makes many (often thousands) model-simulation runs to find the best set of parameter

values that minimizes the residuals (differences) in simulated and observed measurements (e.g., groundwater levels).

PEST is used in the case of the Fenner Gap groundwater model to estimate hydraulic conductivity values of the Alluvial aquifer and Carbonate Rock units in the Fenner Gap given the following constraints (1) areal and vertical distribution of Alluvial and Carbonate Rock units as described above, (2) constant head values (groundwater elevations) of 660 feet and 590 feet on the northern and west-southern boundaries, respectively, (3) a target flux across the northern boundary of 30,000 AFY, (4) target groundwater-level measurements from monitoring wells in the Fenner Gap area based on recent groundwater levels, and (5) estimates of hydraulic conductivity from aquifer tests from previous studies and as a part of this study. These PEST-estimated hydraulic conductivity values are evaluated in the context of the hydrogeology of the gap, including available aquifer test data, to determine if these parameter estimates are reasonable. If these hydraulic conductivity values are considered reasonable, then it is reasonable that groundwater flow through the Fenner Gap is 30,000 AFY.

Regularization in combination with pilot points (Doherty, 2004) is used in the Fenner Gap groundwater flow model to estimate hydraulic conductivity value distributions in the Alluvial and Carbonate Rock unit aquifers. Regularization provides smoothing of parameter estimates, so that each grid cell is not considered to have a unique independent value and there is a smooth transition across the grid from high to low values. In addition, prior information is used to tell PEST the preferred values for each parameter and a range over which PEST may vary parameter values in order to match target values (i.e., measured groundwater levels). Parameter values are estimated by PEST at pilot points; then, kriging techniques are employed to spatially interpolate parameter values to all cells in the MODFLOW-2000 numerical finite-difference grid.

Figures 4-40 and 4-41 show the distribution of pilot points in Layer 1 (Alluvial aquifer unit) and Layer 3 (Carbonate Rock unit), respectively. Also shown are the target wells with water levels obtained from monitoring wells in the area (see Table 4-8).

Figures 4-42, 4-43, and 4-44 show simulated groundwater levels and target residuals, and hydraulic conductivity distributions for Layer 1 (Alluvial aquifer) and Layer 3 (Carbonate Rock unit), respectively, as determined from a PEST run. In this PEST run, hydraulic conductivity values of both the Alluvial aquifer and Carbonate Rock unit were bounded by a range between 1 to 600 ft/d. Groundwater levels and residuals (difference between measured groundwater levels and simulated groundwater levels) are posted at each monitoring well in Figure 4-42. The residuals are extremely low, indicating that the simulated groundwater levels are representative of measured groundwater levels.

Hydraulic conductivity values in the alluvial aquifer range from less than 20 to approximately 600 ft/d. The lowest values occur along the northern boundary, where the Alluvial aquifer is thickest. The Alluvial aquifer unit is represented as one layer in the model, when in actuality, it is likely several layers, with some layers having high hydraulic conductivity and other layers having lower values of hydraulic conductivity. The model-simulated values should be considered as vertically integrated averages of the true hydraulic conductivity. Again, these simulated values are those required to allow 30,000 AFY of groundwater flow into the gap area, assuming the granitic and metamorphic

rock units form the base of the groundwater flow system in this area. PEST iterated to values of hydraulic conductivity close to those starting values, 110 ft/d provided as input at pilot points, in the western and southern areas of the model domain. The highest values of hydraulic conductivity, ranging to just over 600 ft/d are found in the east-central portion of the groundwater flow model. This part of the gap includes thinner alluvium and underlying carbonate units that vary greatly in thickness. PEST likely adjusts the alluvial hydraulic conductivity values in this area to accommodate groundwater flow across the gap. Regardless, the hydraulic conductivity values are within the range of values determined from aquifer tests in the alluvial aquifer, so these values are reasonable.

Hydraulic conductivity values in the carbonate rock unit aquifer range from less than 5 to approximately 600 ft/d. The highest values are located in the central portion of the model area. These values occur in the thinnest sections of alluvial and carbonate rock unit aquifers. PEST indicates that for 30,000 AFY of groundwater flow to occur through the gap, and to match observed groundwater levels, then average hydraulic conductivity values up to 600 ft/d are required in the Carbonate Rock unit aquifer, given the constraints on the Alluvial aquifer unit. Based on aquifer testing of the carbonate rock unit aquifer at TW-1 these values are reasonable.

Figures 4-45, 4-46, and 4-47 show simulated groundwater levels and target residuals, and hydraulic conductivity distributions for Layer 1 (Alluvial aquifer) and Layer 3 (Carbonate Rock unit), respectively, as determined from a second PEST run. In this PEST run, hydraulic conductivity values of both the Alluvial aquifer and Carbonate Rock unit were bounded by a range between 1 to 400 ft/d. Groundwater levels and residuals (difference between measured groundwater levels and simulated groundwater levels) are posted at each monitoring well in Figure 4-45. Again, residuals are low, indicating that the simulated groundwater levels are representative of measured groundwater levels.

Hydraulic conductivity values in the Alluvial aquifer range from less than 20 to approximately 400 ft/d. The lowest values occur along the northern boundary, where the Alluvial aquifer is thickest, similar to the previous PEST run. PEST iterated to values of hydraulic conductivity close to those starting values, 110 ft/d provided as input at pilot points, in the western and extreme southern areas of the model domain. The highest values of hydraulic conductivity, ranging to just over 400 ft/d are found in the central and eastern portion of the groundwater-flow model, which is larger than the extent of high conductivity values in the previous PEST run. PEST adjusts the alluvial hydraulic conductivity values in this area to accommodate groundwater flow across the gap. These hydraulic conductivity values are within the range of values determined from aquifer tests in the Alluvial aquifer, so these values are reasonable.

Hydraulic conductivity values in the carbonate rock unit aquifer range from less than 5 to approximately 400 ft/d. The highest values are located in the central portion of the model area. These values occur in the thinnest sections of alluvial and carbonate rock unit aquifers. PEST indicates that for 30,000 AFY of groundwater flow to occur through the gap, and to match observed groundwater levels, then average hydraulic conductivity values up to 400 ft/d are required in the Carbonate Rock unit aquifer, given the constraints on the Alluvial aquifer unit. Based on aquifer testing of the carbonate rock unit aquifer at TW-1 these values are reasonable.

Figure 4-48 shows a scatter plot of observed groundwater levels with simulated groundwater levels from the two PEST runs. This plot further demonstrates the good fit between the simulated and observed groundwater levels, i.e., the slope of the line is one to one. With 600 ft/d as the maximum hydraulic conductivity, the range of residuals was -0.27 to 0.19 feet, with a mean of -0.002 feet and a standard deviation of 0.10 feet. With 400 ft/d as the maximum hydraulic conductivity, the range of residuals was -0.52 to 0.62 feet, with a mean of -0.04 feet and a standard deviation of 0.34 feet. In addition, the residual standard deviation over the range is 0.008 and 0.026 for the first and second PEST runs, which are well within the 10 percent considered to be an industry standard.

The PEST results for hydraulic conductivity are considered possible sets of hydraulic conductivity values that can accommodate 30,000 AFY of groundwater flow through the Fenner Gap and match groundwater levels in monitoring wells and the range of hydraulic conductivity values observed from available aquifer tests.

4.2.4 Discussion of Groundwater Flow Model Results

The Fenner Gap groundwater flow model relies heavily on relatively high hydraulic conductivity values for the Carbonate Rock unit aquifer. Carbonate rock aquifers are not common in California, so there are not many examples to use for comparison and as a reality check on the groundwater flow model results; therefore, it is necessary to look outside the area for comparable hydrogeologic settings.

A carbonate rock aquifer that has been extensively studied and modeled is the Edwards aquifer in the San Antonio region of Texas. This aquifer is described as one of the most permeable and productive aquifers in the world (Lindgren, et al., 2004). Figure 4-49 shows hydrogeologic zones and catchment area of the Edwards aquifer from Lindgren (2004). The Edwards aquifer ranges to over 1,000 feet in thickness. Three types of permeability are recognized: matrix, fracture, and conduit. Matrix permeability is typically dwarfed by the fracture and conduit permeability and hydraulic conductivity and transmissivity vary over eight orders of magnitude and are multimodal.

Lindgren et al. (2004) and Painter et al. (2007) show the need to upscale hydraulic conductivity values from single-borehole tests. They have found that hydraulic conductivity values need to be increased substantially for use in numerical models, compared to those hydraulic conductivity values obtained from single-well tests. They found that geostatistical methods, such as kriging and cokriging during upscaling of hydraulic conductivity followed by Bayesian updating based on calibration to groundwater levels provided the best estimation of transmissivity and hydraulic conductivity values (Painter, 2007) for use in numerical groundwater flow models. Two component sets of hydraulic conductivity values are used in the Edwards aquifer model: a base component set and a conduit component set. The base component set of values of hydraulic conductivity simulated in a MODFLOW-2000 numerical groundwater flow model, using 0.25-mile grid spacings, of the Edwards aquifer range from less than or equal to 20 to 7,347 ft/d (Lindgren et al., 2004). The conduit component set ranges from 1,000 ft/d in the recharge area to as high as 300,000 ft/d in the confined portions of the aquifer and near spring discharge areas (Lindgren et al., 2004). Figure 4-50 shows the calibrated hydraulic conductivity distribution presented by Lindgren et al., (2004).

The carbonate rock units in Fenner Gap are not necessarily as permeable or productive as the Edwards aquifer; however, it may serve as a relatively representative analog for the Fenner Gap carbonate rock unit. Significant permeability, including the potential for conduit permeability, is evidenced by dissolution features in video logs of test wells, minimal drawdown during constant-rate aquifer tests and flattening of hydraulic gradients (as between MW-7 and MW-5). In addition, Mitchell Caverns itself demonstrates the occurrence of caverns in these Paleozoic carbonates in the area of study. Occurrence of highly permeable dissolution cavities and preferential pathways are expected to exist in the carbonate rock units underlying Fenner Gap. The hydraulic conductivity of these zones is expected to exceed hundreds of feet per day and perhaps approach thousands of feet per day, when upscaled to numerical model grid cells. So, hydraulic conductivity values simulated in the Fenner Gap model are considered reasonable estimates for the actual hydraulic conductivity values.

In total, data obtained from field investigations, INFIL3.0 watershed soil-moisture budget assessments, and Fenner Gap three-dimensional groundwater flow model simulations support a 32,000 AFY estimate of potentially recoverable water from the Fenner and northern Bristol Valley area. However, numerical models are based on simplified conceptual models of the more complex physical groundwater system and processes. Model construction and calibration results in nonunique models, which is demonstrated above in that two conceptual models (i.e., hydraulic conductivity distributions for Layers 1 and 3) provide a good fit to the observed data (groundwater levels and range of hydraulic conductivity values). The Fenner Gap models suggest a large area of highly transmissive alluvium and carbonate rock units, especially along the eastern side of the gap, extending into Bristol Valley. This area should be the focus of any additional field investigations as might be required for development of an operations plan and subsequent environmental impacts assessments, which also will provide further support of these potentially recoverable water estimates.

Tables

TABLE 4-1
Monthly Atmospheric-Parameters Used in INFIL3.0 Simulations

Month	Ozone	WP	Beta	CSR	PG
January	0.29	1.00	0.075	0.85	0.24
February	0.31	1.00	0.075	0.85	0.24
March	0.32	1.05	0.075	0.85	0.24
April	0.33	1.10	0.085	0.85	0.24
May	0.33	1.50	0.085	0.74	0.24
June	0.32	1.80	0.090	0.74	0.24
July	0.30	2.20	0.090	0.57	0.24
August	0.29	2.44	0.084	0.57	0.24
September	0.28	2.00	0.077	0.66	0.24
October	0.27	1.40	0.075	0.74	0.24
November	0.27	1.05	0.075	0.90	0.24
December	0.28	0.95	0.075	0.90	0.24

Ozone – is ozone-layer thickness in (centimeters)

WP – is the precipitable water in the atmosphere in (centimeters)

Beta – is the mean atmospheric turbidity, dimensionless

CSR – is the circumsolar radiation, dimensionless

PG – is the surface reflectivity, dimensionless

TABLE 4-2
Monthly Climate-Regression Models Coefficients Used in INFIL 3.0 Simulations

Month	PPTa	PPTb	MAXa	TMAXb	TMINa	TMINb
January	0.01389	6.666	-0.00514	19.41	-0.0067	4.9
February	0.01979	4.093	-0.00780	24.24	-0.0071	7.5
March	0.01829	3.293	-0.00732	26.70	-0.0075	10.3
April	0.00700	0	-0.00785	32.25	-0.0080	14.2
May	0.00295	0.397	-0.00752	36.65	-0.0081	18.6
June	0.00170	0.029	-0.00778	41.95	-0.0082	23.2
July	0.00903	5.081	-0.00824	44.72	-0.0084	27.2
August	0.01499	6.134	-0.00764	43.71	-0.0086	26.5
September	0.01384	2.125	-0.00799	40.5	-0.0084	22.3
October	0.00525	2.949	-0.00446	26.71	-0.0077	15.7
November	0.00641	1.467	-0.00355	20.06	-0.0068	8.9
December	0.00925	3.523	-0.00456	16.39	-0.0065	4.8

ppta, pptb – are the regression-model coefficients (real variables) for the precipitation-elevation model for each month.

maxa, tmaxb – are the regression-model coefficients (real variables) for the maximum air temperature-elevation model for each month.

tmina, tminb – are the regression-model coefficients (real variables) for the minimum air temperature-elevation model for each month.

TABLE 4-3
Soil Parameter Values Used in INFIL 3.0 Simulations

Soil Map ID (MUID)	Porosity (Dimensionless)	Field Capacity (Dimensionless)	Wilting Point (Dimensionless)	Drainage Parameter (Dimensionless)	Saturated Soil Hydraulic Conductivity (mm/d)
CA909	0.3021	0.1567	0.302	4.3784	1935
CA907	0.3013	0.1441	0.0261	4.3133	1470
CA930	0.1608	0.1158	0.0144	3.7086	3779
CA933	0.3714	0.2479	0.0688	5.1954	3008
CA926	0.2328	0.1619	0.0413	5.734	1384
CA788	0.2452	0.1557	0.0424	6.304	980
CA931	0.2798	0.1265	0.0131	3.0042	6075
CA919	0.3254	0.1952	0.0477	4.8078	2046
CA905	0.2809	0.1363	0.0253	4.7288	2213
CA906	0.2189	0.1700	0.0511	6.6944	486.3
CA913	0.3388	0.1676	0.0335	4.3381	1437
CA782	0.2131	0.1617	0.0414	5.7577	1433
CA922	0.1958	0.1191	0.0144	3.5114	7942
CA927	0.2707	0.1930	0.0510	5.4338	2243
CA910	0.2854	0.1557	0.0272	4.0032	3683

TABLE 4-4
Root Zone Porosity, Initial and Calibrated Saturated Hydraulic Conductivity for Bedrock and Deep Soil Used in INFIL v3.0

Map Code	Rock Descriptions	Root-zone Porosity	Ksat 1 mm/day	Ksat 2 mm/day
100	alluv	0.26	1000.00	1000.00
101	basal	0.05	1.0	10.00
102	congl	0.001	0.00005	0.005
103	dune	0.35	1000.00	1000.00
104	felsi	0.05	1.00	10.00
105	gneis	0.05	1.00	10.00
106	grani	0.05	1.00	10.00
107	grano	0.05	1.00	10.00
108	limes	0.10	2.00	20.00
109	pluto	0.05	1.00	10.00
110	rhyol	0.05	1.00	10.00
111	sands	0.05	1.00	10.00
112	schis	0.05	1.00	10.00
113	tephr	0.05	1.00	10.00
114	ml	0.26	500.00	500.00
115	Qaa	0.26	1000.00	1000.00
116	Qaa+Qya	0.26	1000.00	1000.00
117	Qaag	0.26	1000.00	1000.00
118	Qae/Qmv	0.26	1000.00	1000.00
119	Qae/Qyea	0.26	1000.00	1000.00
120	Qaw	0.26	1000.00	1000.00
121	Qaw+Qyw	0.26	1000.00	1000.00
122	Qawg+Qywg	0.26	1000.00	1000.00
123	Qha/ca	0.05	1.00	10.00
124	Qha/ca+sl	0.05	1.00	10.00
125	Qha/fp	0.05	1.00	10.00
126	Qha/fp?	0.05	1.00	10.00
127	Qha/fpg	0.05	1.00	10.00
128	Qha/fv	0.05	1.00	10.00
129	Qha/fv+mv	0.05	1.00	10.00
130	Qha/mp	0.05	1.00	10.00
131	Qha/mp?	0.05	1.00	10.00
132	Qha/mr	0.05	1.00	10.00
133	Qha/mr?	0.05	1.00	10.00
134	Qha/mr+fp	0.05	1.00	10.00

TABLE 4-4
Root Zone Porosity, Initial and Calibrated Saturated Hydraulic Conductivity for Bedrock and Deep Soil Used in INFIL v3.0

Map Code	Rock Descriptions	Root-zone Porosity	Ksat 1 mm/day	Ksat 2 mm/day
135	Qha/mv	0.05	1.00	10.00
136	Qha/mv?	0.05	1.00	10.00
137	Qha/pc	0.05	1.00	10.00
138	Qha/Qmv	0.05	1.00	10.00
139	Qha/sl	0.05	1.00	10.00
140	Qha/sl?	0.05	1.00	10.00
141	Qhs/ca	0.05	1.00	10.00
142	Qhs/fp	0.05	1.00	10.00
143	Qhs/fp?	0.05	1.00	10.00
144	Qhs/fpg	0.05	1.00	10.00
145	Qhs/fv	0.05	1.00	10.00
146	Qhs/mr+fp	0.05	1.00	10.00
147	Qia	0.26	1000.00	1000.00
148	Qia/fp	0.26	1000.00	1000.00
149	Qia/fv	0.26	1000.00	1000.00
150	Qia/pc	0.26	1000.00	1000.00
151	Qia/Qoa	0.26	1000.00	1000.00
152	Qia?	0.26	1000.00	1000.00
153	Qia+Qaa	0.26	1000.00	1000.00
154	Qia+Qaa	0.26	1000.00	1000.00
155	Qia+Qya	0.26	1000.00	1000.00
156	Qia+Qyao	0.26	1000.00	1000.00
157	Qiad	0.26	1000.00	1000.00
158	Qiag	0.26	1000.00	1000.00
159	Qiag/fpg	0.26	1000.00	1000.00
160	Qiag+Qyag	0.26	1000.00	1000.00
161	Qiao	0.26	1000.00	1000.00
162	Qiao+Qia	0.26	1000.00	1000.00
163	Qiao+Qoa	0.26	1000.00	1000.00
164	Qiaog	0.26	1000.00	1000.00
165	Qimc	0.26	1000.00	1000.00
166	Qimc+Qymc	0.26	1000.00	1000.00
167	Qiw	0.26	1000.00	1000.00
168	Qmc	0.26	1000.00	1000.00
169	Qmc/mv	0.05	1.00	10.00
170	Qoa	0.26	1000.00	1000.00

TABLE 4-4
Root Zone Porosity, Initial and Calibrated Saturated Hydraulic Conductivity for Bedrock and Deep Soil Used in INFIL v3.0

Map Code	Rock Descriptions	Root-zone Porosity	Ksat 1 mm/day	Ksat 2 mm/day
171	Qoa/fp	0.26	1000.00	1000.00
172	Qoa/fv	0.26	1000.00	1000.00
173	Qoa/mr	0.26	1000.00	1000.00
174	Qoa?	0.26	1000.00	1000.00
175	Qoa?+Qya	0.26	1000.00	1000.00
176	Qoa+Qia	0.26	1000.00	1000.00
177	Qoa+Qya	0.26	1000.00	1000.00
178	Qoad	0.26	1000.00	1000.00
179	Qoag	0.26	1000.00	1000.00
180	Qoag/fv	0.26	1000.00	1000.00
181	Qpd-fp	0.26	1000.00	1000.00
182	Qpd-fpg	0.26	1000.00	1000.00
183	Qpd-mr	0.26	1000.00	1000.00
184	Qpi-fp	0.26	1000.00	1000.00
185	Qpi-fp?	0.26	1000.00	1000.00
186	Qpi-fpg	0.26	1000.00	1000.00
187	Qpi-mr	0.26	1000.00	1000.00
188	Qpv-fp	0.26	1000.00	1000.00
189	Qpv-fpg	0.26	1000.00	1000.00
190	Qpv-fpg+Qiag	0.26	1000.00	1000.00
191	Qpv-mr	0.26	1000.00	1000.00
192	QToa	0.26	1000.00	1000.00
193	QToa?	0.20	100.00	100.00
194	Qya	0.26	1000.00	1000.00
195	Qya/Qia	0.26	1000.00	1000.00
196	Qya/Qia+Qia	0.26	1000.00	1000.00
197	Qya/Qoa	0.26	1000.00	1000.00
198	Qya/Qoa?	0.26	1000.00	1000.00
199	Qya+Qaa	0.26	1000.00	1000.00
200	Qya+Qia	0.26	1000.00	1000.00
201	Qya+Qoa	0.26	1000.00	1000.00
202	Qya+Qyao	0.26	1000.00	1000.00
203	Qya+Qye	0.26	1000.00	1000.00
204	Qya+Qyg	0.26	1000.00	1000.00
205	Qyae	0.26	1000.00	1000.00
206	Qyaf	0.26	1000.00	1000.00

TABLE 4-4
Root Zone Porosity, Initial and Calibrated Saturated Hydraulic Conductivity for Bedrock and Deep Soil Used in INFIL v3.0

Map Code	Rock Descriptions	Root-zone Porosity	Ksat 1 mm/day	Ksat 2 mm/day
207	Qyag	0.26	1000.00	1000.00
208	Qyag/Qia	0.26	1000.00	1000.00
209	Qyag/Qiag	0.26	1000.00	1000.00
210	Qyag/Qoa	0.26	1000.00	1000.00
211	Qyag/Qoag	0.26	1000.00	1000.00
212	Qyag+Qaag	0.26	1000.00	1000.00
213	Qyag+Qia	0.26	1000.00	1000.00
214	Qyag+Qiag	0.26	1000.00	1000.00
215	Qyao	0.26	1000.00	1000.00
216	Qyao/Qia	0.26	1000.00	1000.00
217	Qyao+Qia	0.26	1000.00	1000.00
218	Qyay	0.26	1000.00	1000.00
219	Qyay+Qaa	0.26	1000.00	1000.00
220	Qyay+Qyao	0.26	1000.00	1000.00
221	Qye/fv	0.26	1000.00	1000.00
222	Qye/mv	0.26	1000.00	1000.00
223	Qye/Qmv	0.26	1000.00	1000.00
224	Qye+Qha/Qmv	0.26	1000.00	1000.00
225	Qyea	0.26	1000.00	1000.00
226	Qyea/Qia	0.26	1000.00	1000.00
227	Qyea/Qia?	0.26	1000.00	1000.00
228	Qyea+Qae	0.26	1000.00	1000.00
229	Qyg	0.26	1000.00	1000.00
230	Qymc	0.26	1000.00	1000.00
231	Qyp	0.26	1000.00	1000.00
232	Qypf	0.26	1000.00	1000.00
233	Qyv	0.26	1000.00	1000.00
234	Qyv+Qav	0.26	1000.00	1000.00
235	Qyv+Qia	0.26	1000.00	1000.00
236	Qyw	0.26	1000.00	1000.00
237	Qyw/Qiw	0.26	1000.00	1000.00
238	Qyw+Qaw	0.26	1000.00	1000.00
239	Qyw+Qiw	0.26	1000.00	1000.00
240	Qywg+Qawg	0.26	1000.00	1000.00

TABLE 4-5
Vegetation Properties Used in INFIL 3.0 Simulations

Vegetation Name	% Cover	Vegetation Class	Cover 1	Cover 2	Cover 3	Cover 4	Cover 5	Cover 6	Soil Layer Depth (rzdpth) 1	rzdpth 2	rzdpth 3	rzdpth 4	rzdpth 5	rzdpth 6	rzdpthf
Agricultural Land	40	Agricultural Land	90	90	90	30	20	5	0.1	0.3	1	3	6	1.5	1
Alkali Playa	0	Alkali Playa	0	0	0	0	0	0	0	0	0	0	0	0	1
Bare Exposed Rock	0	Bare Exposed Rock	0	0	0	0	0	0	0	0	0	0	0	0	1
Big Sagebrush Scrub	35	Big Sagebrush Scrub	70	70	50	50	50	30	0.1	0.3	1	3	6	1.5	1
Blackbush Scrub	35	Blackbush Scrub	50	50	50	30	30	30	0.1	0.3	1	3	8	2	1
Desert Dry Wash Woodland	5	Desert Dry Wash Woodland	50	50	50	50	50	50	0.1	0.3	1	3	8	2	1
Desert Dunes	0	Desert Dunes	0	0	0	0	0	0	0	0	0	0	0	0	1
Desert Saltbrush Scrub	25	Desert Saltbrush Scrub	25	25	12.5	6.25	2.5	1.25	0.1	0.2	0.7	2	3	2	1
Mojave Creosote Bush Scrub	30	Mojave Creosote Bush Scrub	50	50	40	30	30	30	0.1	0.3	1	3	8	3	1
Mojave Mixed Steppe	40	Mojave Mixed Steppe	40	40	20	10	4	2	0.1	0.2	0.7	2	3	2	1
Mojave Mixed Woody & Succulent Scrub	40	Mojave Mixed Woody & Succulent Scrub	30	30	15	7.5	3	1.5	0.1	0.2	0.7	2	3	2	1
Mojave Mixed Woody Scrub	30	Mojave Mixed Woody Scrub	30	30	15	7.5	3	1.5	0.1	0.2	0.7	2	3	2	1

TABLE 4-5
Vegetation Properties Used in INFIL 3.0 Simulations

Vegetation Name	% Cover	Vegetation Class	Cover 1	Cover 2	Cover 3	Cover 4	Cover 5	Cover 6	Soil Layer Depth (rzdpth) 1	rzdpth 2	rzdpth 3	rzdpth 4	rzdpth 5	rzdpth 6	rzdpthf
Mojavean Pinyon & Juniper Woodland	50	Mojavean Pinyon & Juniper Woodland	60	60	60	60	50	50	0.1	0.3	1	3	8	4	1
Semi-Desert Chaparral	50	Semi-Desert Chaparral	50	50	25	12.5	5	2.5	0.1	0.2	0.7	2	3	2	1
Sonoran Creosote Bush Scrub	5	Sonoran Creosote Bush Scrub	30	30	30	30	30	10	0.1	0.3	1	3	6	1.5	1
Urban or Built-up Land	5	Urban or Built-up Land	50	50	50	50	50	50	0.1	0.3	1	3	6	2.5	1

% Cover – is the percentage of land covered by this vegetation type.

Cover (1 – 6) – is the root zone density (in percent) for each model layer.

rzdpth – is depth (in meters) from land surface to base of soil layer (layers 1 – 5), and thickness of layer 6 (in meters).

TABLE 4-6
Geologic Units of the Fenner Gap Area

Era	Period	Geologic Unit	Thickness (feet)	Description
Cenozoic	Quaternary	Alluvium	Up to 900	Unconsolidated cobbles, gravel, and sand with minor silt and clay.
	Late Tertiary to Early Quaternary	Older Alluvium	Over 6,000, but < 1,000 in the Gap	Poorly to well consolidated conglomerate consisting of cobbles, gravel, and sand with minor silt and clay.
	Tertiary	Volcanics	Variable	Volcanic rocks of basaltic and intermediate composition.
Mesozoic	Jurassic	Ship Mountains Pluton	-	Granitic rocks.
Paleozoic	Permian-Pennsylvanian	Undifferentiated Carbonates	Up to 3,500 regionally, but unknown in the Gap	Thick to massively bedded limestone, with some interbedded cherty and sandy limestone.
		Bonanza King Formation	Up to 2,000	Non-fossiliferous, light gray to dark smoky gray dolomite and dolomitic limestone; contains algal laminations and chert nodules.
		Cadiz Formation	400-600	Interbedded limestone, siltstone, quartzite, and shale; commonly fossiliferous and locally cross-bedded.
	Cambrian	Chambless Limestone	140-200	Massive to thick-bedded, light to dark gray limestone with abundant algal nodules. Some fossiliferous zones with braciopods and trilobites
		Latham Shale	50-75	Olive to gray platy shale, some sandy limestone interbeds.
		Zabriskie Quartzite	50	Reddish brown to white sedimentary quartzite; locally conglomeratic.
Precambrian	-	Precambrian Basement	-	Granitic and metamorphic rocks.

TABLE 4-7
Summary of Aquifer Test Data – Fenner Gap Area

Well Name	Unit	Test Type	Saturated Thickness (ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d)
TW-1	Alluvium	Constant Rate	128	6,080	50
TW-1	Carbonate	Constant Rate	548	631,000	1,150
TW-2	Alluvium	Step Drawdown and Constant Rate	478	291,000	610
TW-3	Old Alluvium (Fanglomerate)	Packer Test	NA	NA	$3.1x10^{-3}$
5N/14E-13[a]	Alluvium	Specific Capacity	310	28,985	95
Cadiz 1[a]	Alluvium	Step Drawdown	90	24,330	270
Cadiz 2[a]	Alluvium	Step Drawdown	111	28,880	260
PW-1[a]	Alluvium	Step Drawdown and Constant Rate	464	52,810	115

[a] - screened interval used for saturated thickness

TABLE 4-8

Summary of Survey Data and Groundwater Elevation Measurements - Fenner Gap Area

Well Designation	Coordinates (1)		Ground Surface Elevation (2) (ft msl)	Reference Point Stickup (3) (ft ags)	Depth to Groundwater (ft brp)	Groundwater Elevation (ft msl)	Measurement Date
	Latitude	Longitude					
#5/14-13	34-31.239 N	115-28.185 W	892.84	1.46	297.84	596.46	7/30/2009
					296.88	597.42	1/13/2010
#6/15-1	34-38.378 N	115-21.362 W	1372.42	1.00	295.75	1077.67	7/30/2009
					295.73	1077.69	1/13/2010
#6/15-29	34-34.545 N	115-26.060 W	1134.84	1.39	450.36	685.87	7/30/2009
					450.31	685.92	8/27/2009
					450.25	685.98	1/13/2010
CI-1	34-30.940 N	115-27.677 W	894.86	1.76	296.27	600.35	8/1/2009
					296.49	600.13	1/13/2010
CI-2	34-31.232 N	115-27.738 W	902.67	2.08	304.61	600.14	8/2/2009
					304.68	600.07	1/13/2010
CI-3	34-30.769 N	115-28.233 W	874.33	1.56	278.48	597.41	8/1/2009
					278.46	597.43	1/13/2010
MW-1	34-31.012 N	115-27.730 W	894.92	2.10	297.16	599.86	8/2/2009
					297.29	599.73	1/13/2010
MW-2	34-30.648 N	115-27.948 W	875.20	1.79	278.58	598.41	8/1/2009
					278.48	598.51	1/13/2010
MW-3	34-30.834 N	115-27.414 W	895.46	2.09	295.97	601.58	8/1/2009
					295.90	601.65	1/13/2010
MW-5	34-31.138 N	115-27.367 W	911.19	2.10	307.85	605.44	8/2/2009
					307.97	605.32	8/26/2009
					308.13	605.16	1/8/2010
					308.00	605.29	1/13/2010
MW-6	34-31.330 N	115-27.017 W	926.66	2.11	321.84	606.93	8/1/2009
					321.91	606.86	1/13/2010
MW-7	34-31.638 N	115-26.907 W	938.46	2.26	332.53	608.19	8/2/2009
					332.45	608.27	10/7/2009
					332.61	608.11	1/13/2010
MW-7A			938.46	2.26	332.42	608.30	10/7/2009
					332.51	608.21	1/13/2010
PW-1	34-30.764 N	115-28.213 W	873.62	-	-	-	-

Notes:

(1) Geographic coordinates, degrees, decimal minutes, NAD 83

(2) Surveyed to NAVD 29. Ground surface survey location marked on well pad with 'X' or tag.

(3) Reference point stickup refers to the top of steel casing or monument height above ground surface.

ft ags - feet above ground surface

ft brp - feet below reference point

ft msl - feet (relative to) mean sea level

Figures

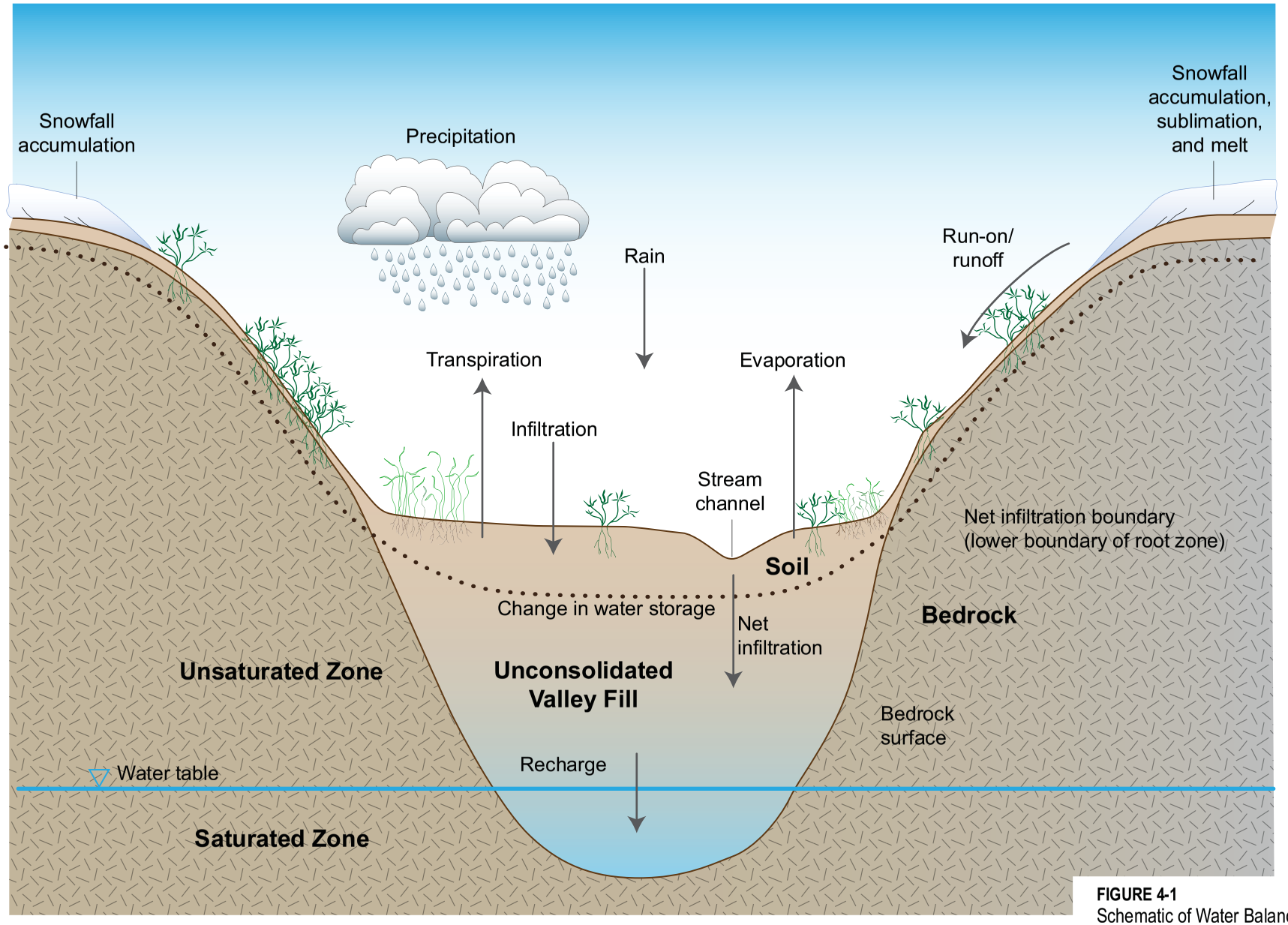
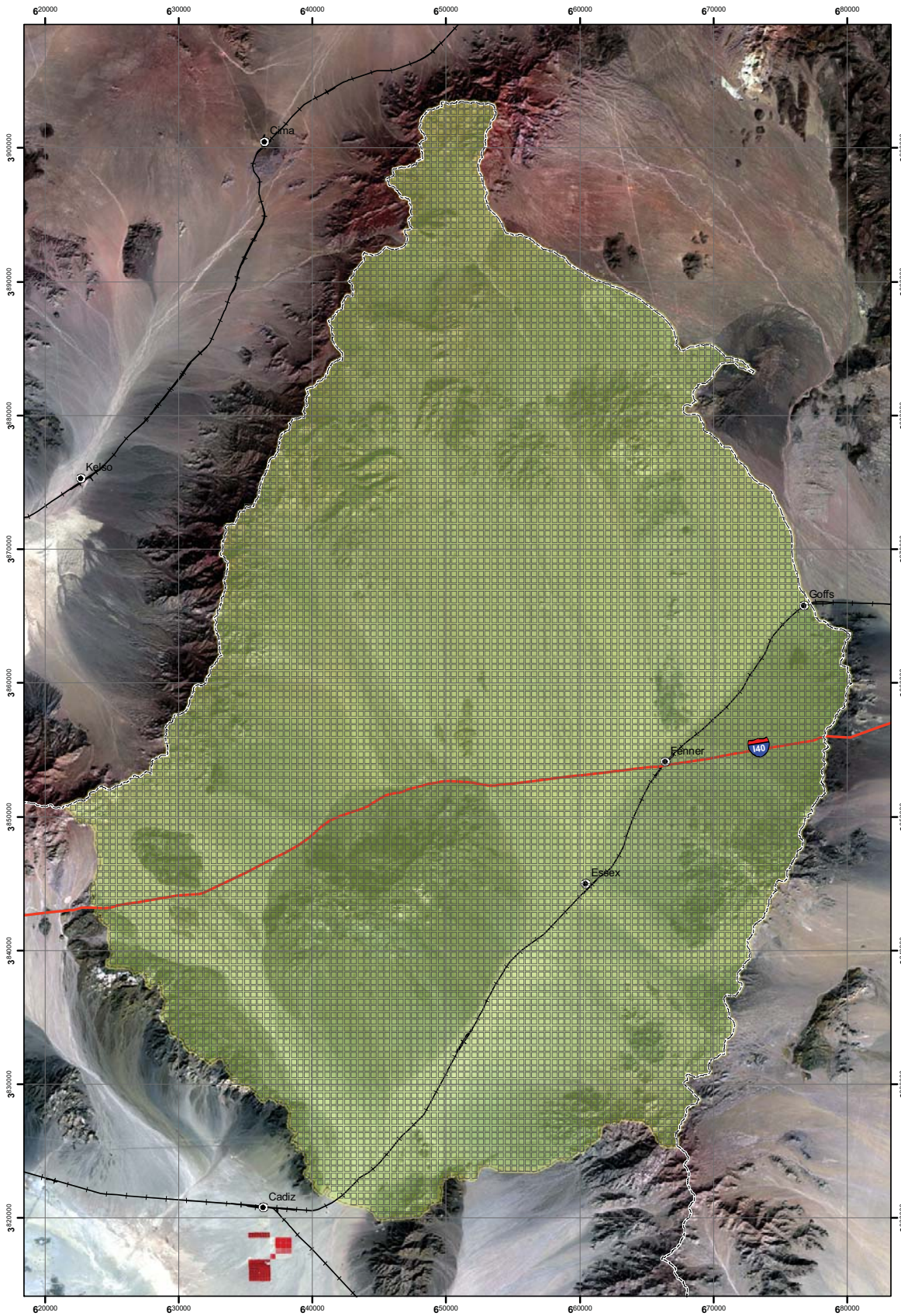


FIGURE 4-1
Schematic of Water Balance Processes Simulated in INFIL3.0



Legend

- Model 500m Grid
- Cities/Communities
- Cadiz Study Area
- Interstates
- Rail Roads
- Fenner Valley Model Boundary

N

0 1.25 2.5 5 Miles

0 1.5 3 6 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-2
INFIL3.0 Grid - Fenner Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303CadizGIS\ArcMap\TMFigures\Fig4-2_CADIZ_TM_INFIL_FNRModelGrid_V3_MR.mxd

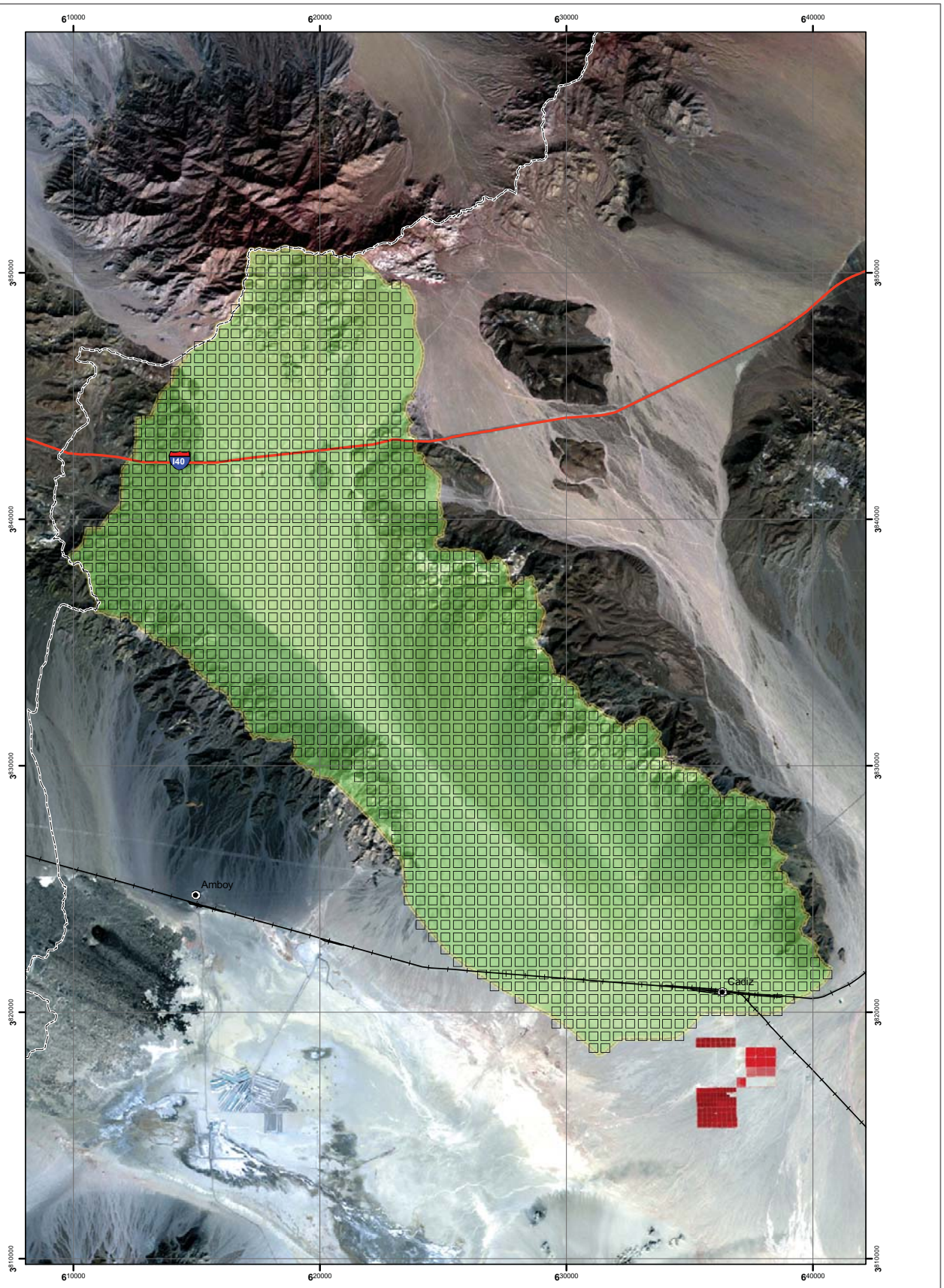


Figure 4-3
INFIL3.0 Grid - Orange Blossom Wash Area

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-3_CADIZ_TM_INFILF_ORBModelGrid_v1_MR.mxd

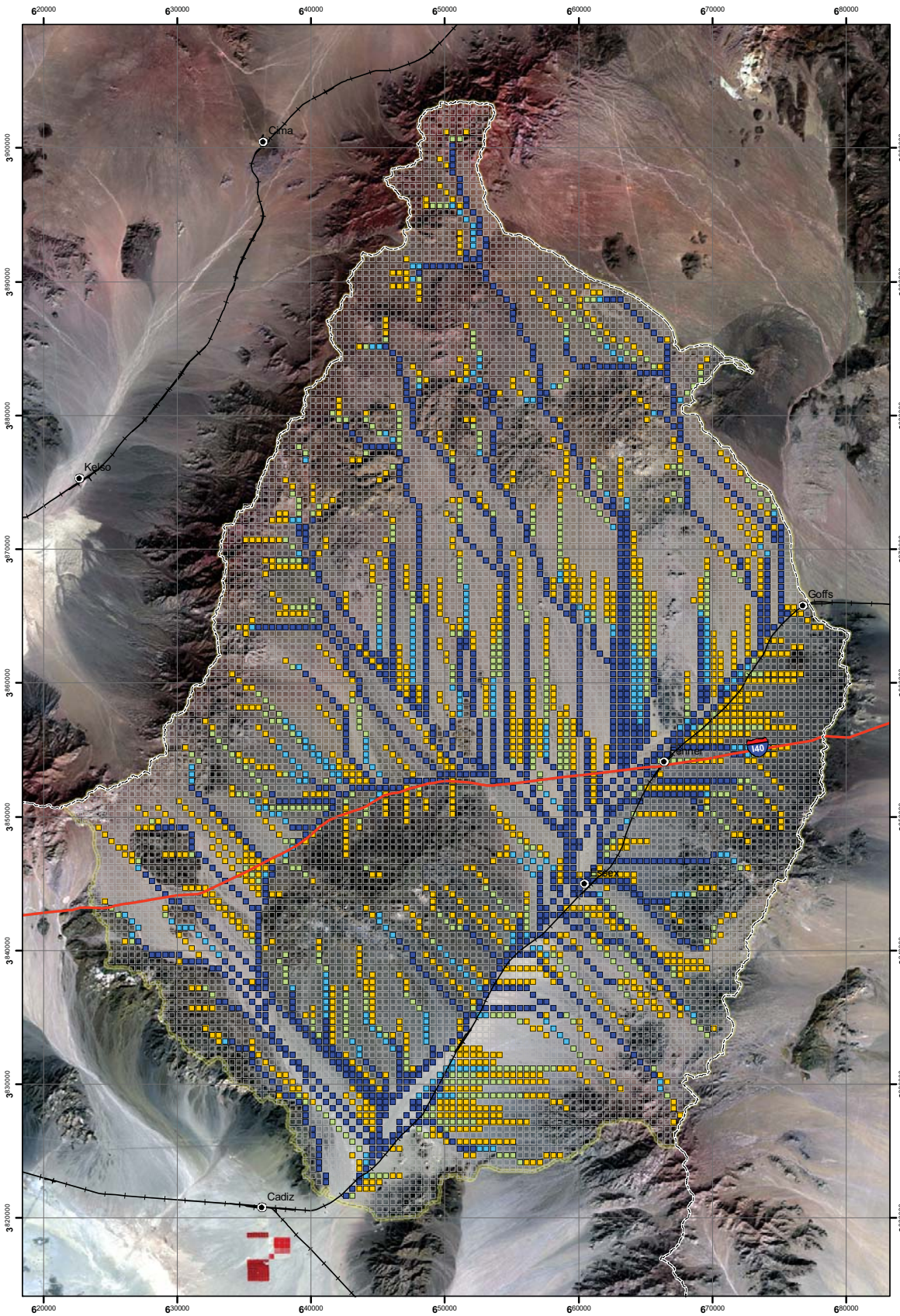
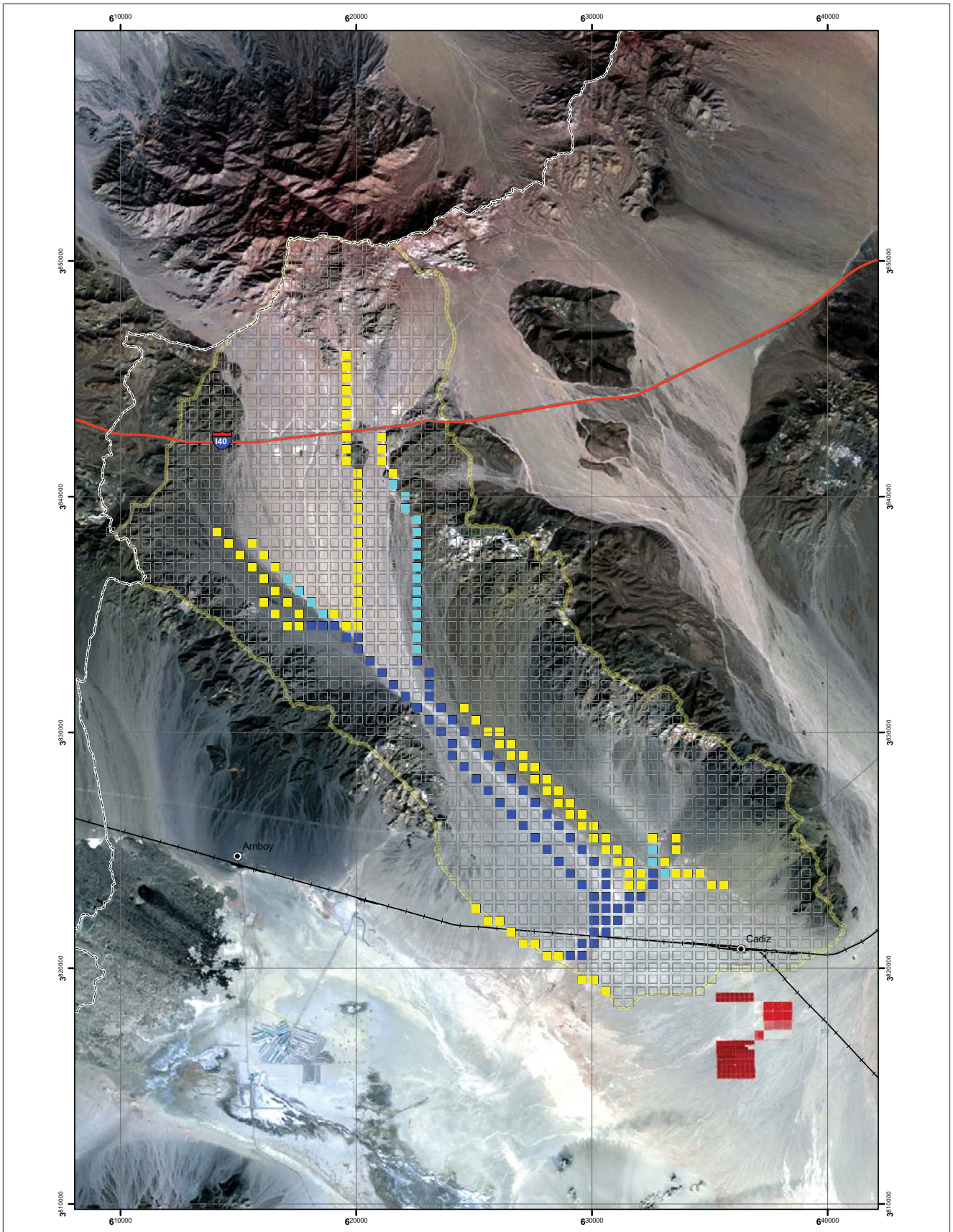


Figure 4-4
INFIL3.0 Flow Accumulation/Routing - Fenner Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-4_CADIZ_TM_INFILFlowAccFenner_v1_MR.mxd



Legend

- Cities/Communities
- Cadiz Study Area
- Interstates
- Rail Roads
- Orange Blossom Model Boundary

Model Drainage
Upstream number of Cells

- 0.0 - 50.0
- 50.1 - 100.0
- 100.1 - 150.0
- >150

N

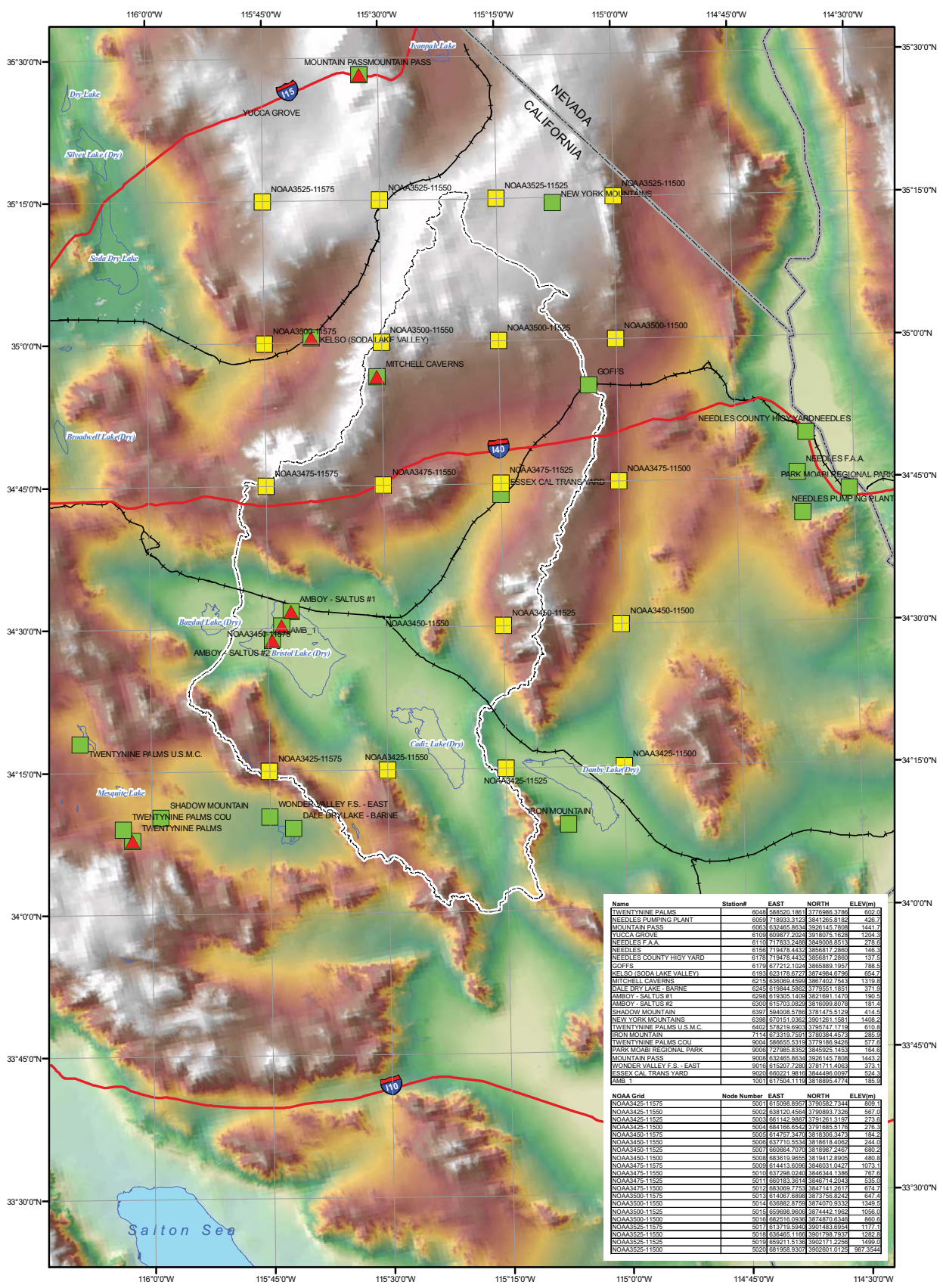
0 0.5 1 2 Miles

0 1 2 4 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-5
INFIL3.0 Flow Accumulation/Routing - Orange Blossom Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-5_CADIZ_TM_INFILFlowAccOB_v1_MR.mxd



Name	Station#	EAST	NORTH	ELEV(m)
TWENTYNINE PALMS	6048	588520.1861	3776986.3786	602.0
NEEDLES PUMPING PLANT	6059	718933.3123	3841265.8182	426.7
MOUNTAIN PASS	6063	632465.8634	3926145.7808	1441.7
YUCCA GROVE	6109	609877.2024	3918075.1628	1204.3
NEEDLES F.A.A.	6110	717833.2488	3849008.8513	278.6
NEEDLES	6156	719478.4432	3856817.2860	146.3
NEEDLES COUNTY HIGY YARD	6178	719478.4432	3856817.2860	137.5
GOFFS	6179	677212.1024	3865889.1957	788.5
KELSO (SODA LAKE VALLEY)	6193	623178.6727	3874984.6796	654.7
MITCHELL CAVERNS	6215	636069.4599	3867402.7543	1319.8
DALE DRY LAKE - BARNE	6245	619844.5862	3779551.1851	371.9
AMBOY - SALTUS #1	6298	619305.1409	3821691.1470	190.5
AMBOY - SALTUS #2	6300	615703.0829	3816099.8078	181.4
SHADOW MOUNTAIN	6397	594008.5786	3781475.5129	414.5
NEW YORK MOUNTAINS	6398	670151.0362	3901261.1581	1408.2
TWENTYNINE PALMS U.S.M.C.	6402	578219.6903	3795747.1719	610.8
IRON MOUNTAIN	7114	673319.7591	3780384.4573	285.9
TWENTYNINE PALMS COU	9004	586655.5319	3779186.9426	577.6
PARK MOABI REGIONAL PARK	9006	727985.8352	3845925.1453	164.6
MOUNTAIN PASS	9008	632465.8634	3926145.7808	1443.2
WONDER VALLEY F.S. - EAST	9016	615207.7280	3781711.4063	373.1
ESSEX CAL TRANS YARD	9020	660221.9816	3844496.0097	524.3
AMB_1	1001	617504.1119	3818895.4774	185.9

NOAA Grid	Node Number	EAST	NORTH	ELEV(m)
NOAA3425-11575	5001	615098.8957	3790582.7344	809.1
NOAA3425-11550	5002	638120.4564	3790893.7326	567.0
NOAA3425-11525	5003	661142.9887	3791261.3197	273.6
NOAA3425-11500	5004	684166.6542	3791685.5176	276.3
NOAA3450-11575	5005	614757.3470	3818306.3473	184.2
NOAA3450-11550	5006	637710.5534	3818618.4082	244.0
NOAA3450-11525	5007	660664.7070	3818987.2467	680.2
NOAA3450-11500	5008	683619.9655	3819412.8905	480.8
NOAA3475-11575	5009	614413.6096	3846031.0427	1073.1
NOAA3475-11550	5010	637298.0240	3846344.1388	767.6
NOAA3475-11525	5011	660183.3614	3846714.2043	535.0
NOAA3475-11500	5012	683069.7753	3847141.2617	674.7
NOAA3500-11575	5013	614067.6898	3873756.8242	647.4
NOAA3500-11550	5014	636882.8759	3874070.9332	1349.5
NOAA3500-11525	5015	659698.9608	3874442.1962	1056.0
NOAA3500-11500	5016	682516.0936	3874870.6346	860.6
NOAA3525-11575	5017	613719.5940	3901483.6954	1177.1
NOAA3525-11550	5018	636465.1168	3901798.7937	1282.8
NOAA3525-11525	5019	659211.5136	3902171.2256	1499.0
NOAA3525-11500	5020	681958.9307	3902601.0125	987.3544

Legend

- Temperature Data
- NOAA Grid Precipitation
- San Bernardino County Precipitation
- Interstates
- States
- Rail Roads
- Dry Lake Beds
- Cadiz Study Area

Elevation Meters

High : 2394

Low : -87

N

0 2 4 8 Miles

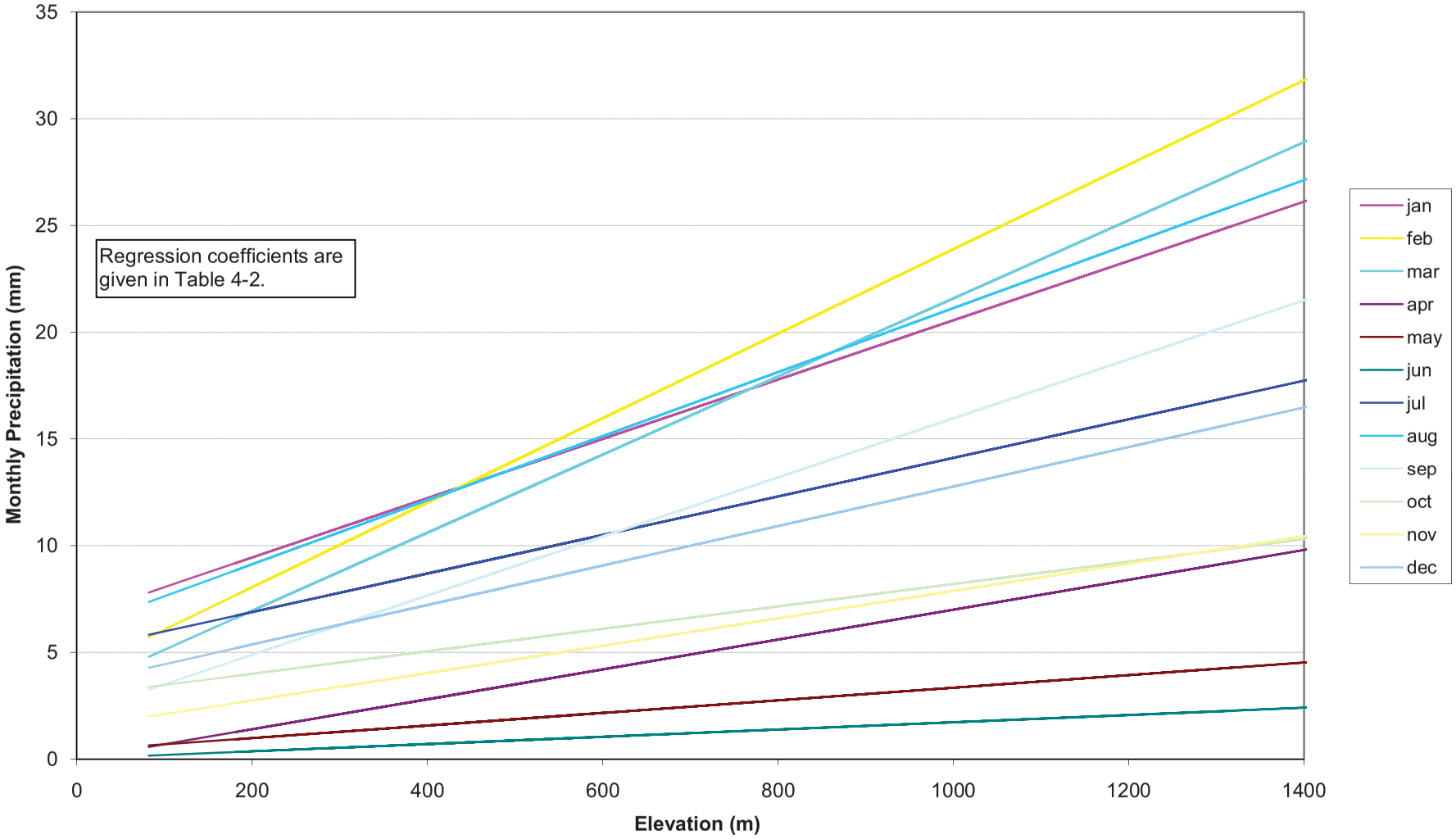
0 5 10 Kilometers

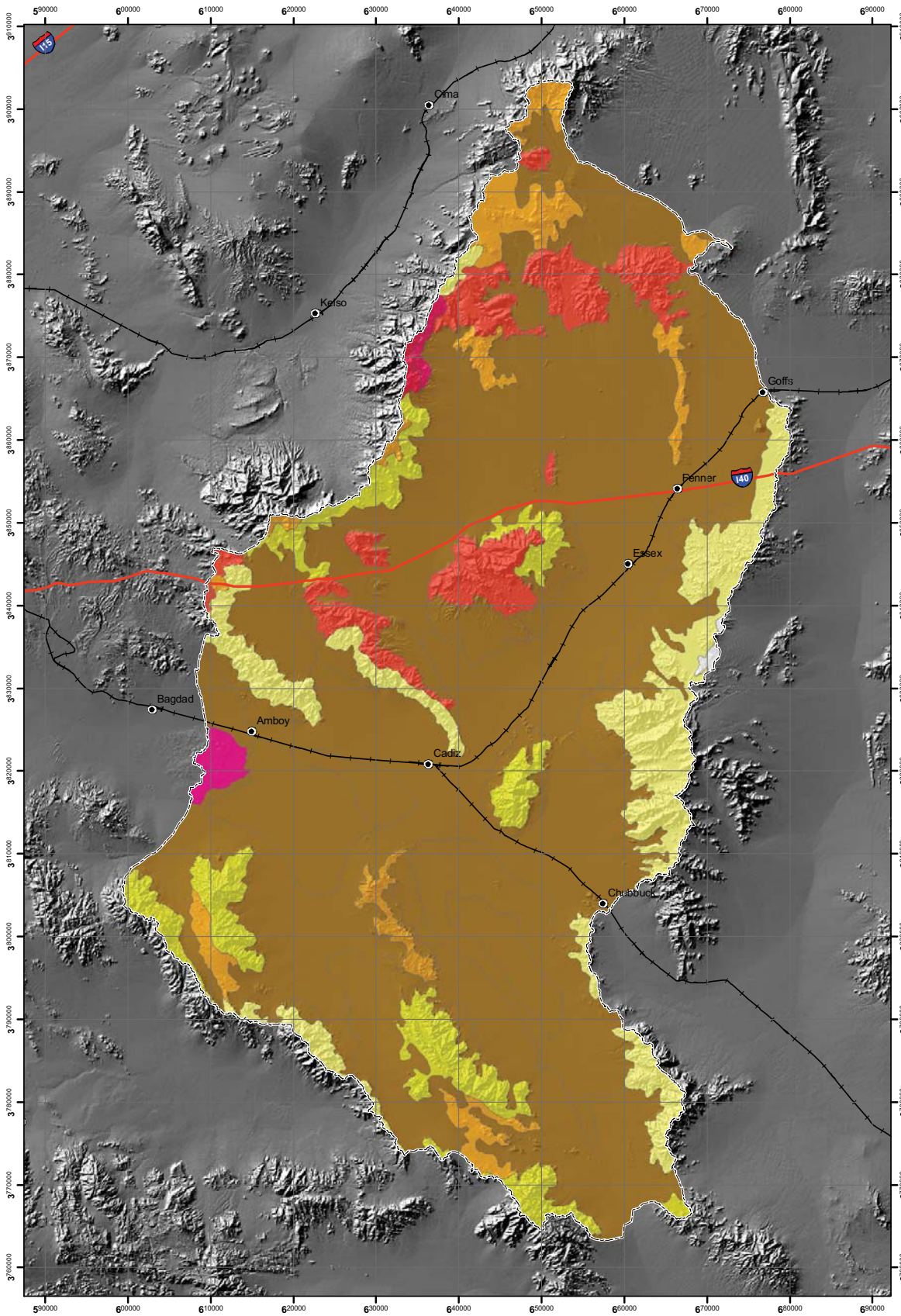
Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-6
Climate Stations Used in INFIL3.0
For Fenner Watershed and Orange Blossom Wash Area

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-6_CADIZ_TM_ClimateStations_V4_MR.mxd

Figure 4-7.
Monthly Precipitation Versus Elevation Regressions Used In INFIL3.0





Legend

STATSGO Soil Types

Average Depth to Bedrock (m)

- 0.0381
- 0.1524
- 0.1778
- 0.2286
- 0.2413
- 0.3048
- 0.3175
- 0.4318
- 0.762
- 1.524

Cadiz Study Area

Interstates

Rail Roads

Cities/Communities

0 2 4 8 Miles

0 2.5 5 10 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-8
Soil Depths Determined From STATSGO Database

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-8_CADIZ_TM_SoilsMap_SoilDepths_V3_MR.mxd

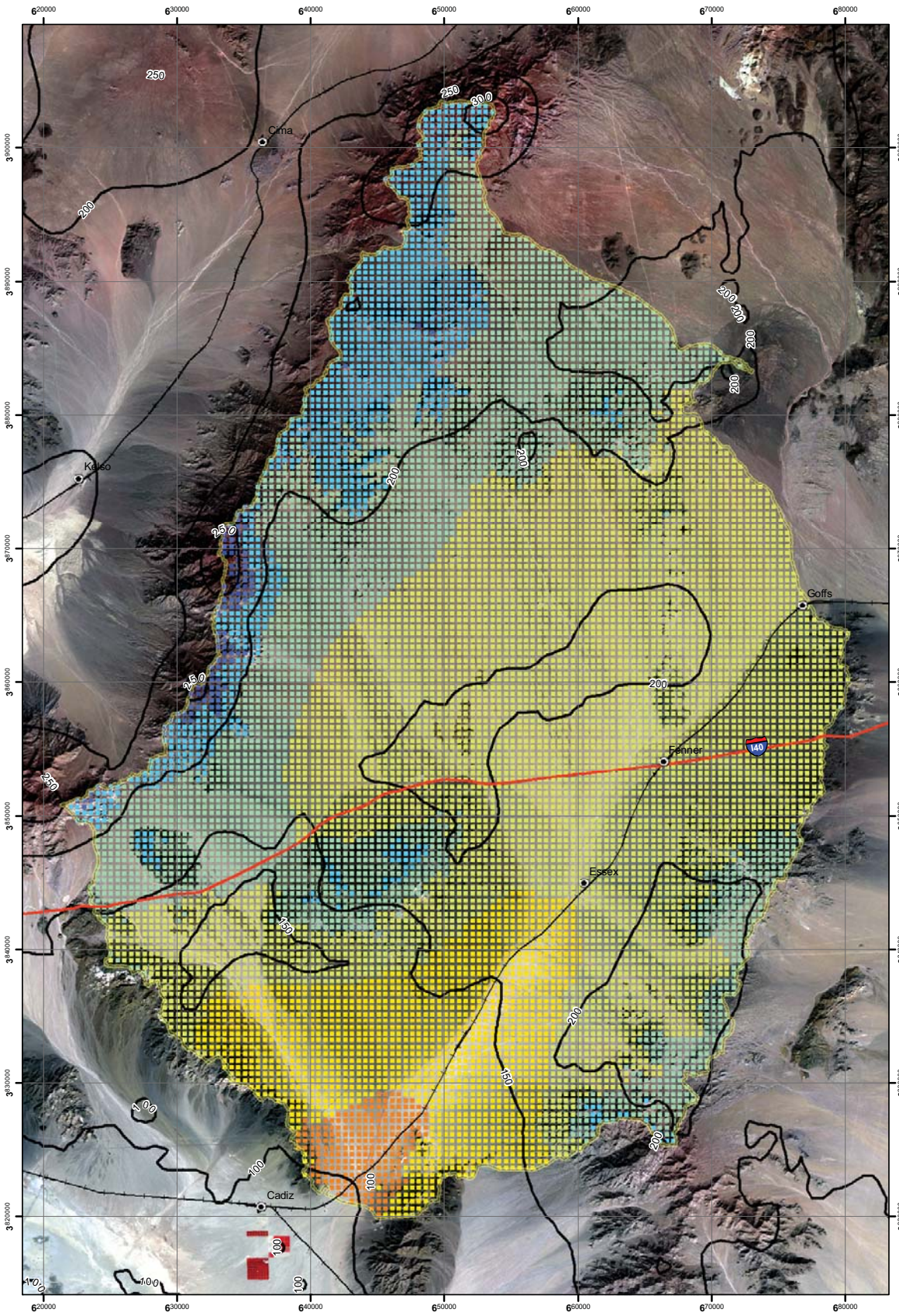


Figure 4-9a

INFIL3.0 Modeled Average Annual Precipitation For 1971 Through 2000 Period Compared with PRISM - Fenner Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-9a_CADIZ_TM_INFIL_Precip_V1_MR.mxd

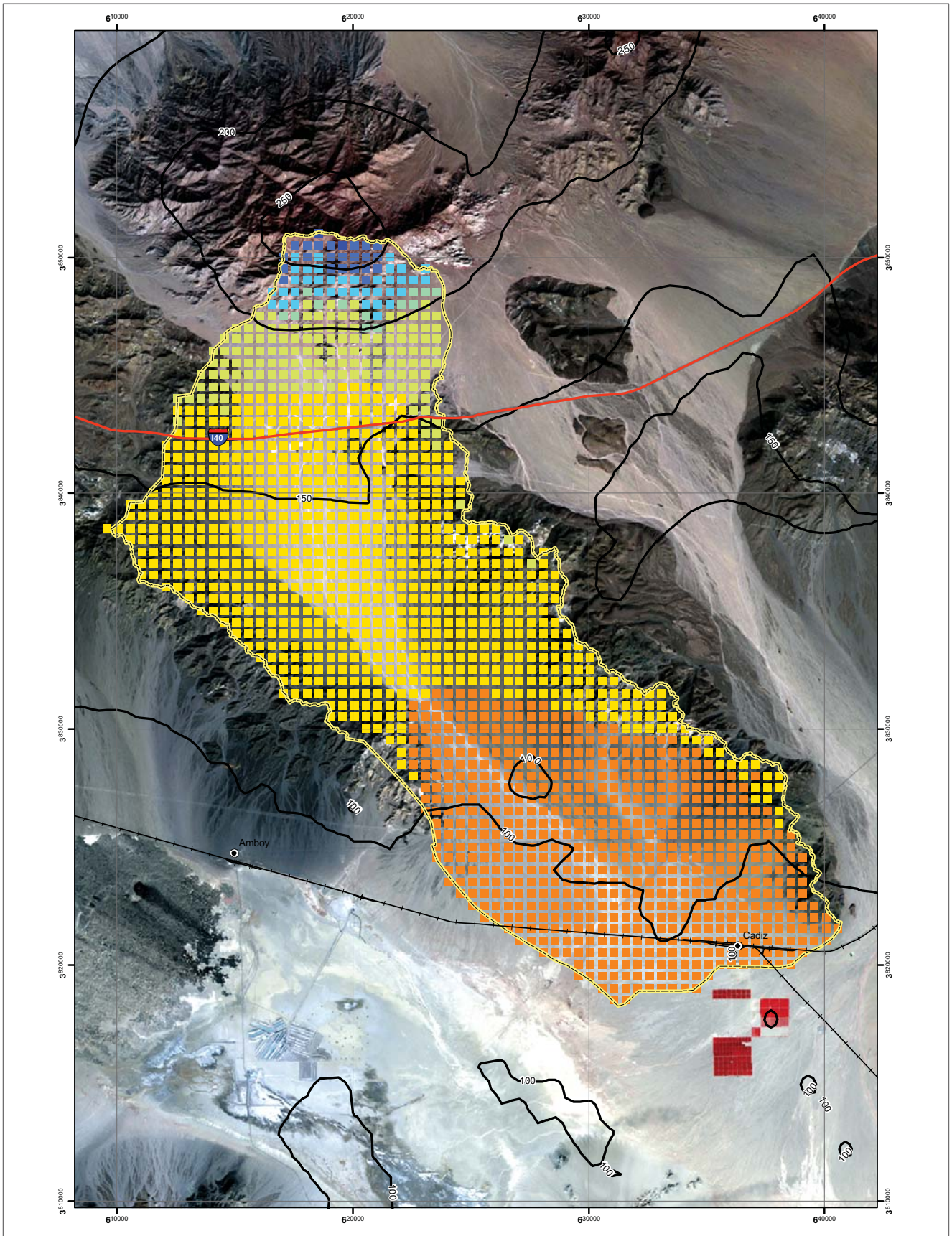
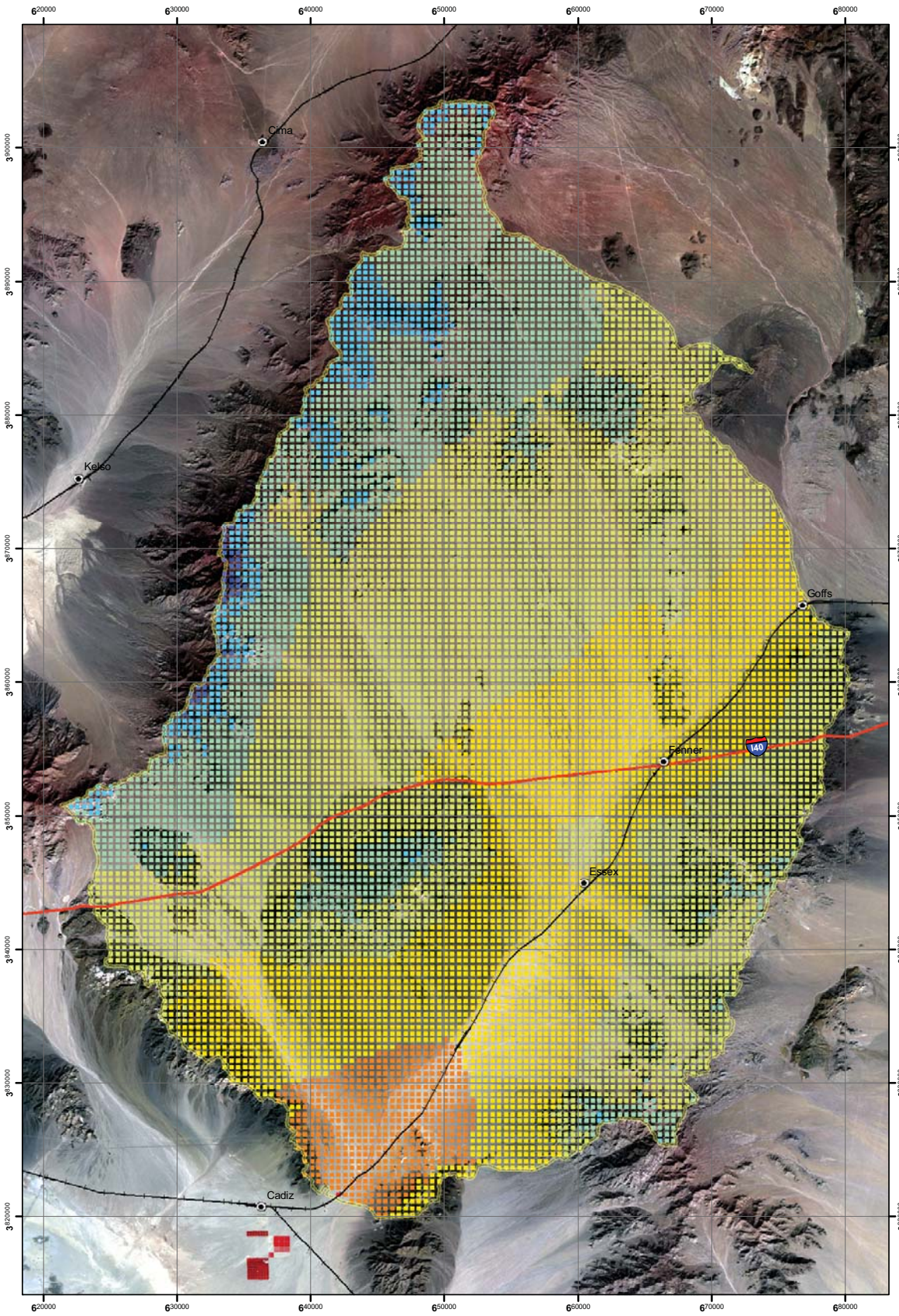


Figure 4-9b
INFIL3.0 Modeled Average Annual Precipitation For 1971 Through 2000 Period Compared with PRISM - Orange Blossom Wash

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-9b_CADIZ_TM_INFIL_Precip_V1_MR.mxd



Legend

- Cities/Communities
- Interstates
- Rail Roads
- Fenner Valley Model Boundary

INFIL
AVG Precipitation mm/yr (1958-2007)

- 75.3
- 75.4 - 100.0
- 100.1 - 150.0
- 150.1 - 200.0
- 200.1 - 250.0
- 250.1 - 300.0
- 300.1 - 350.0
- 350.1 - 400.0

N

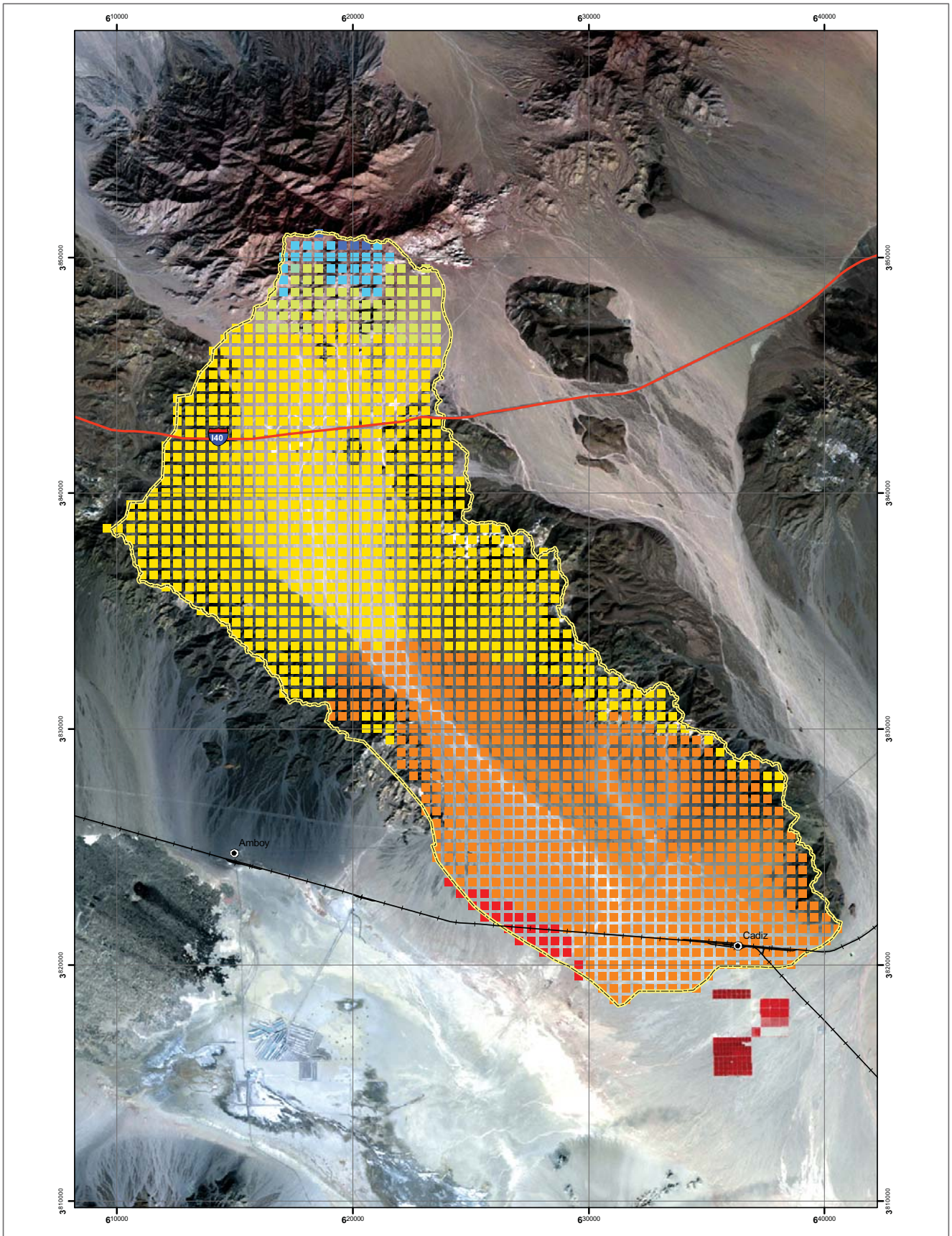
0 1.25 2.5 5 Miles

0 1.5 3 6 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-9c
INFIL3.0 Modeled Average Annual Precipitation For 1958 Through 2007 Period - Fenner Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-9c_CADIZ_TM_INFIL_Precip_V1_MR.mxd



Legend

- Cities/Communities
- Interstates
- Rail Roads
- Orange Blossom Model Boundary

INFIL

AVG Precipitation mm/yr (1958-2007)

- 46.5 - 50.0
- 50.1 - 100.0
- 100.1 - 200.0
- 200.1 - 242.9
- 243.0 - 250.0
- 250.1 - 300.0
- 300.1 - 350.0
- 350.1 - 400.0

N

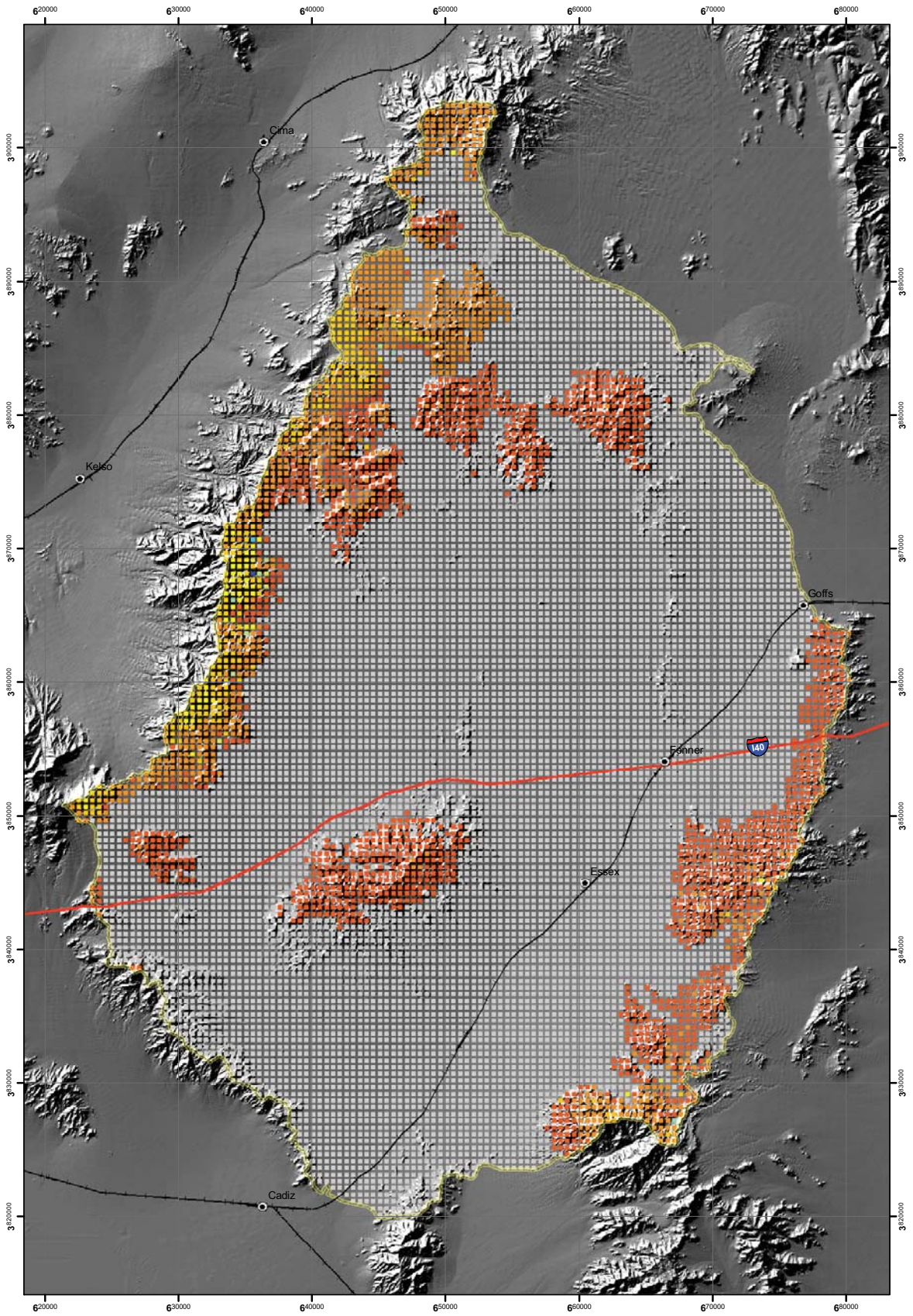
0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-9d
INFIL3.0 Modeled Average Annual Precipitation For 1958 Through 2007 Period - Orange Blossom Wash

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-9d_CADIZ_TM_INFIL_Precip_V1_MR.mxd



Legend

- Cities/Communities
- Interstates
- Rail Roads
- Fenner Valley Model Boundary

INFIL
Net Infiltration Annual Average (mm/yr)

- 0.0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 - 225.0
- 225.1 - 250.0
- 250.1 - 275.0
- 275.1 - 300.0
- 300.1 - 325.0

N

0 1 2 4 Miles

0 1 2 4 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 4-10a
INFIL3.0 Average Annual Infiltration
For 1958-2007 - Fenner Watershed

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-10a_CADIZ_TM_INFIL_Infiltration_V1_MR.mxd

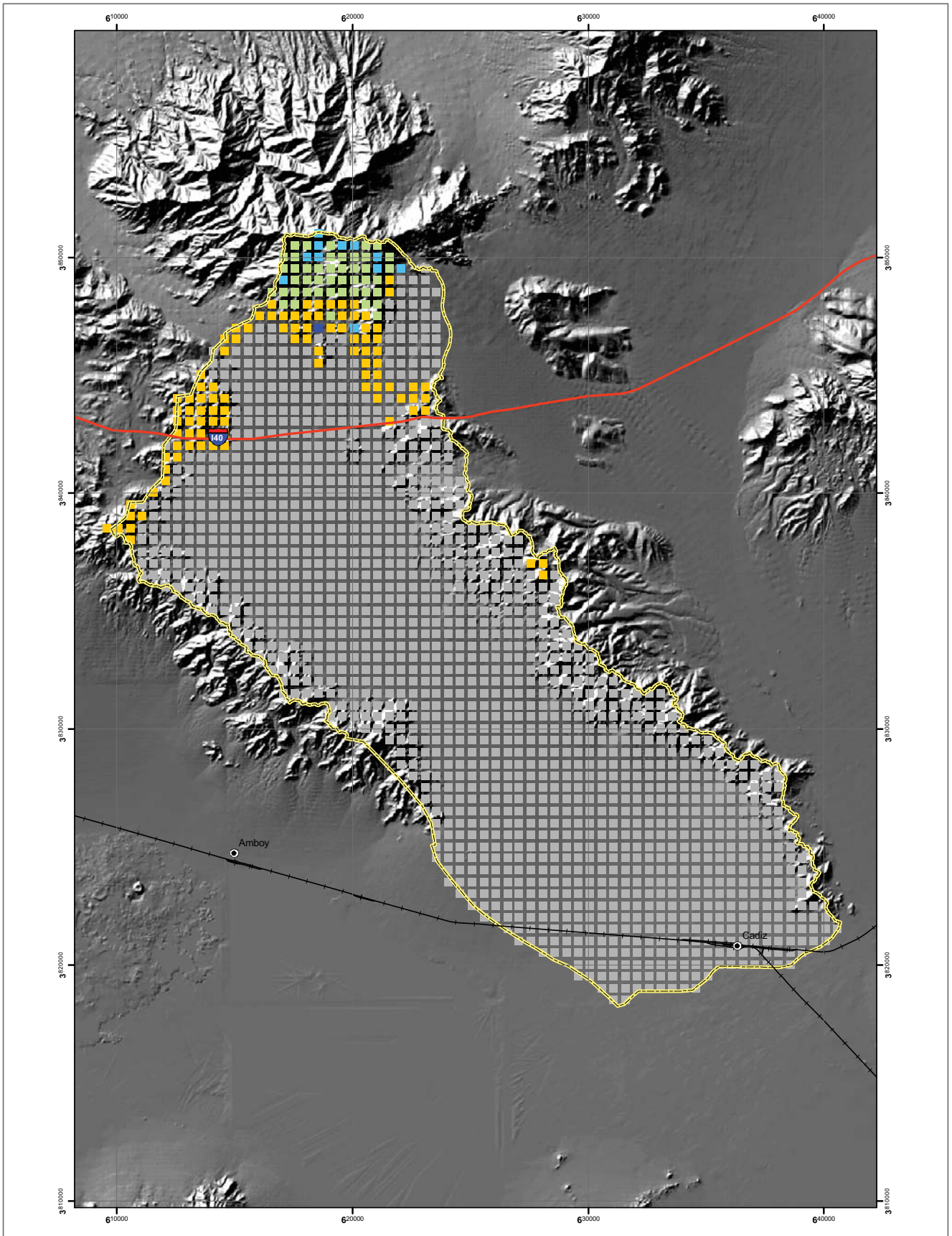


Figure 4-10b
INFIL3.0 Average Annual Infiltration
For 1958-2007 - Orange Blossom Wash

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-10b_CADIZ_TM_INFIL_Infiltration_V1_MR.mxd

Figure 4-11.
Fenner Watershed
Recoverable Water
INFIL3.0 Simulation Results

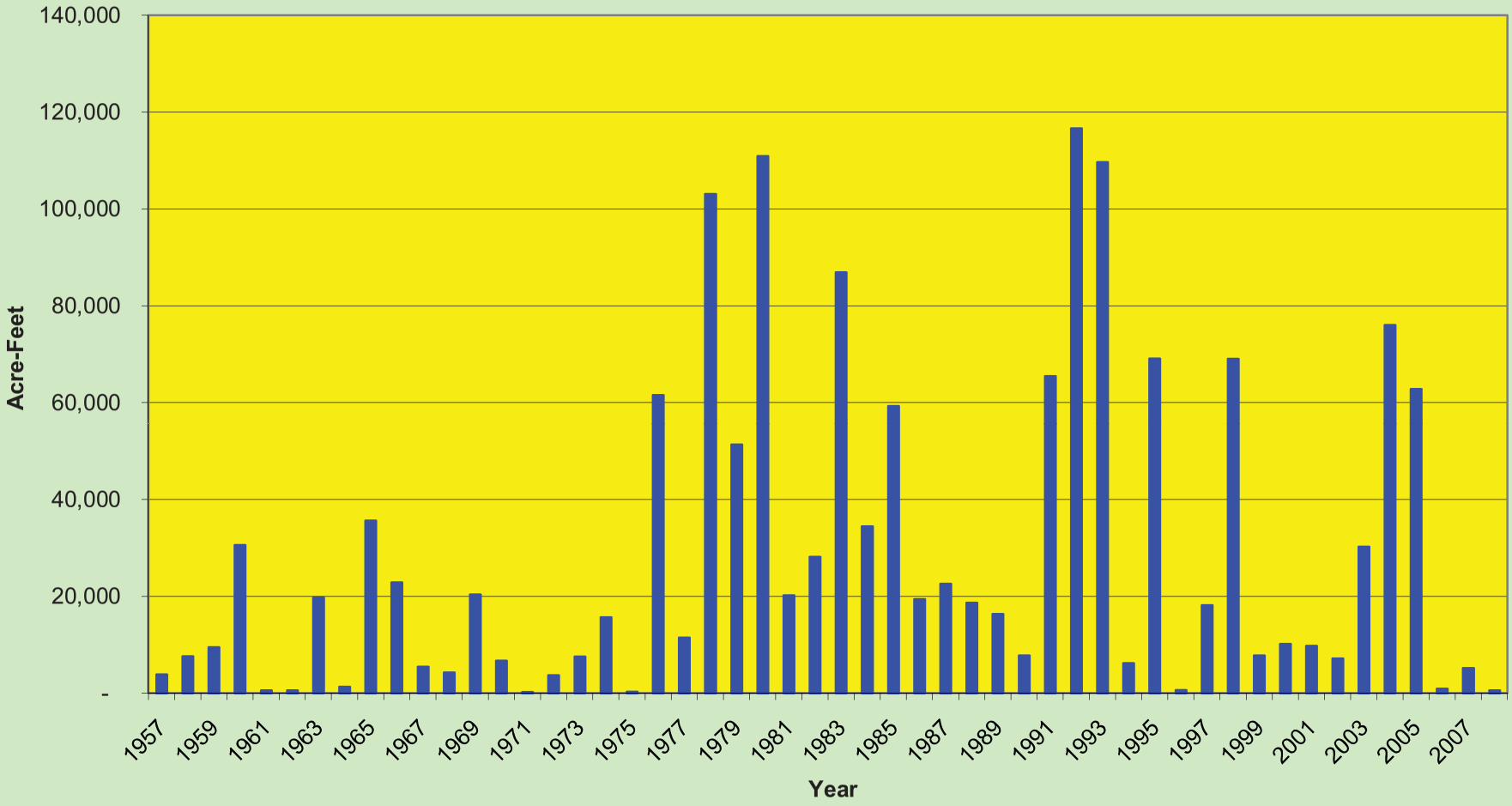


Figure 4-12.
Orange Blossom Wash Area
Recoverable Water
INFIL3.0 Simulation Results

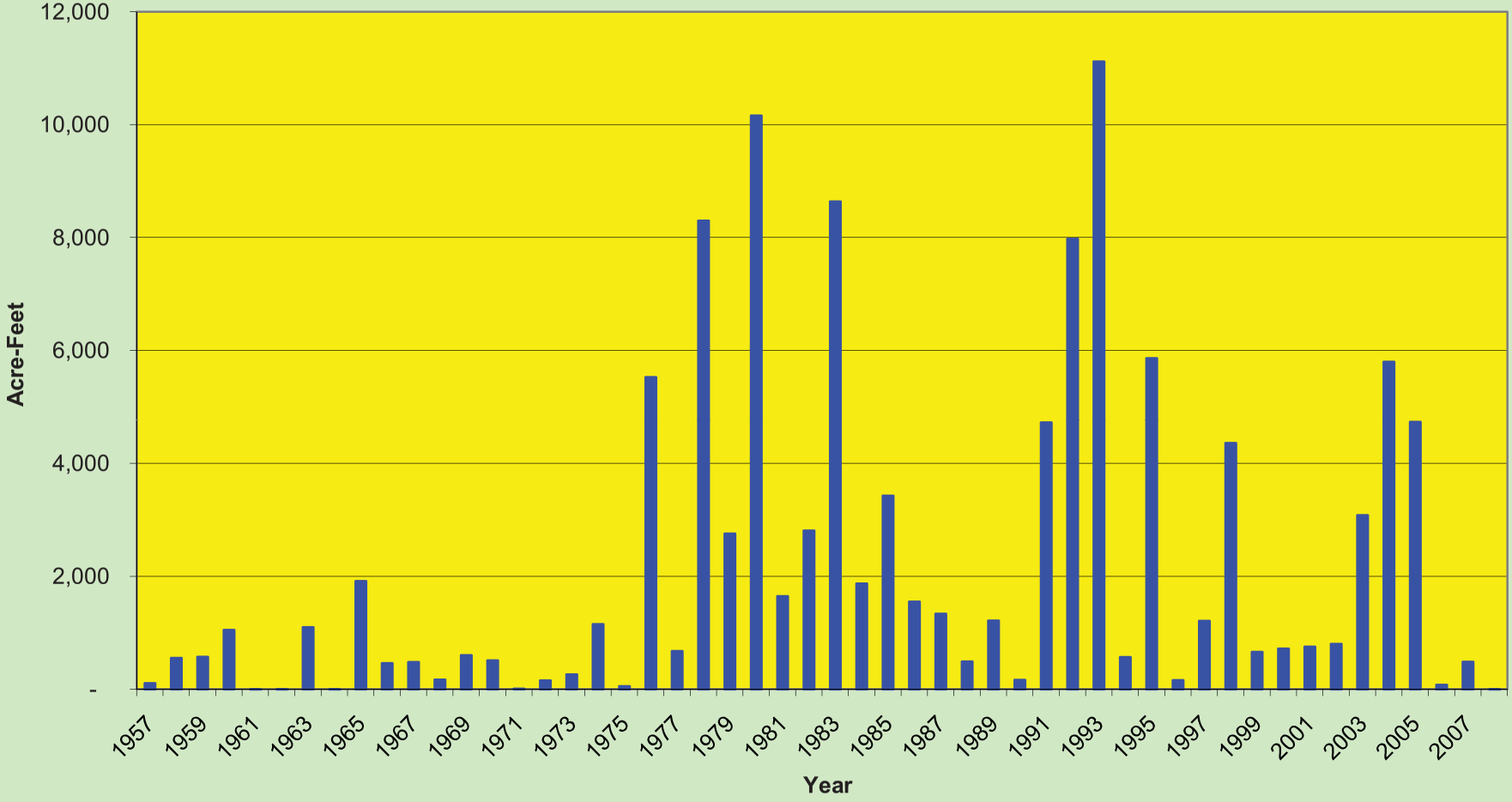


Figure 4-13.
Fenner Watershed
Recoverable Water
INFIL3.0 versus GSSI High Estimate

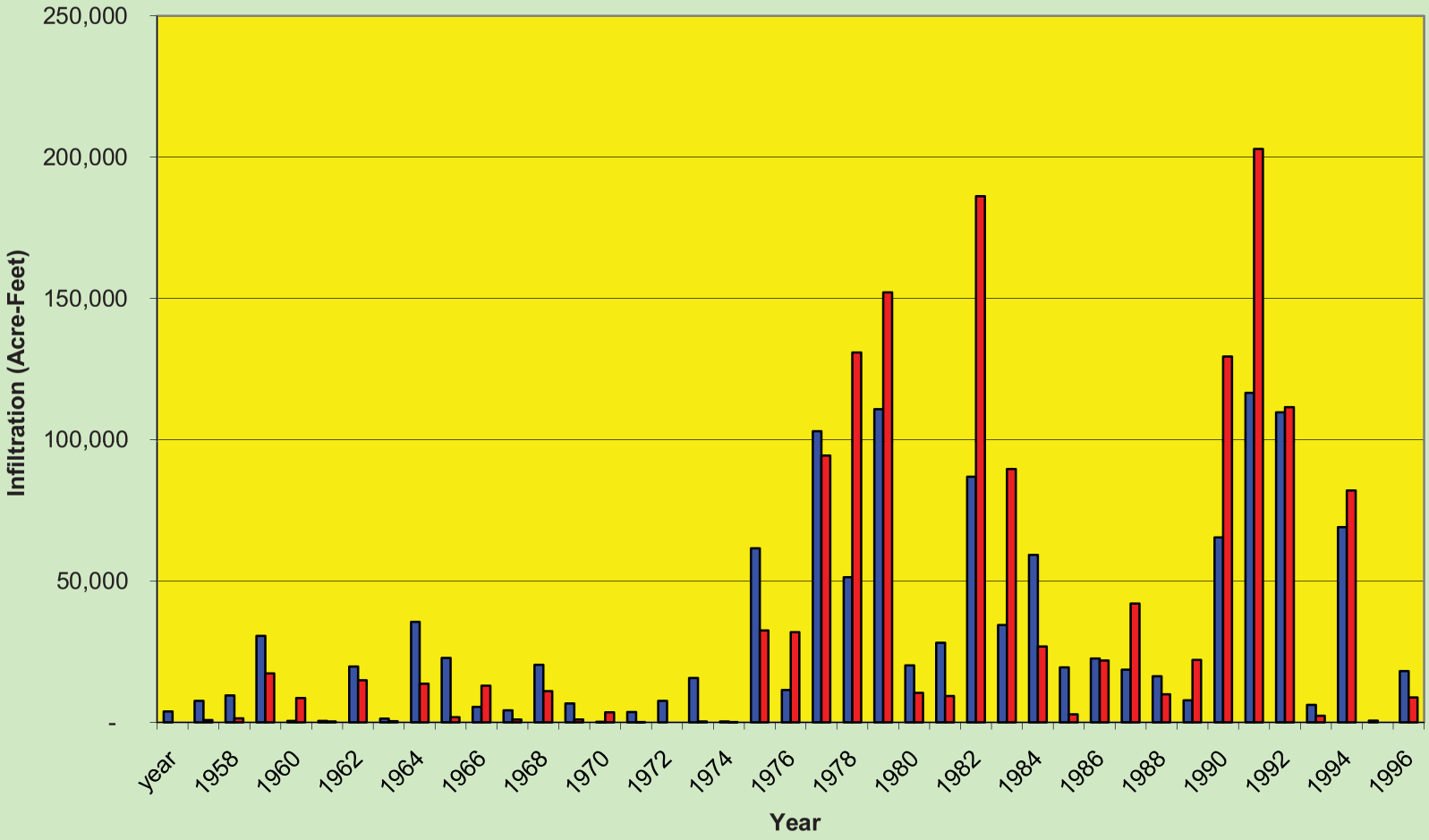


Figure 4-14.
Fenner Watershed
Recoverable Water
INFIL3.0 versus GSSI Low Estimate

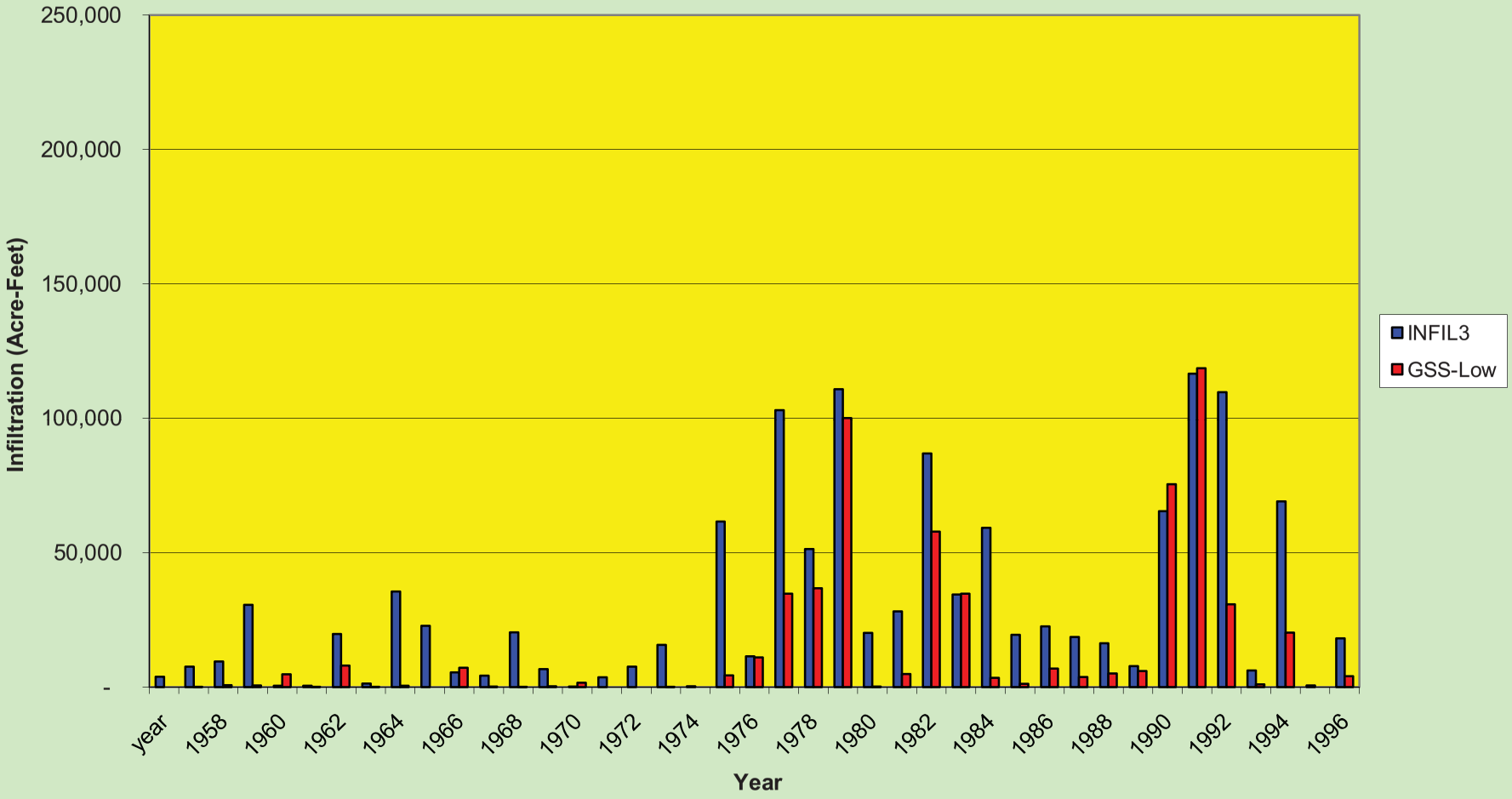


Figure 4-15.
Orange Blossom Wash Area
Recoverable Water
INFIL3.0 versus GSSI High Estimate

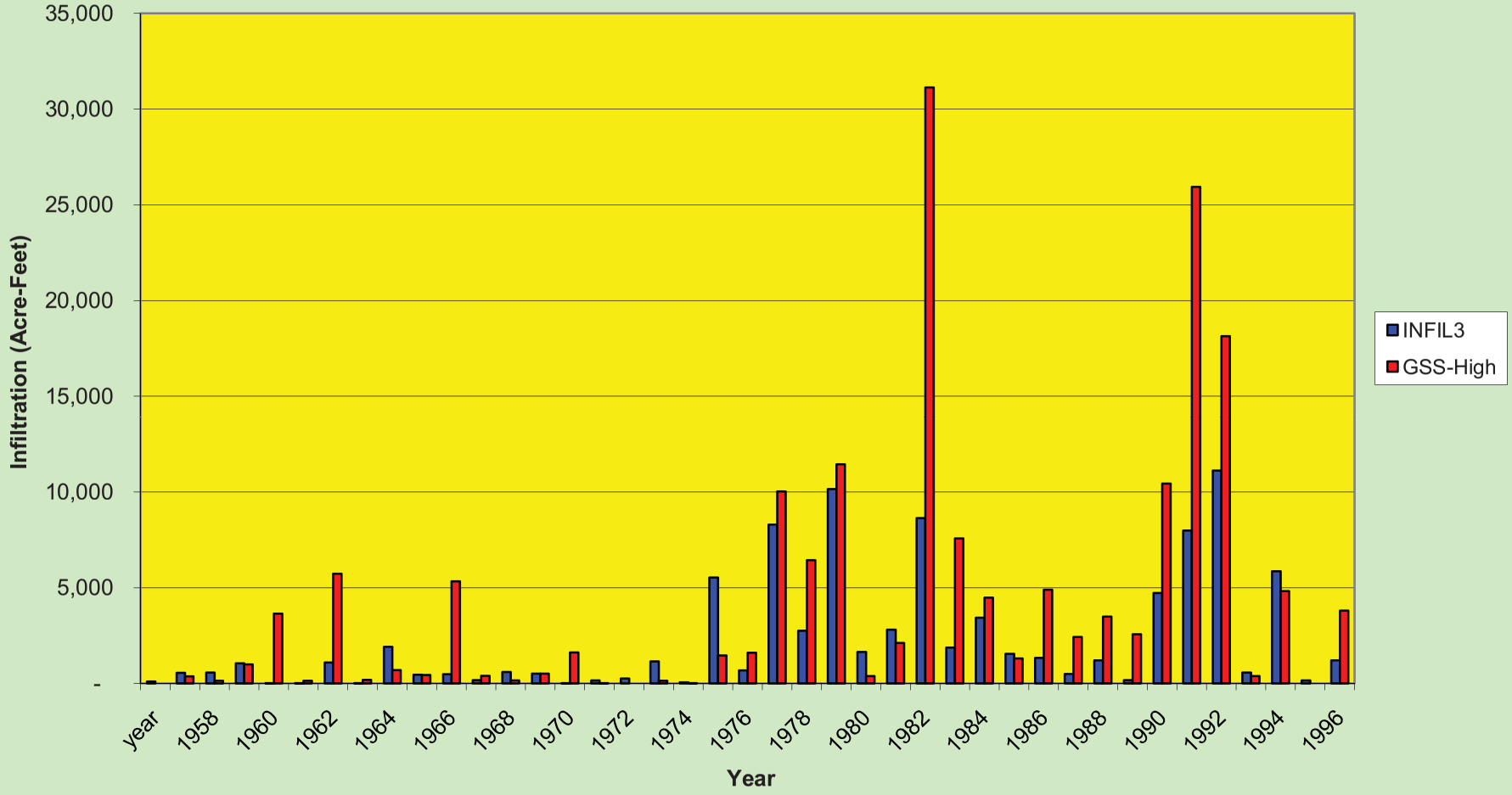
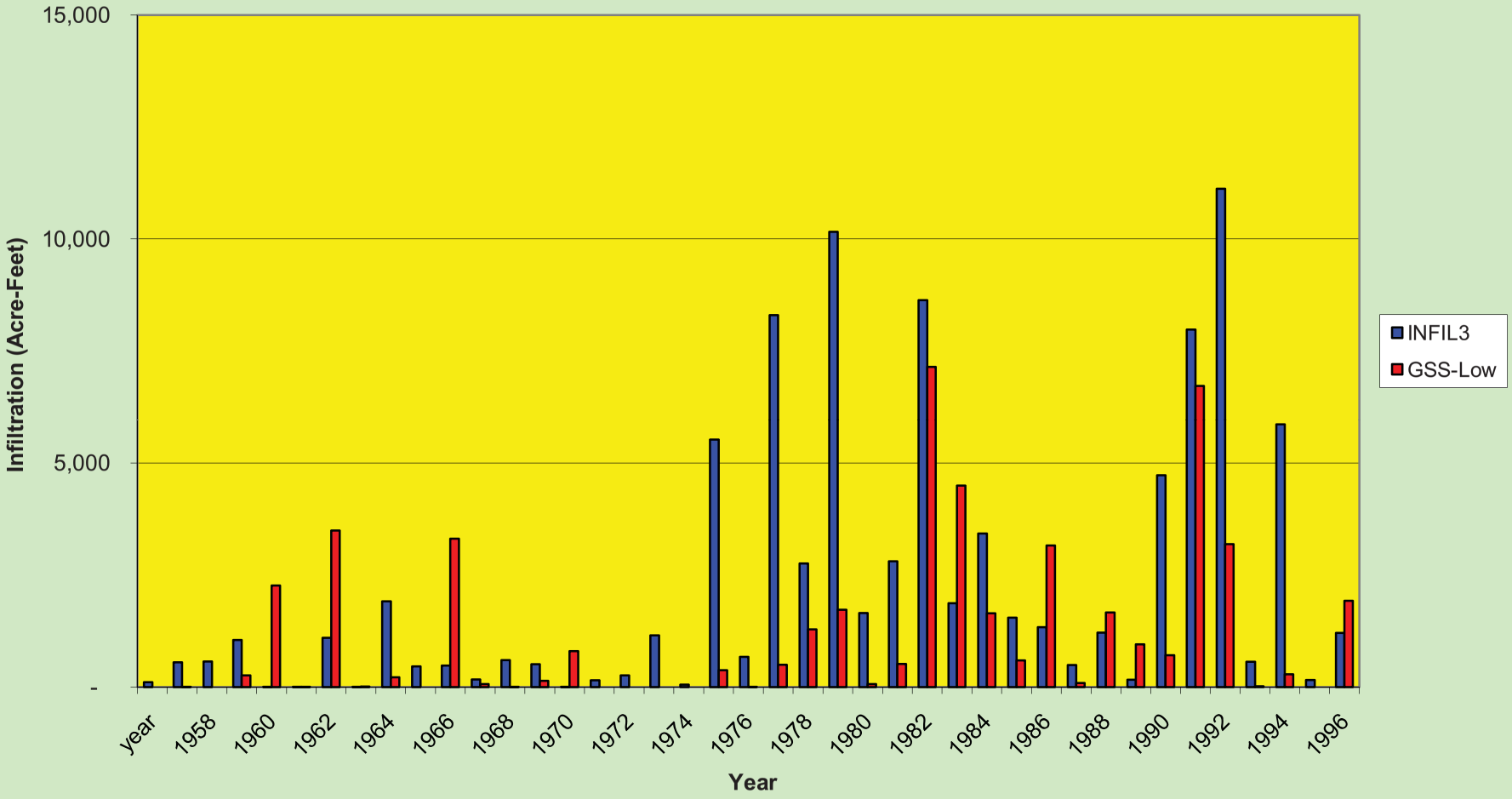


Figure 4-16.
Orange Blossom Wash Area
Recoverable Water
INFIL3.0 versue GSSI Low Estimate



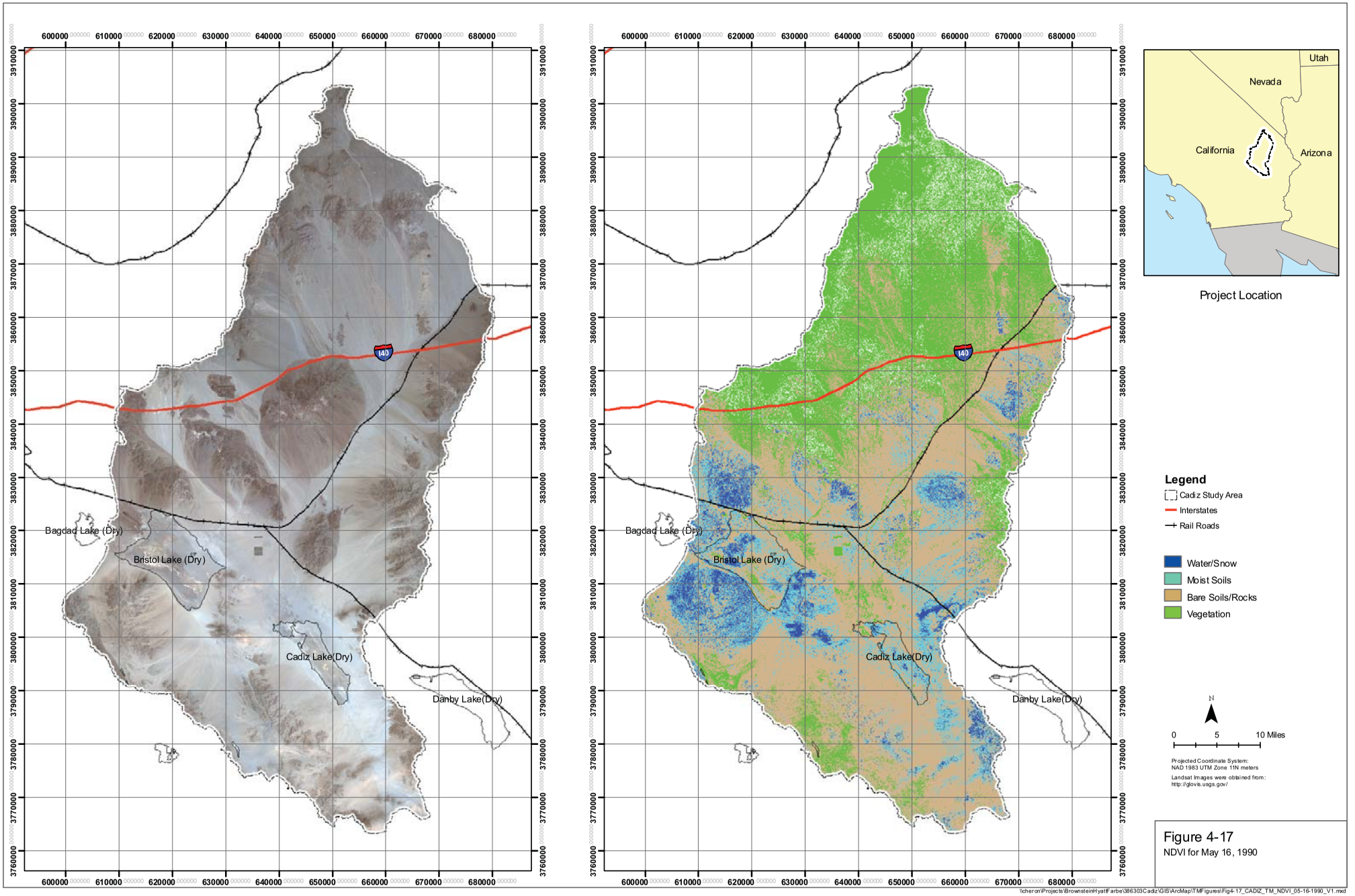


Figure 4-17
NDVI for May 16, 1990

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-17_CADIZ_TM_NDVI_05-16-1990_V1.mxd

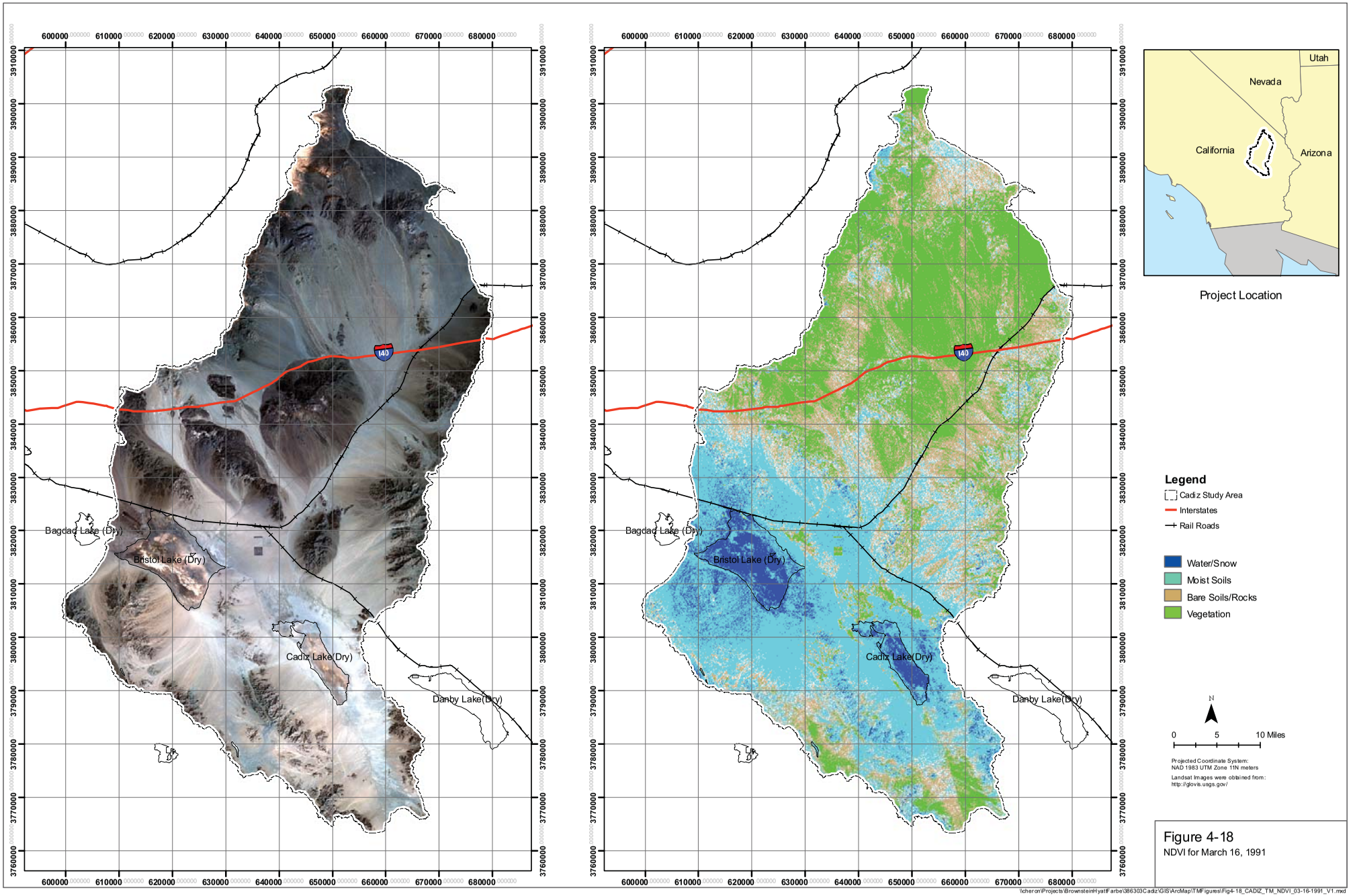


Figure 4-18
NDVI for March 16, 1991

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-18_CADIZ_TM_NDVI_03-16-1991_V1.mxd

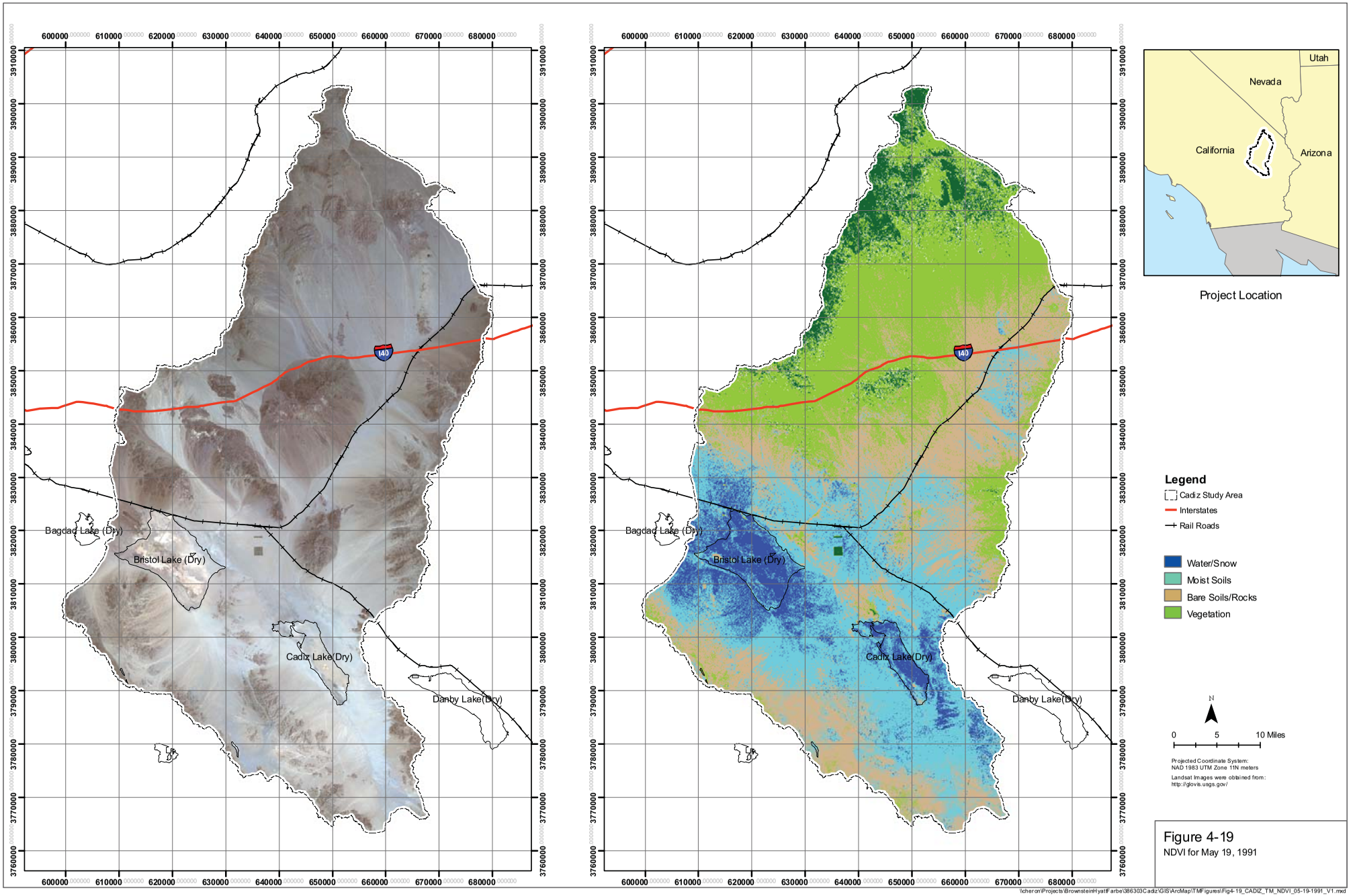


Figure 4-19
NDVI for May 19, 1991

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-19_CADIZ_TM_NDVI_05-19-1991_V1.mxd

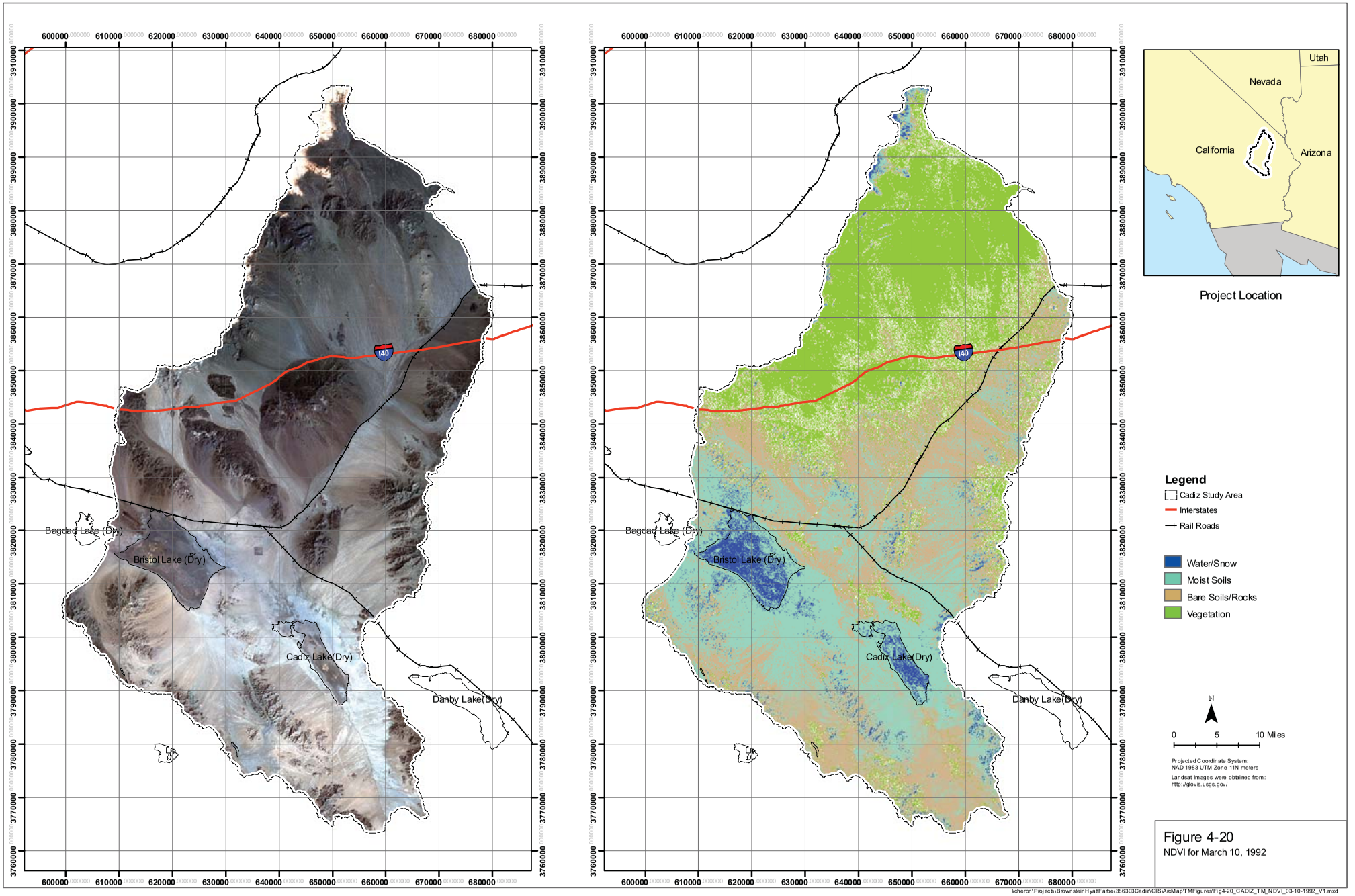


Figure 4-20
NDVI for March 10, 1992

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-20_CADIZ_TM_NDVI_03-10-1992_V1.mxd

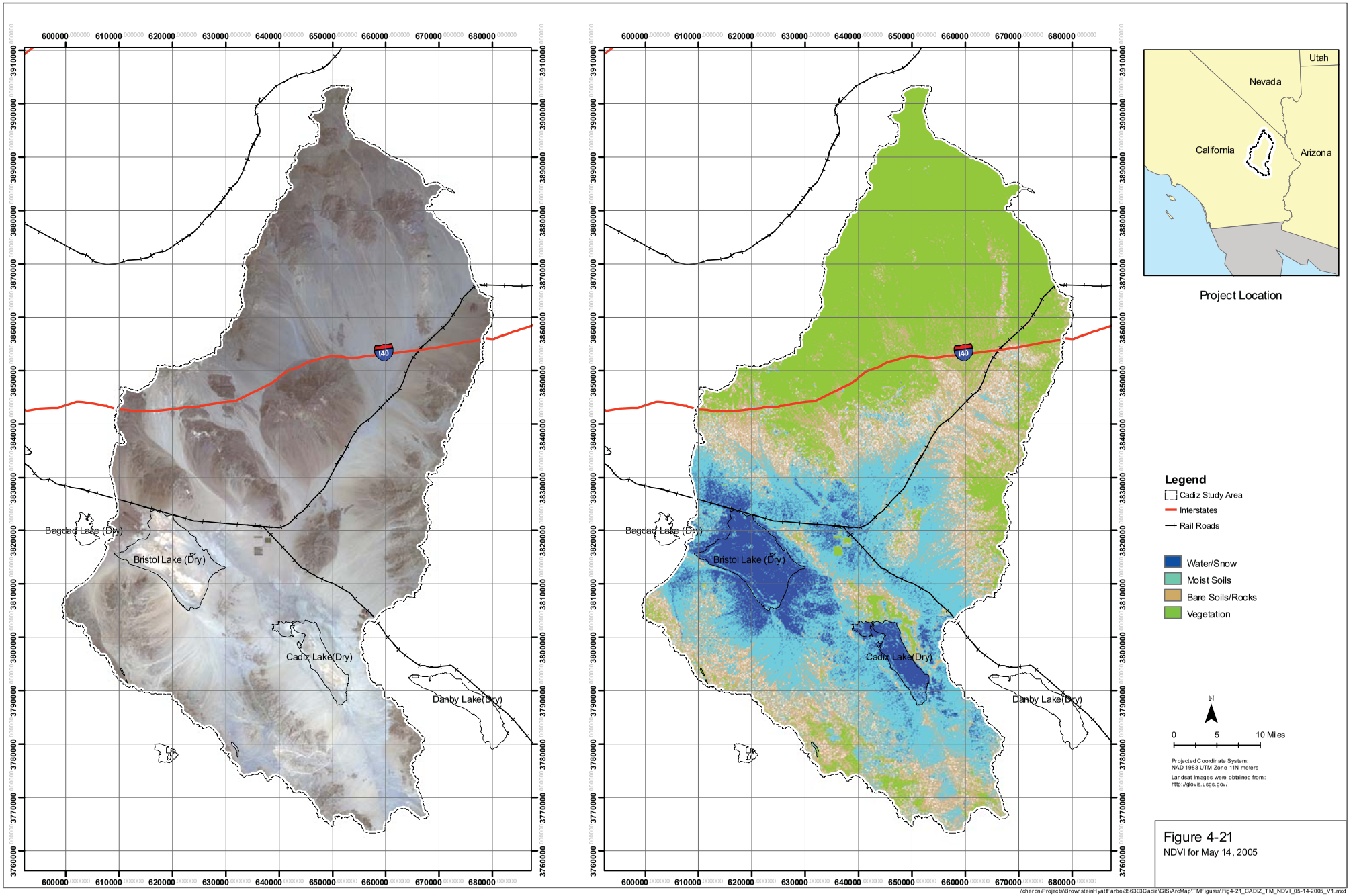
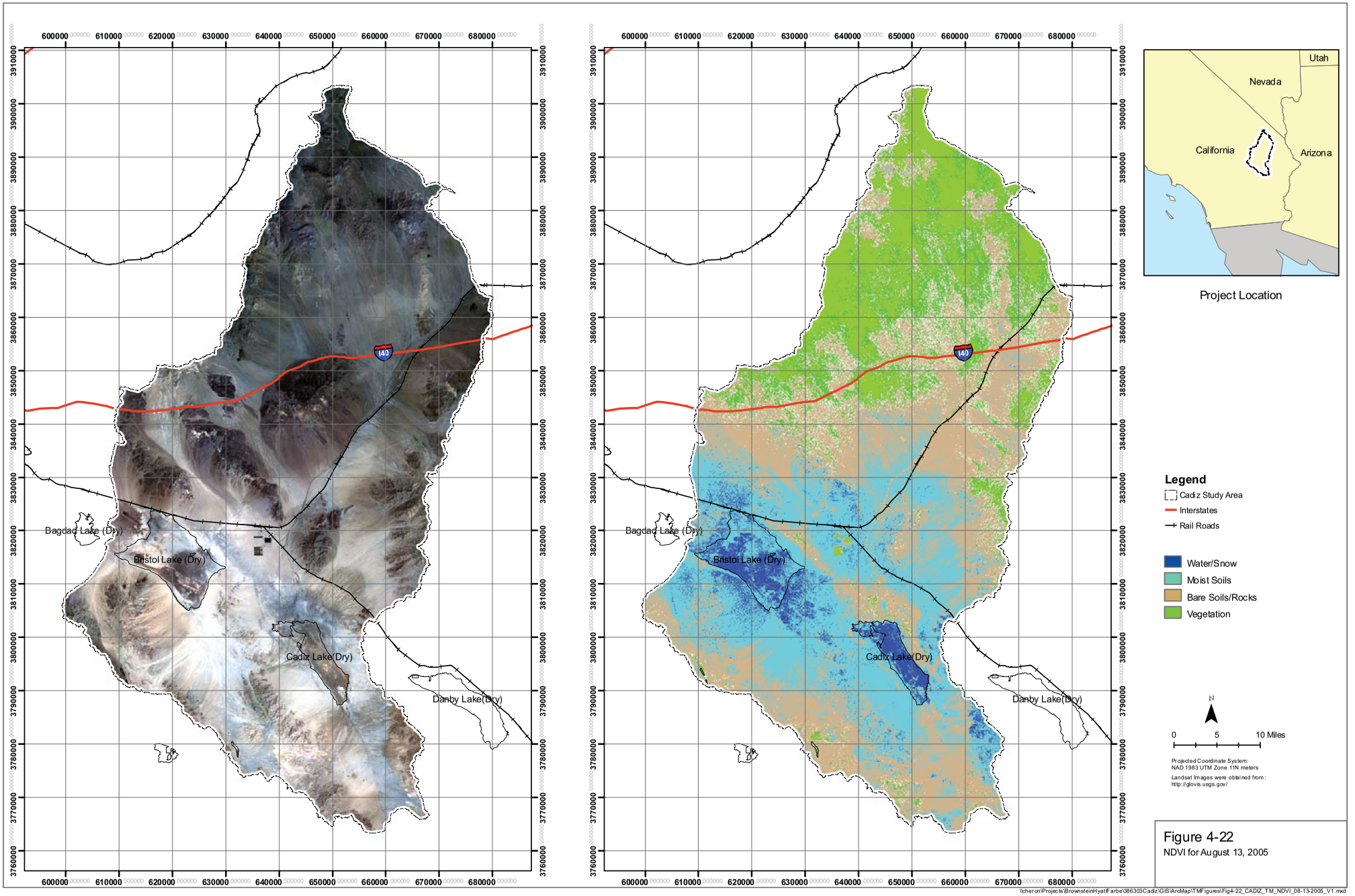
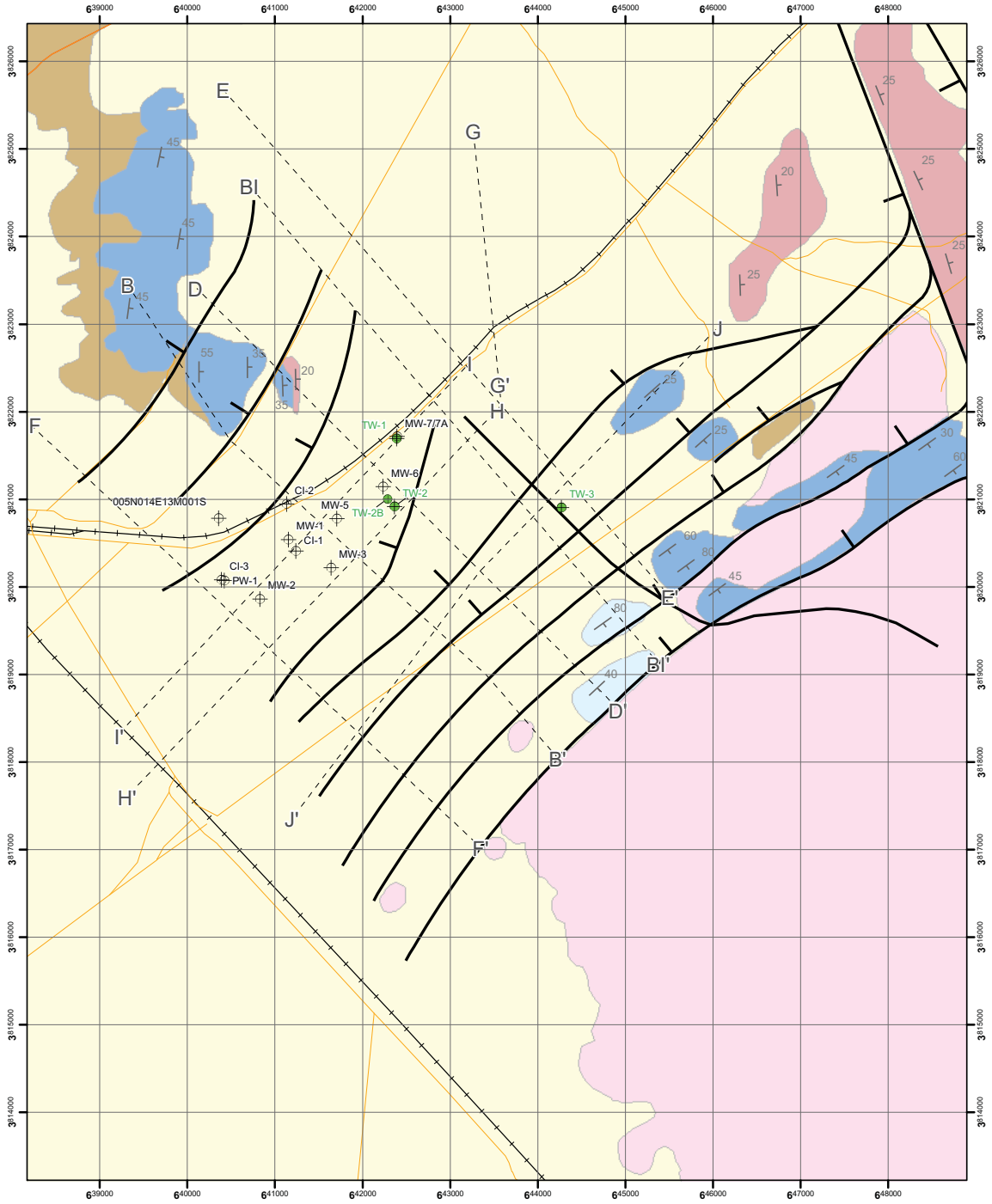


Figure 4-21
NDVI for May 14, 2005

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-21_CADIZ_TM_NDVI_05-14-2005_V1.mxd


600000 610000 620000 630000 640000 650000 660000 670000 680000
3910000 3900000 3890000 3880000 3870000 3860000 3850000 3840000 3830000 3820000 3810000 3800000 3790000 3780000 3770000 3760000
140
Bagdad Lake (Dry)
Bristol Lake (Dry)
Cadiz Lake (Dry)
Danby Lake (Dry)
Utah
Nevada
California
Arizona
Project Location
Legend
Cadiz Study Area
Interstates
Rail Roads
Water/Snow
Moist Soils
Bare Soils/Rocks
Vegetation
N
0 5 10 Miles
Projected Coordinate System:
NAD 1983 UTM Zone 11N meters
Landsat Images were obtained from:
http://glovis.usgs.gov/
Figure 4-22
NDVI for August 13, 2005
\\cheron\Projects\BrownsteinHyatt\Farbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-22_CADIZ_TM_NDVI_08-13-2005_V1.mxd



Legend

- Existing Wells
- Test Wells
- Test Borings
- Cross Section
- Fault
- Interstates
- Roads
- Rail Roads

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters
Vertical Datum NAVD88

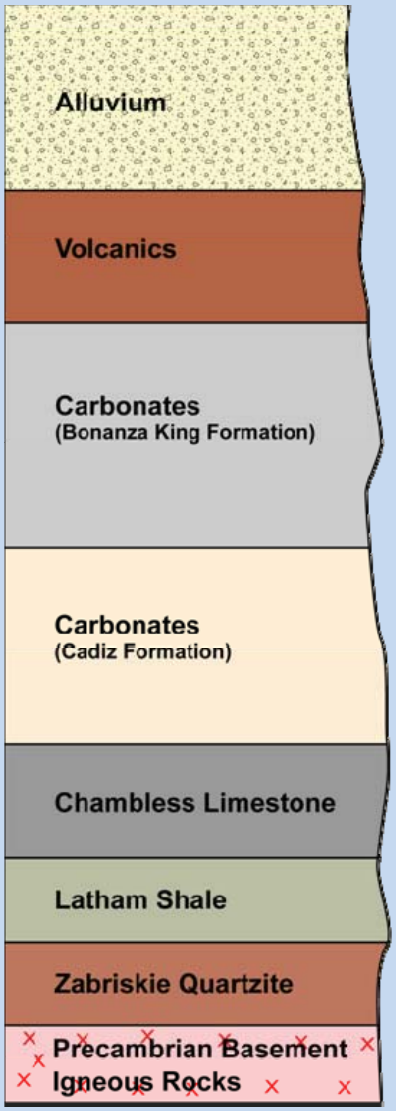
N

Modified from Liggett (2010) and Bishop (1963)

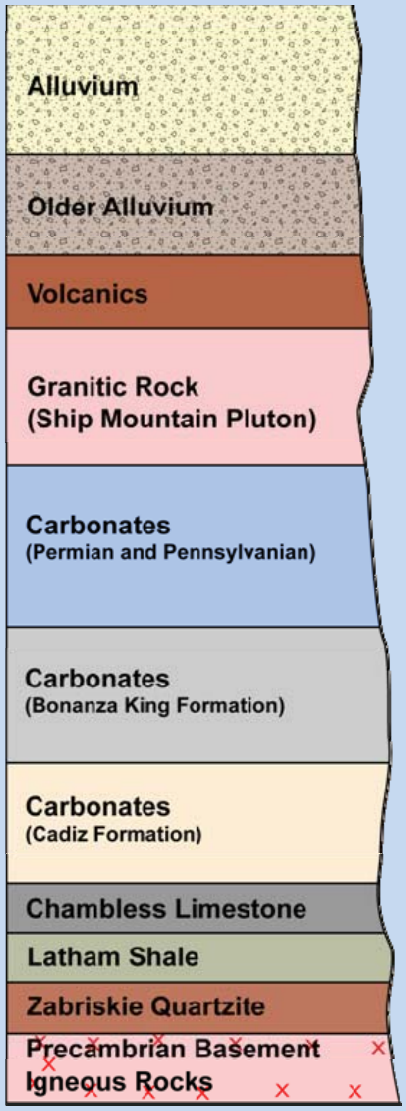
Figure 4-23
Geology of Fenner Gap Area, Location of Cross Sections and Test Borings/Wells

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-23_CADIZ_TM_GeologyofFennerGap_XSec_Wells_V2_MH_9.2.mxd

Western Fenner Gap Area (Marble Mountains)



Eastern Fenner Gap Area (Ship Mountains)



Not to scale

Note: See Table 4-6 for description of geologic units.

FIGURE 4-24
Generalized Stratigraphic Column of Fenner Gap Area
Cadiz Groundwater Plan

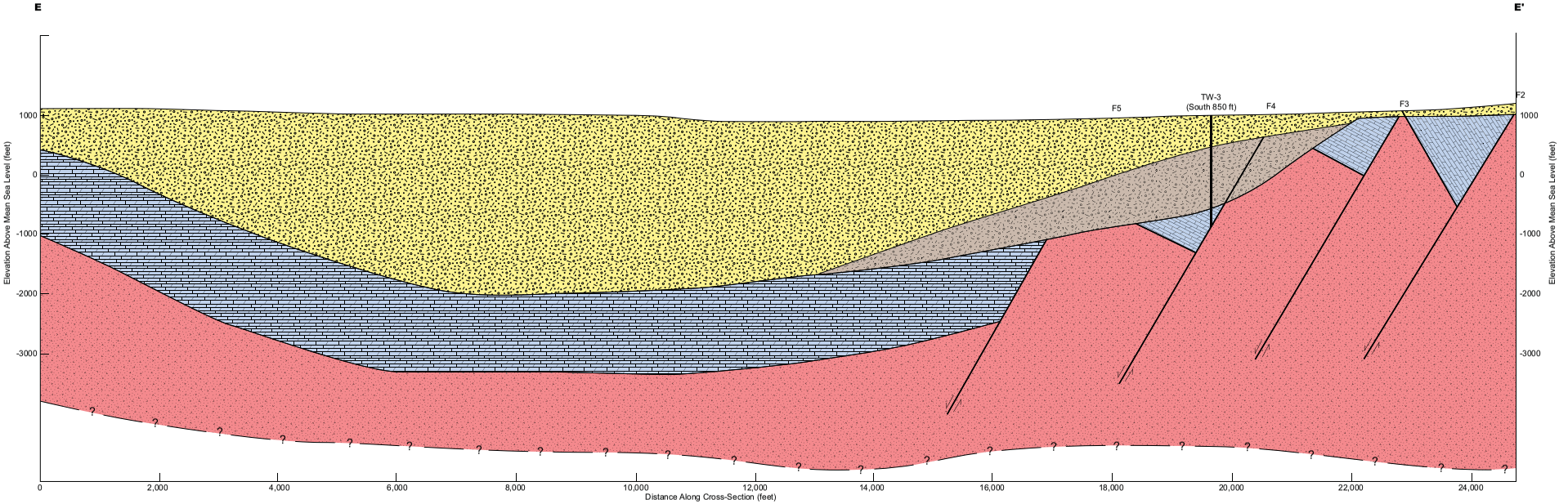


FIGURE 4-25
Cross-Section E-E'
Cadiz Groundwater Plan

CH2MHILL

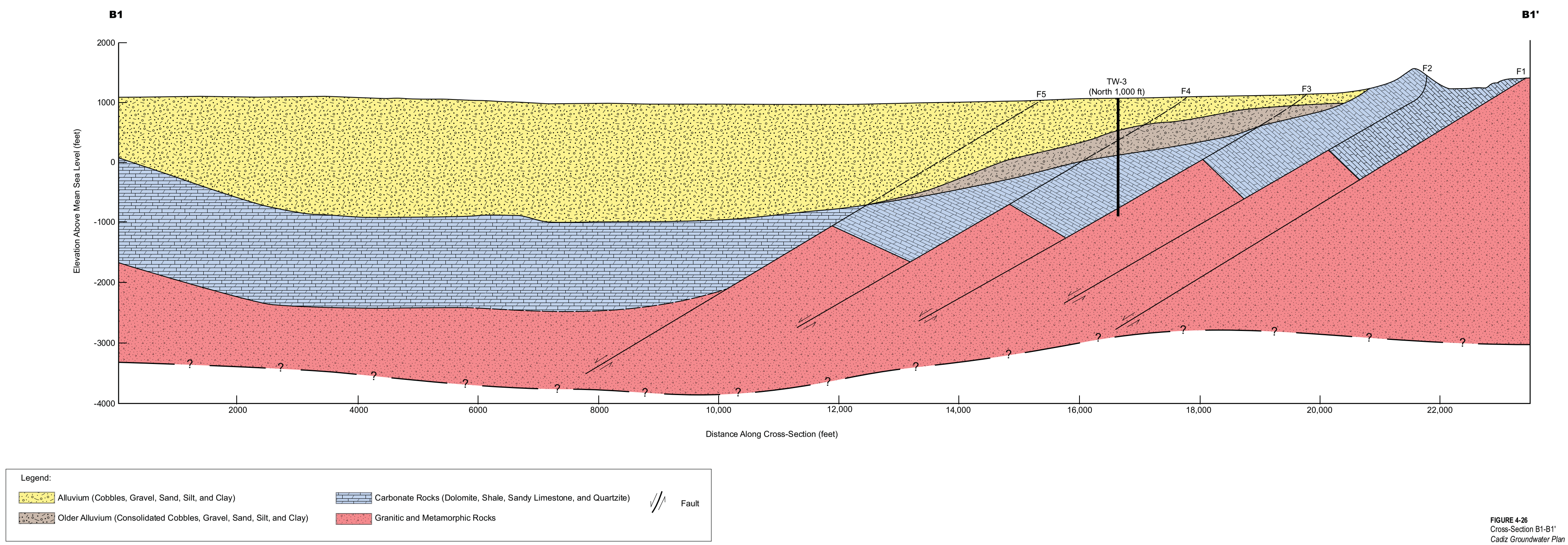


FIGURE 4-26
Cross-Section B1-B1'
Cadiz Groundwater Plan

CH2MHILL

WB052009005SCO386303.AA.05 Cadiz_Cross_section_15_B1.ai 3/10

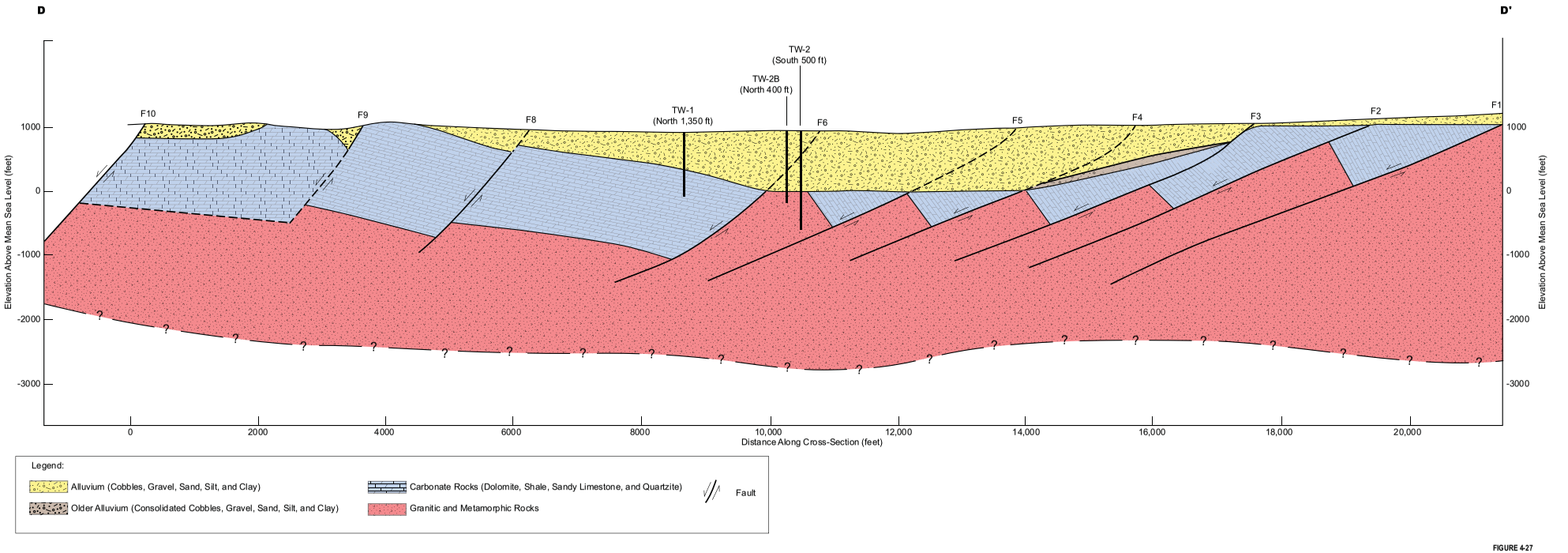


FIGURE 4-27
Cross-Section D-D'
Cadiz Groundwater Plan

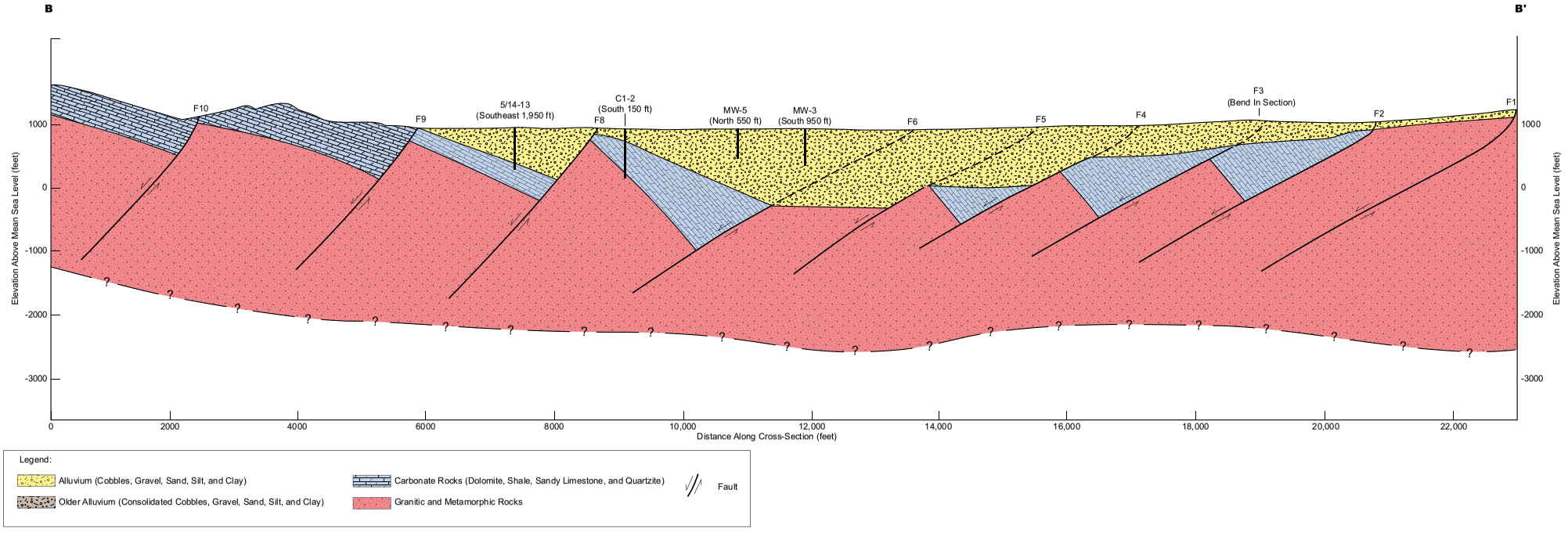


FIGURE 4-28
Cross-Section B-B'
Cadiz Groundwater Plan

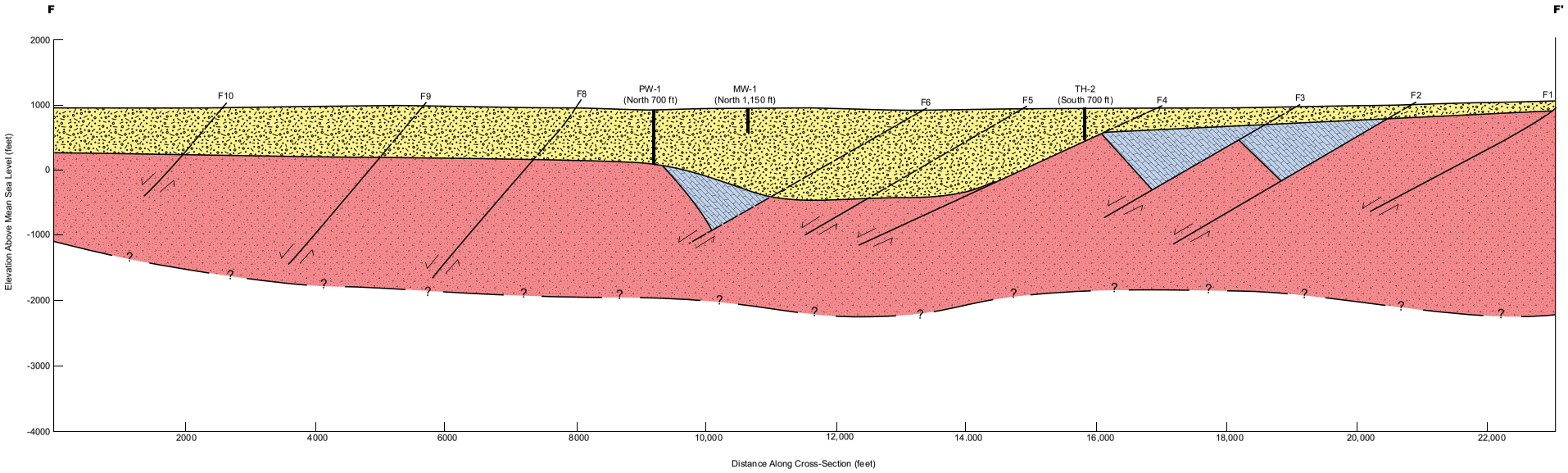
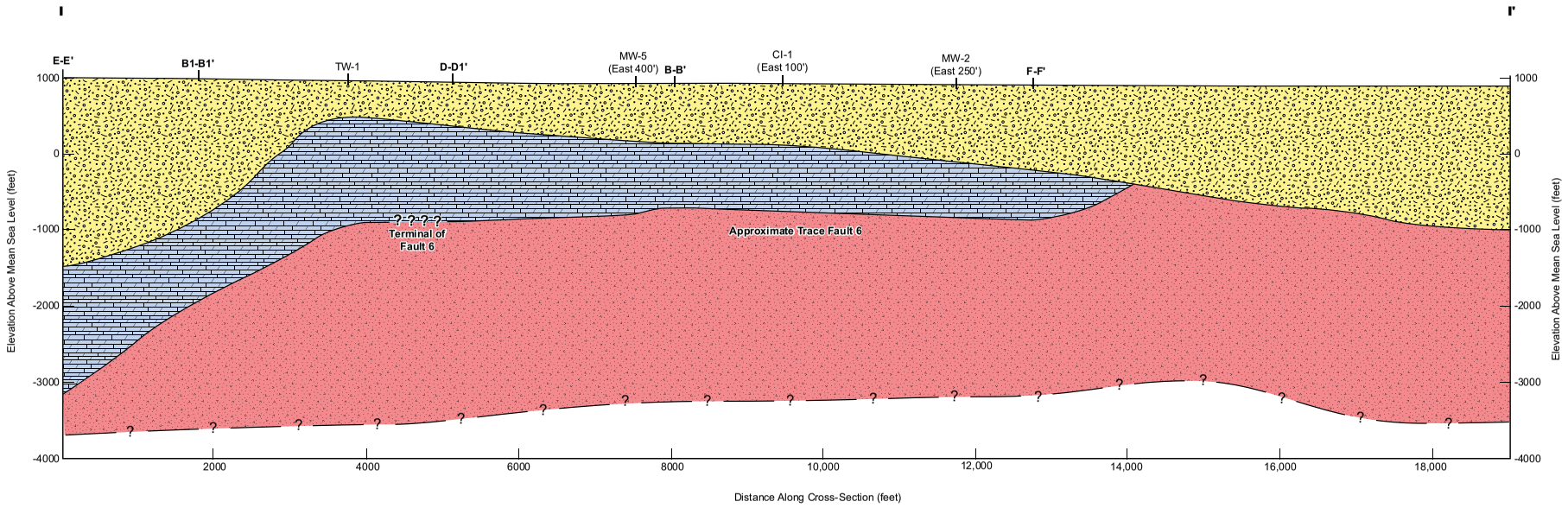


FIGURE 4-29
Cross-Section F-F'
Cadiz Groundwater Plan



Legend:

- Alluvium (Cobbles, Gravel, Sand, Silt, and Clay)
- Carbonate Rocks (Dolomite, Shale, Sandy Limestone, and Quartzite)
- Granitic and Metamorphic Rocks

FIGURE 4-30
Cross-Section I-I'
Cadiz Groundwater Plan

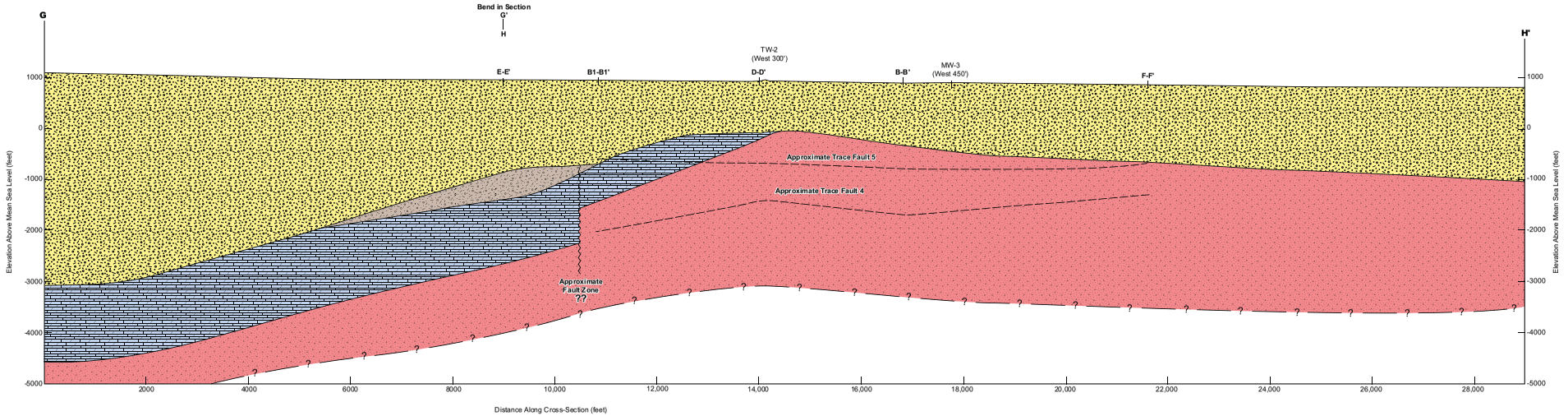
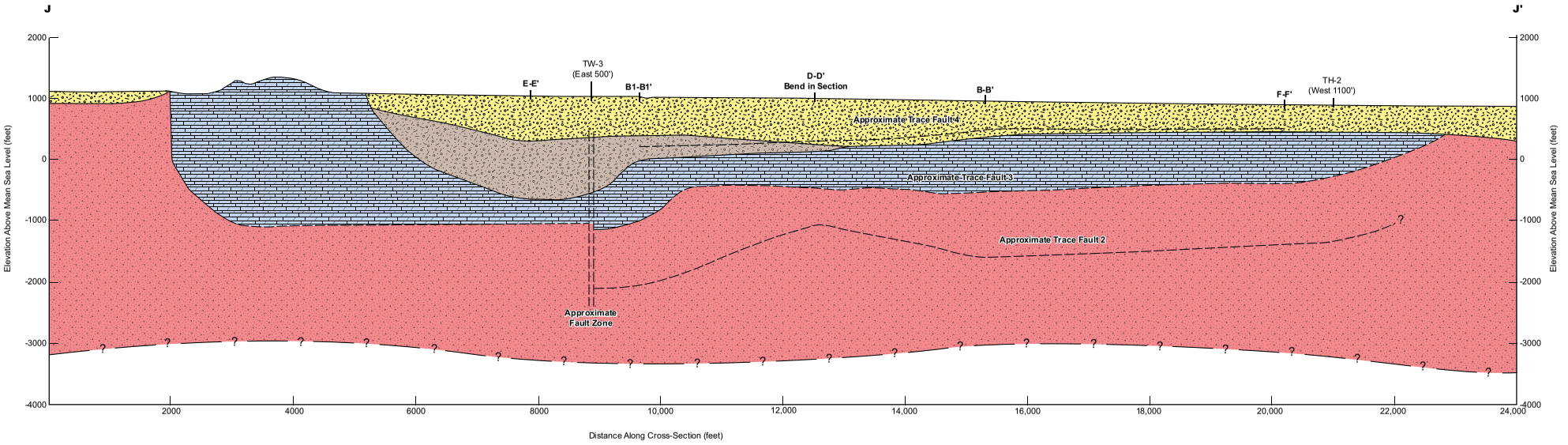


FIGURE 4-31
Cross-Section H-H'
Cadiz Groundwater Plan

CH2MHILL

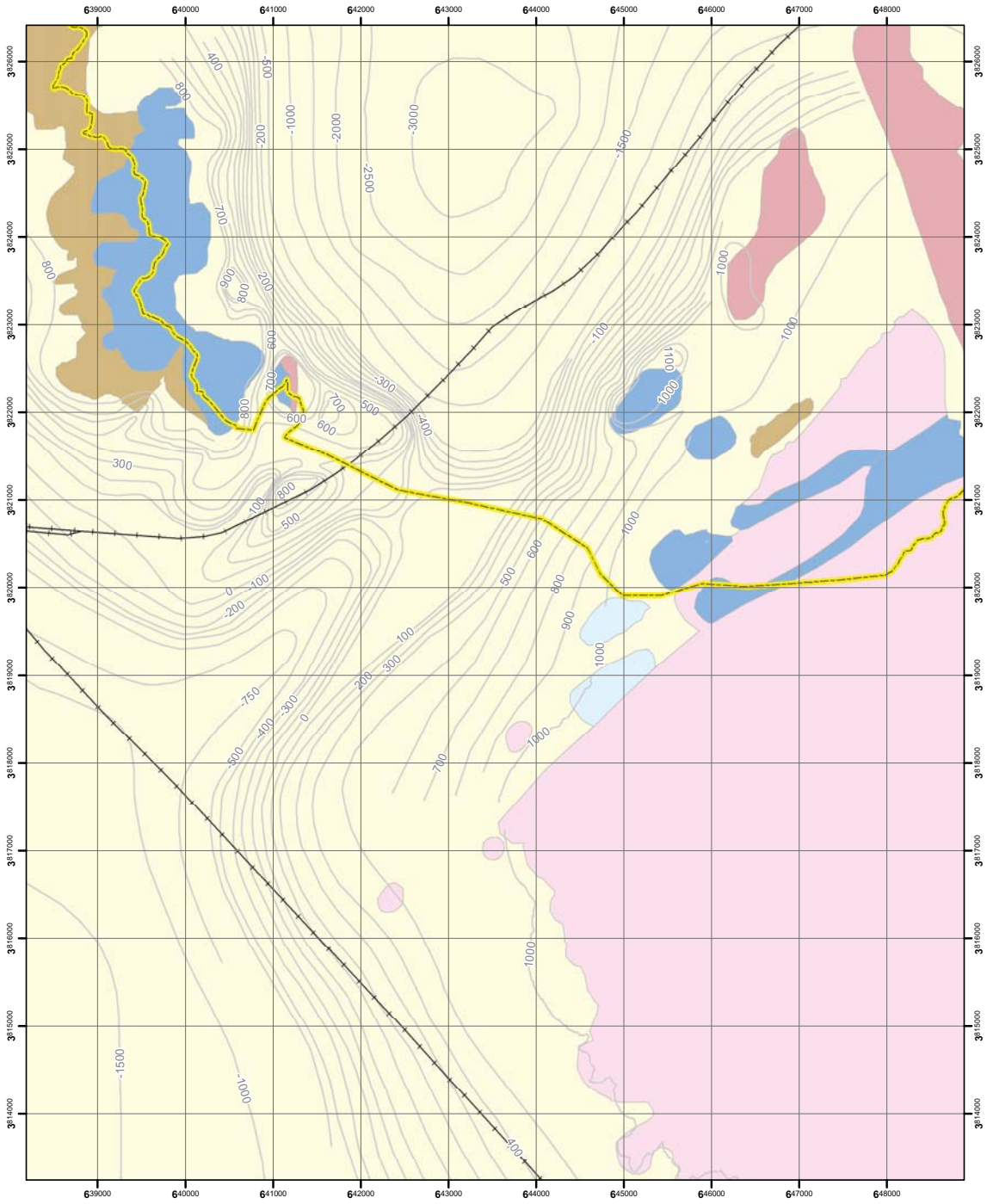


Legend:

- Alluvium (Cobbles, Gravel, Sand, Silt, and Clay)
- Older Alluvium (Consolidated Cobbles, Gravel, Sand, Silt, and Clay)
- Carbonate Rocks (Dolomite, Shale, Sandy Limestone, and Quartzite)
- Granitic and Metamorphic Rocks

FIGURE 4-32
Cross-Section J-J'
Cadiz Groundwater Plan

CH2MHILL



Legend

- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads
- Base of Alluvium
- WaterBodies

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

N

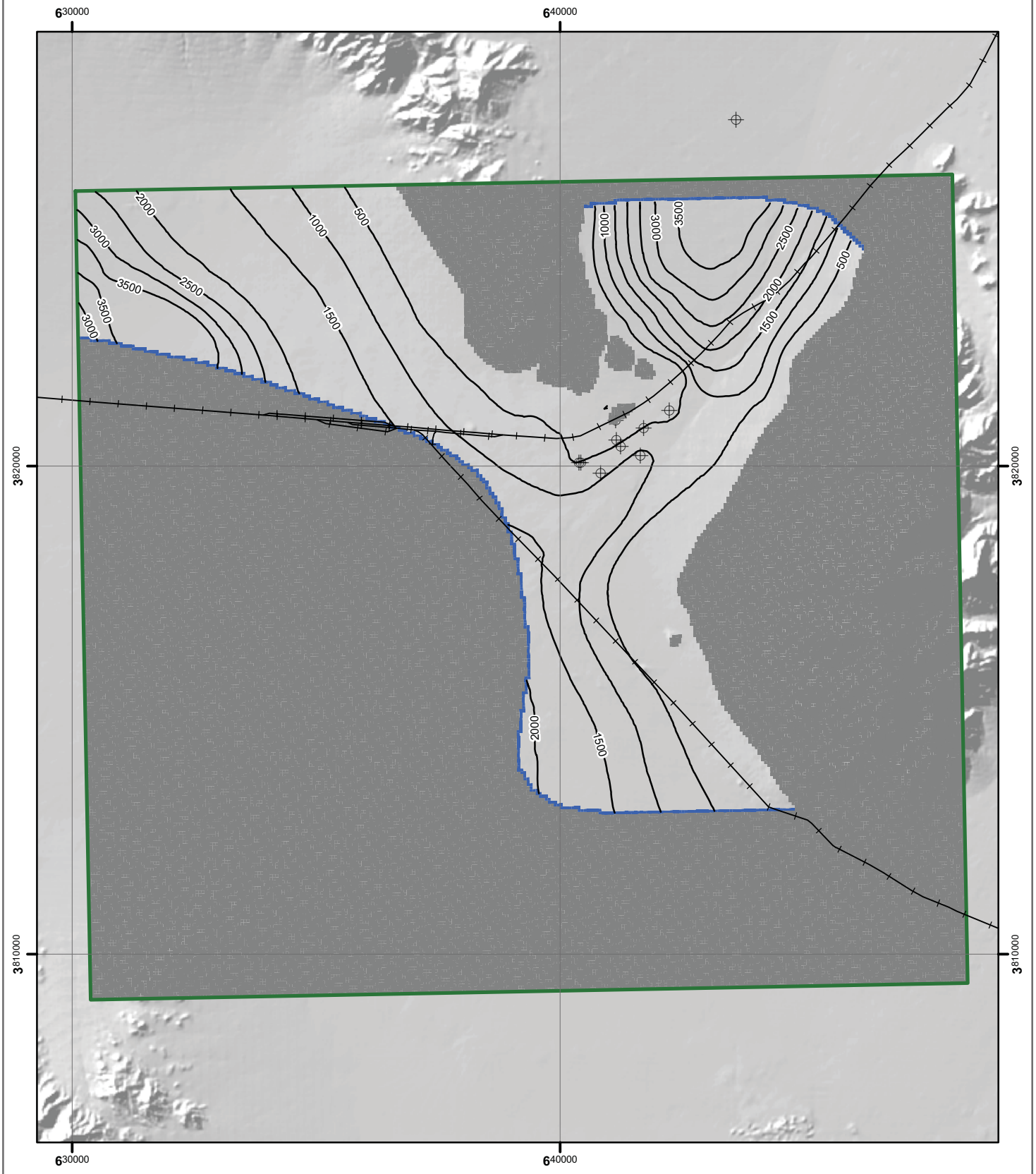
0 0.2 0.4 0.8 Miles

0 0.2 0.4 0.8 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-33
Structure Contour Map of Base of Alluvium in the Fenner Gap Area

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-33_CADIZ_TM_BaseAlluv_V1_MH.mxd



Legend

Saturated Thickness (ft), Alluvium

Rail Roads

Model Domain

Boundary Conditions

Constant Head Boundary

No Flow Boundary

CADIZ Wells

0 0.5 1 2 Miles

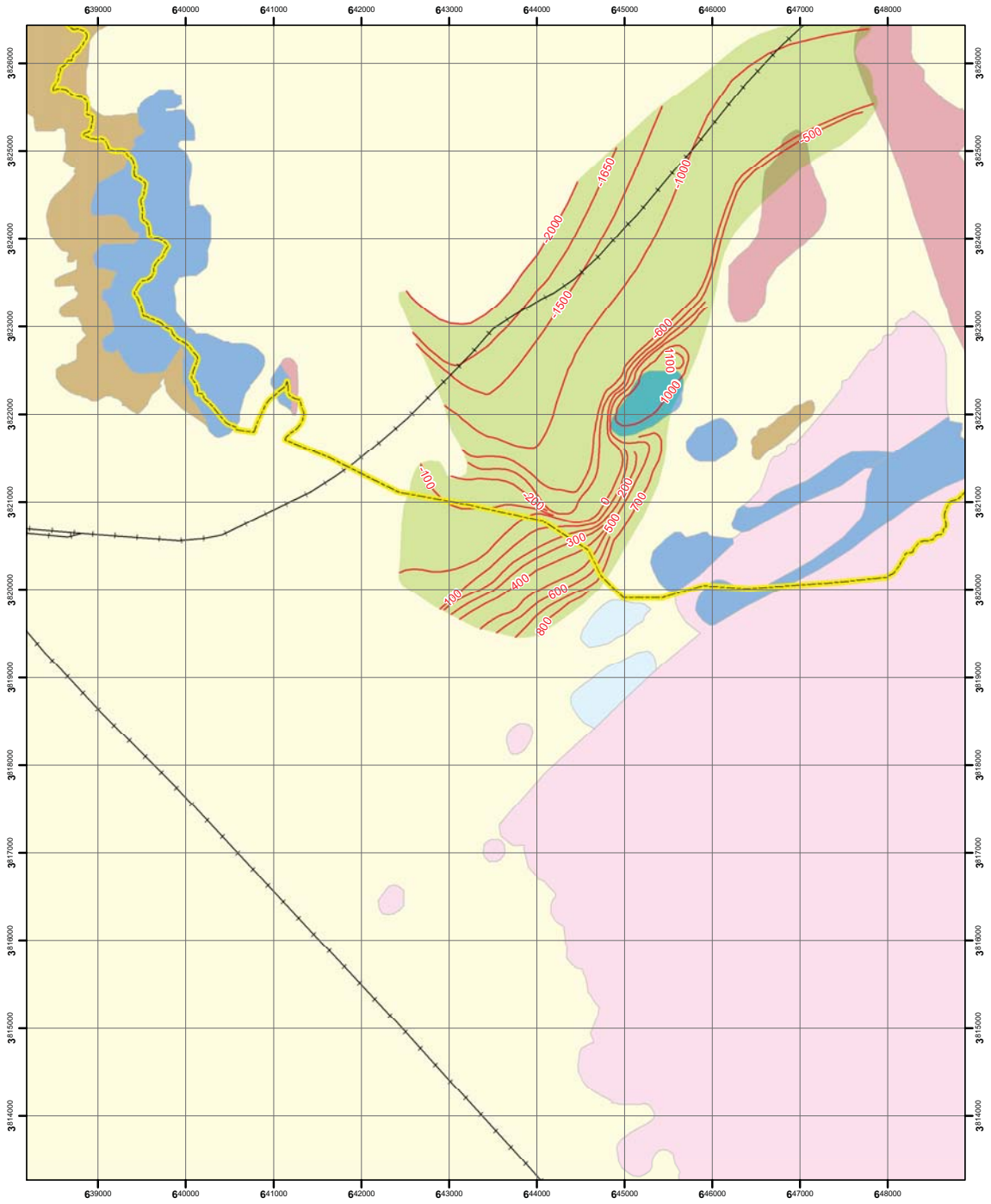
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-34

Isopach Map
Saturated Alluvium

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-34_CADIZ_TM_SatThick_Alluvium_FG033.mxd



Legend

- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads
- Base of Old Alluvium
- WaterBodies

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks
- Approximate Extent of Consolidated Fanglomerates

N

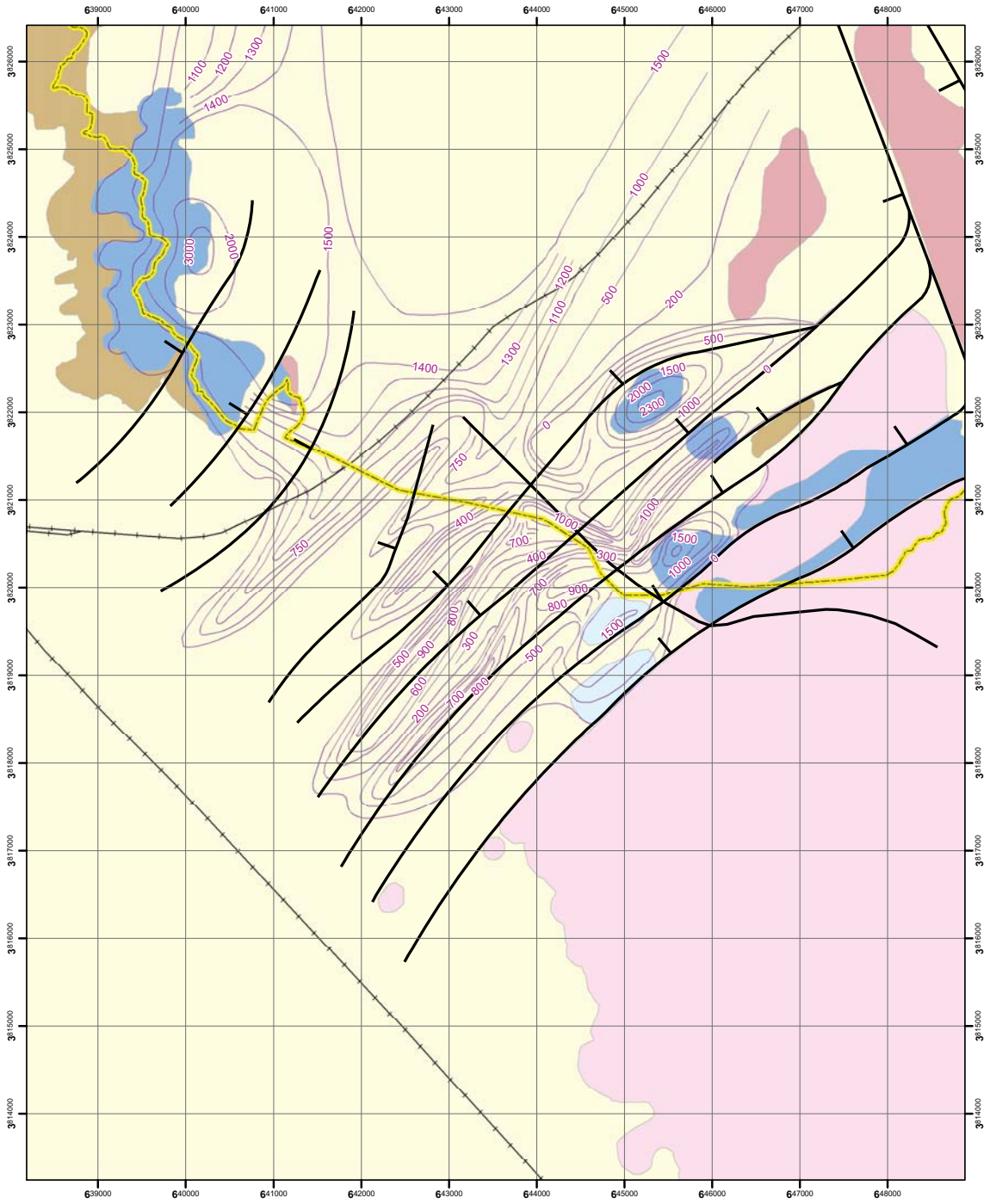
0 0.2 0.4 0.8 Miles

0 0.2 0.4 0.8 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-35
Estimated Extent of Consolidated Fanglomerates in the Fenner Gap Area

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-35_CADIZ_TM_BaseOldAlluv_V1_MR.mxd



Legend

- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads
- Carbonate Thickness (ft)
- Fault
- WaterBodies

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

N

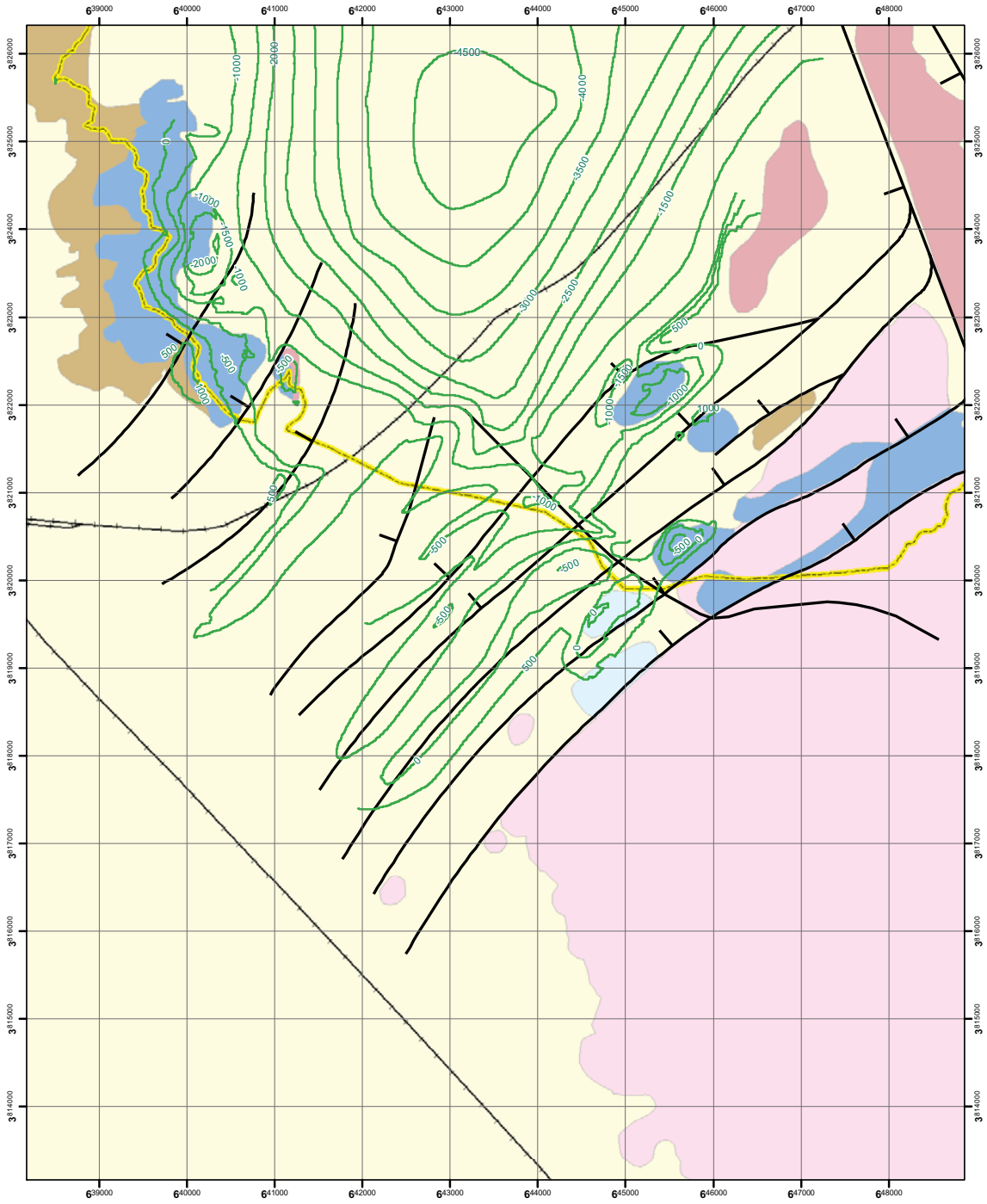
0 0.2 0.4 0.8 Miles

0 0.2 0.4 0.8 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-36
Isopach Map of Carbonate Rock Unit in the Fenner Gap Area

\\cheron\Projects\BrownsteinHyattFarber\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-36_CADIZ_TM_CarbThick_V1_MR.mxd



Legend

- Base of Carbonates
- Fault
- Fenner_BND
- Cadiz Study Area
- Interstates
- Rail Roads

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

N

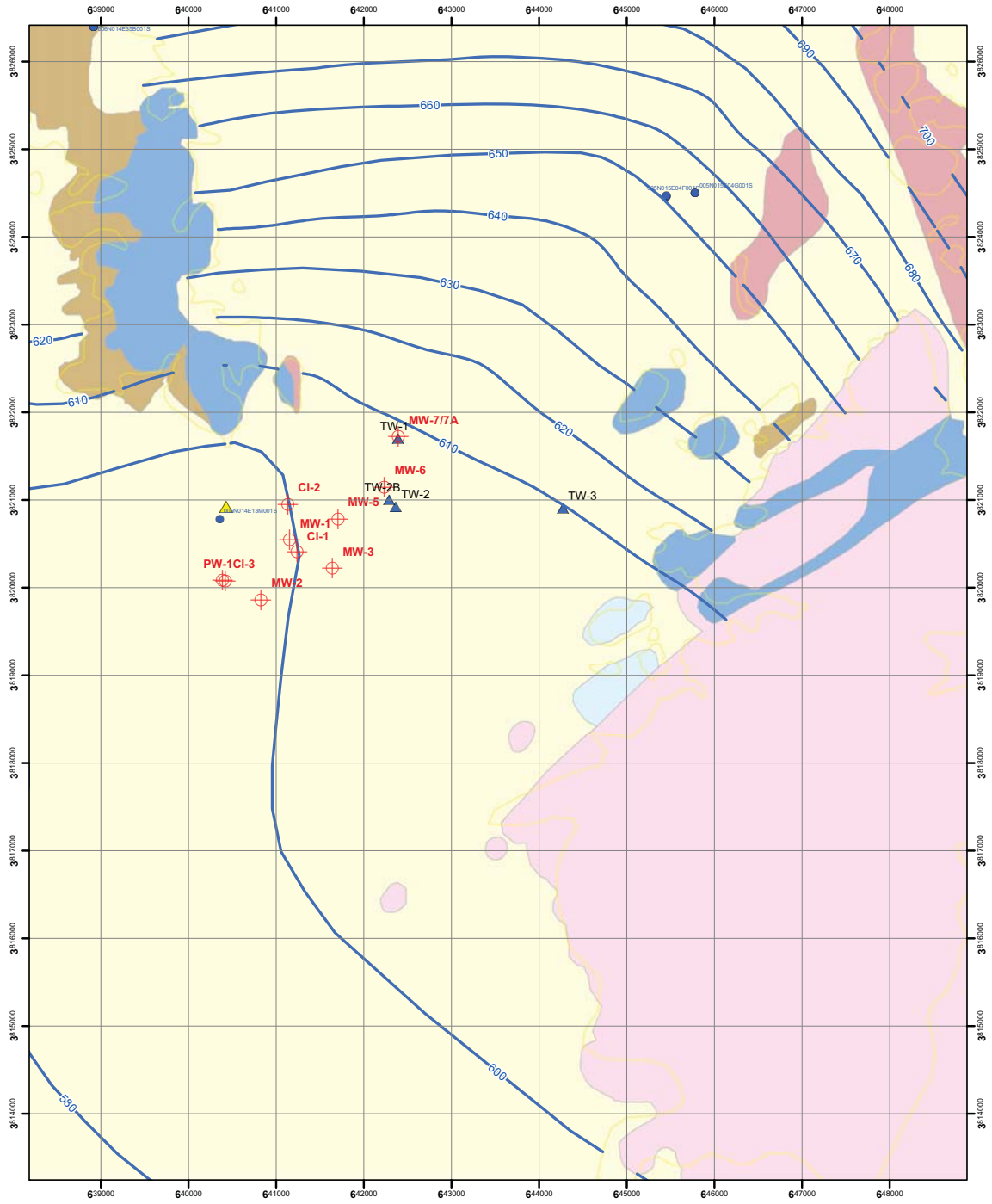
0 0.2 0.4 0.8 Miles

0 0.2 0.4 0.8 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-37
Structure Contour Map on Base of Carbonate Rock Unit in the Fenner Gap Area

\\cheron\Projects\Brownstein\HyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig4-37_CADIZ_TM_BaseOfCarb_V3_MR.mxd



Legend

- Existing Cadiz Wells
- GW Elevation contour (ft msl)*
- Exploratory Drilling/Test Well Location
- CADIZ AG Wells
- Springs
- Wells
- Interstates
- Alluvium-Bedrock Contact

Geology Units

- Alluvium
- Teritary Volcanics
- Mesozoic Granitic Rocks
- Permian/Pennsylvanian Carbonate Rock Units
- Cambrian Carbonate Rock Units
- Precambrian Granitic Rocks

N

0 0.25 0.5 1 Miles

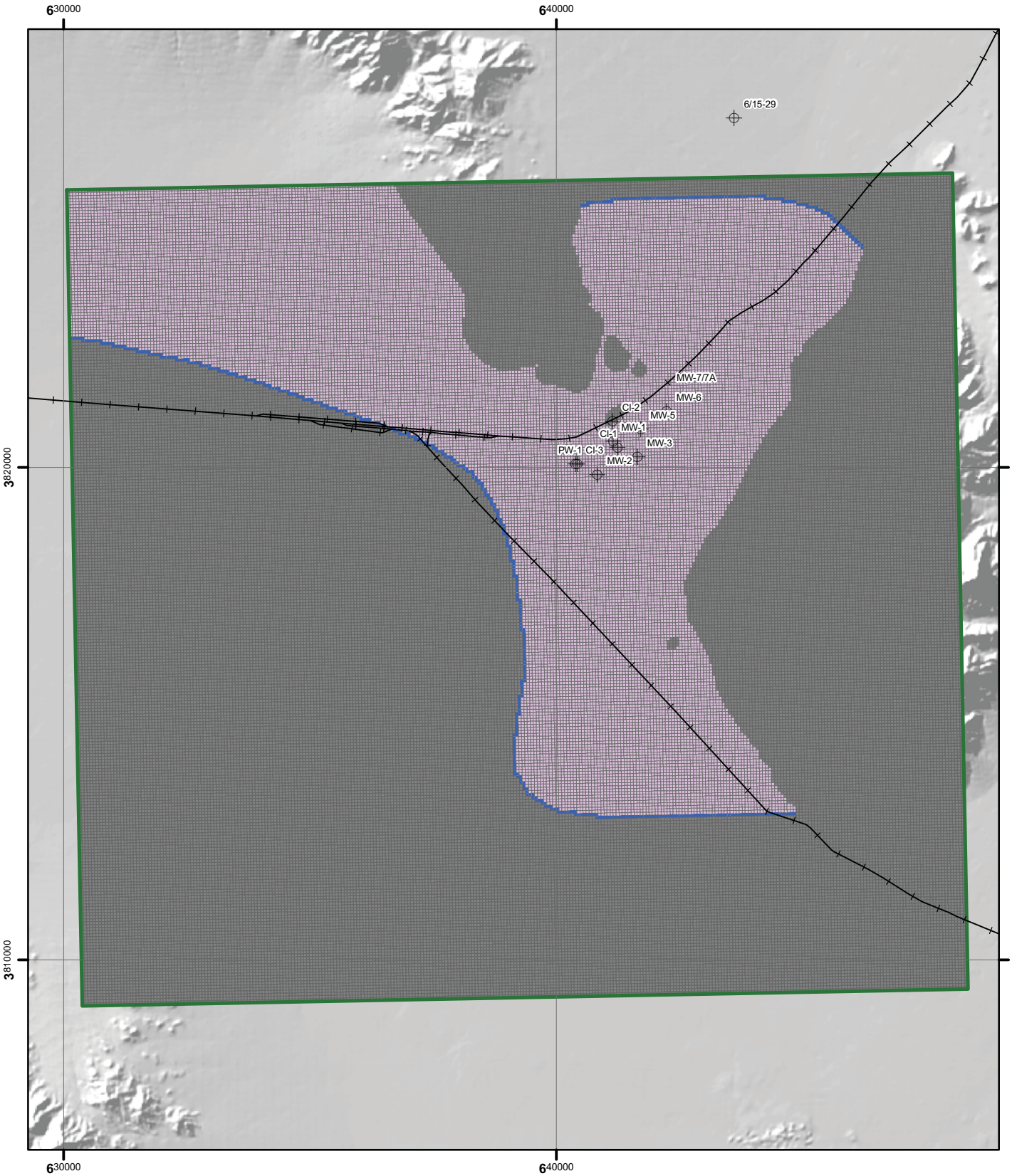
0 0.25 0.5 1 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

* Refer to Table 4 for summary of groundwater elevation measurements

Figure 4-38
Groundwater Elevation Contour Map in the Fenner Gap Area

\\cheron\Proj\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TM\Figures\Fig4-38_CADIZ_TM_GW_ElevationContourMap_V1_MH.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary
- Active Grid

0 0.35 0.7 1.4 Miles

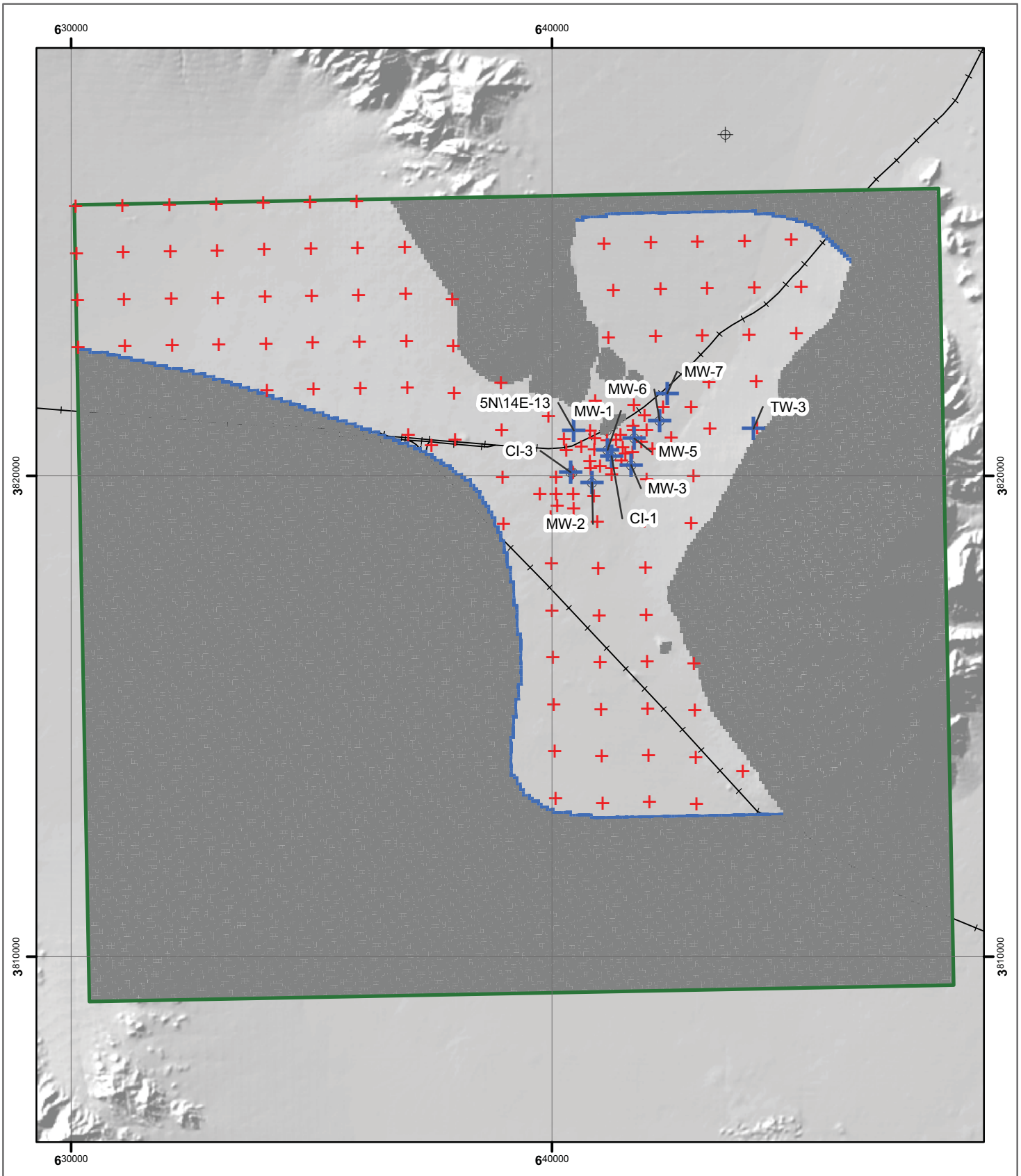
0 0.35 0.7 1.4 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-39

Groundwater Flow Model Extents, Grid and Boundary Conditions

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-39_CADIZ_TM_GroundwaterModelFlowExtents.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary

- Groundwater Elevation Targets
- PEST Pilot Points

0 0.5 1 2 Miles

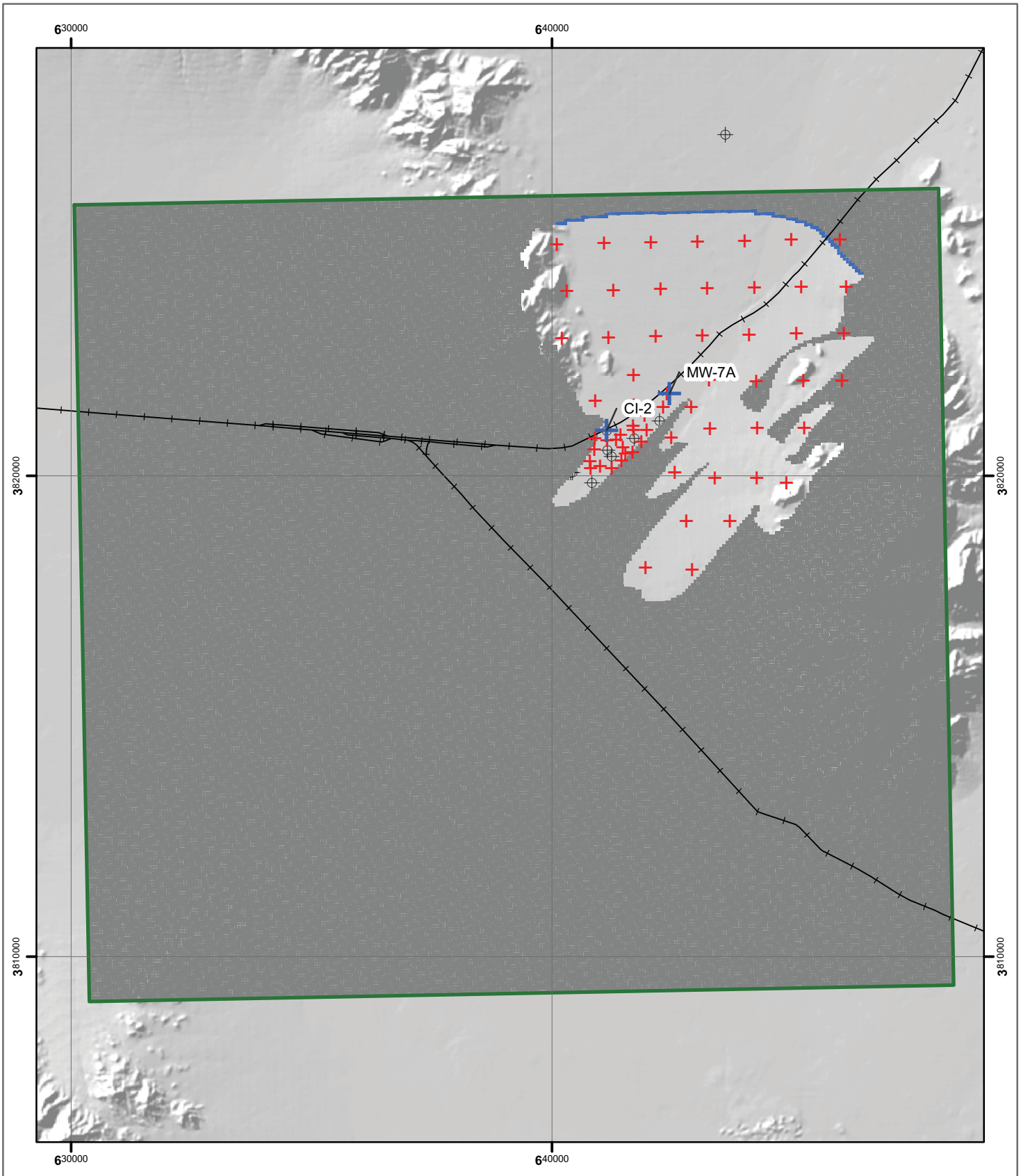
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-40

PEST Pilot Points and Targets in Layer 1

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-40_CADIZ_TM_PESTPilotPtsandTargetsL1_V1_SS.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary

- Groundwater Elevation Targets
- PEST Pilot Points

0 0.5 1 2 Miles

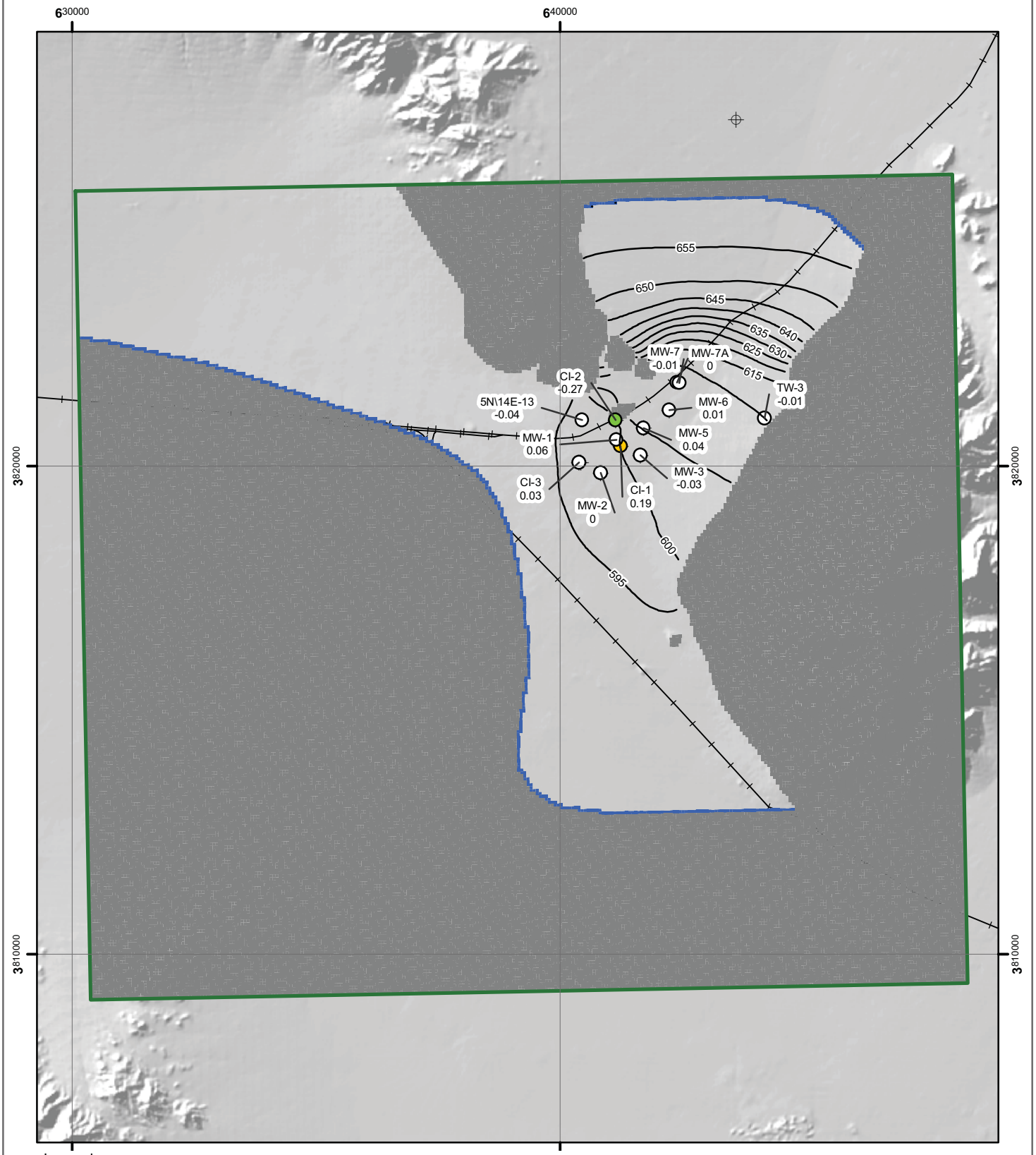
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-41

PEST Pilot Points and Targets in Layer 3

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-41_CADIZ_TM_PESTPilotPtsandTargetsL3_V1_SS.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary

Residual (Obs - Sim)

- < -1
- -1 - -0.1
- -0.1 - 0.1
- 0.1 - 1
- > 1
- Groundwater Contours (ft)

0 0.5 1 2 Miles

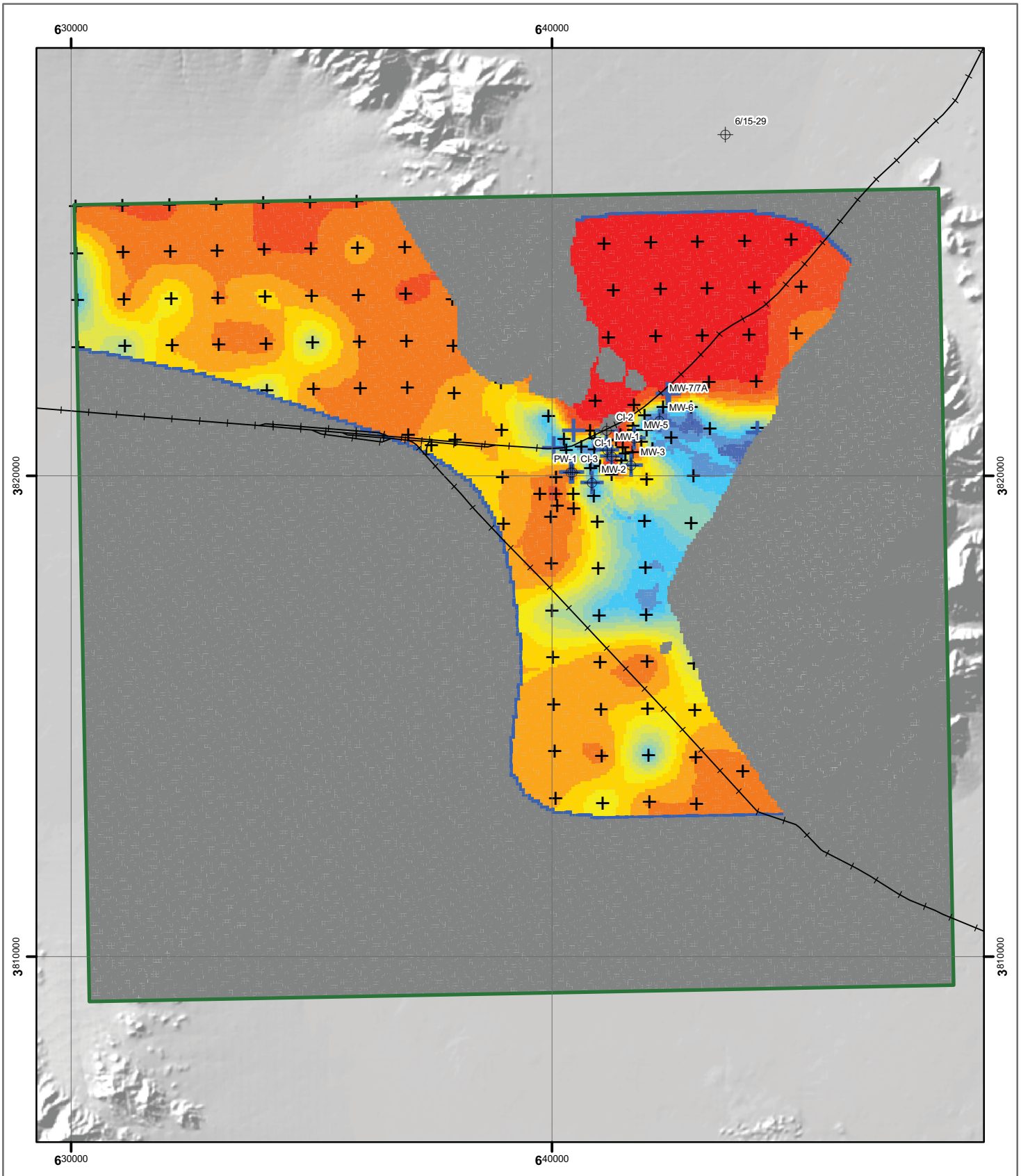
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-42

PEST Simulated Groundwater Contours and Target Residuals - K Upper Limit = 600 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-42_CADIZ_TM_GWContours_TargetResiduals_FG033.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary
- Groundwater Elevation Targets
- PEST Pilot Points

Hydraulic Conductivity Layer 1
Kh (ft/day)

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800

0 0.5 1 2 Miles

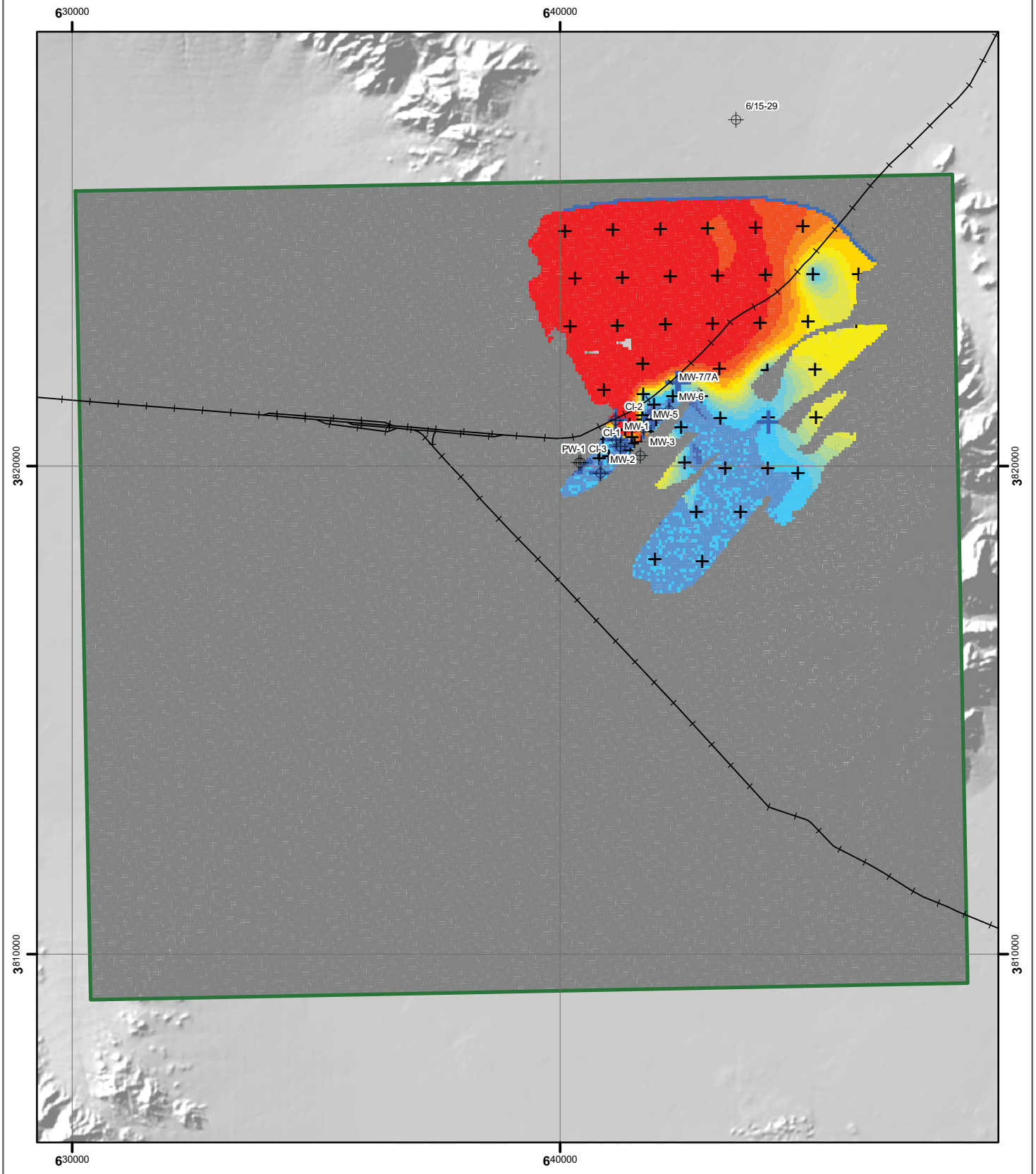
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-43

PEST Computed Hydraulic Conductivity Distribution in Layer 1
with K Upper Limit = 600 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-43_CADIZ_TM_K_L1_FG033.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary
- Groundwater Elevation Targets
- PEST Pilot Points

Hydraulic Conductivity Layer 3
Kh (ft/day)

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-44

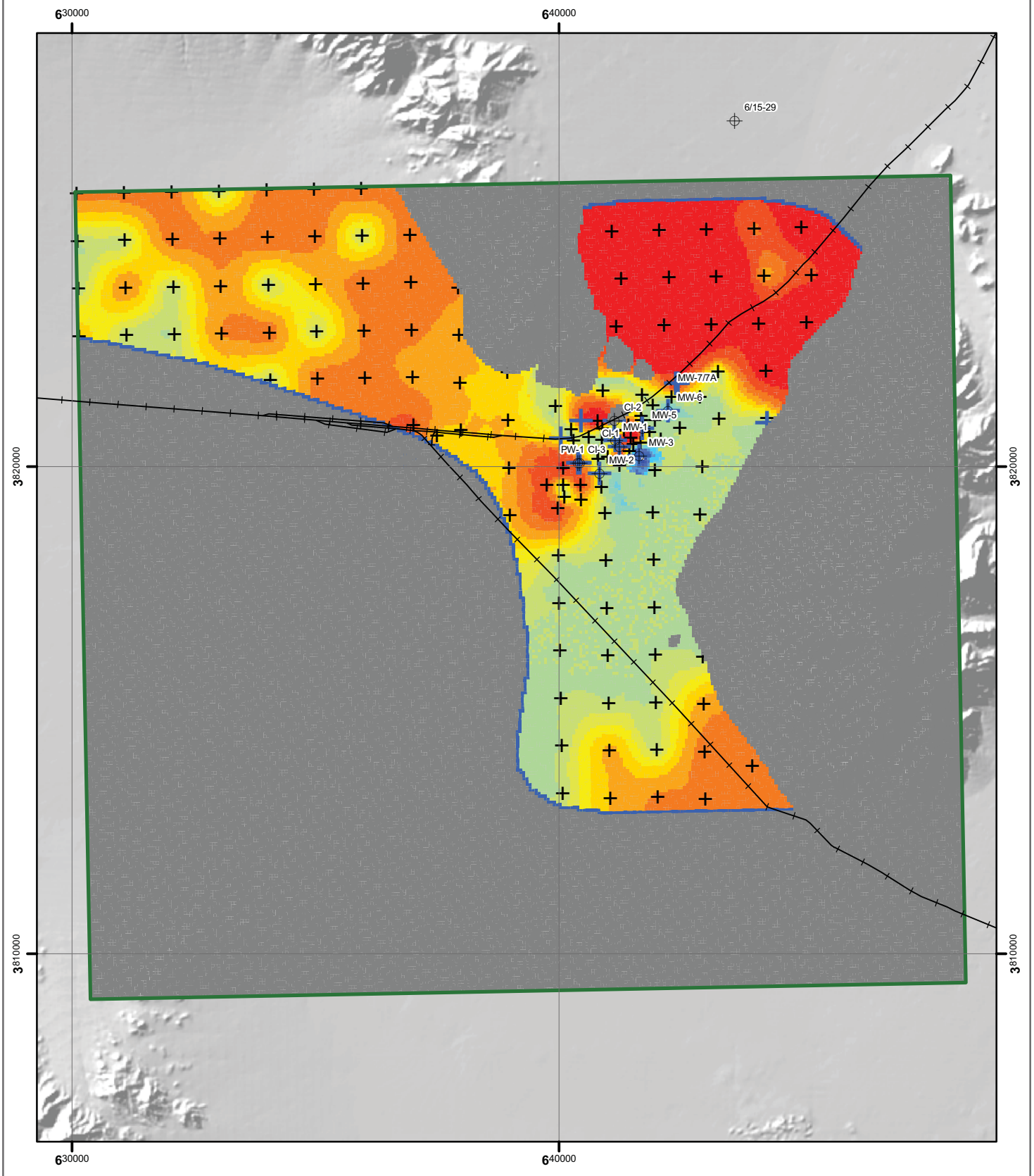
PEST Computed Hydraulic Conductivity Distribution in Layer 3
with K Upper Limit = 600 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-44_CADIZ_TM_K_L3_FG033.mxd

Figure 4-45

PEST Simulated Groundwater Contours and Target Residuals - K Upper Limit = 400 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-45_CADIZ_TM_GWContours_TargetResiduals_FG032c.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary
- Groundwater Elevation Targets
- PEST Pilot Points

Hydraulic Conductivity Layer 1
Kh (ft/day)

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800

0 0.5 1 2 Miles

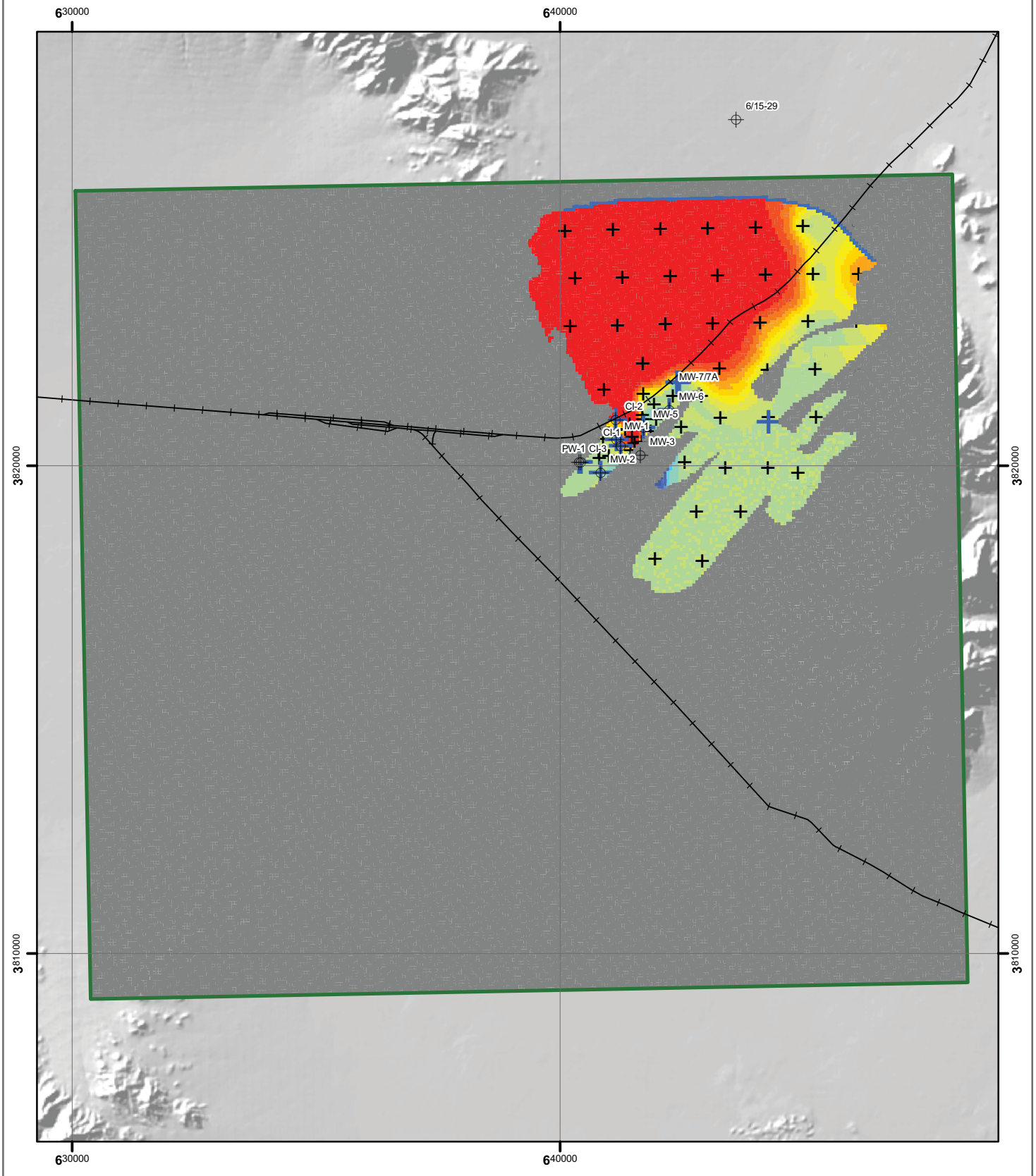
0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-46

PEST Computed Hydraulic Conductivity Distribution in Layer 1
with K Upper Limit = 400 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-46_CADIZ_TM_K_L1_FG032c.mxd



Legend

- CADIZ Wells
- Rail Roads
- Model Domain

Boundary Conditions

- Constant Head Boundary
- No Flow Boundary
- Groundwater Elevation Targets
- PEST Pilot Points

Hydraulic Conductivity Layer 3
Kh (ft/day)

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters. Vertical Datum NAVD88

Figure 4-47

PEST Computed Hydraulic Conductivity Distribution in Layer 3
with K Upper Limit = 400 ft/d

\\cheron\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\TMFigures\Fig_4-47_CADIZ_TM_K_L3_FG032c.mxd

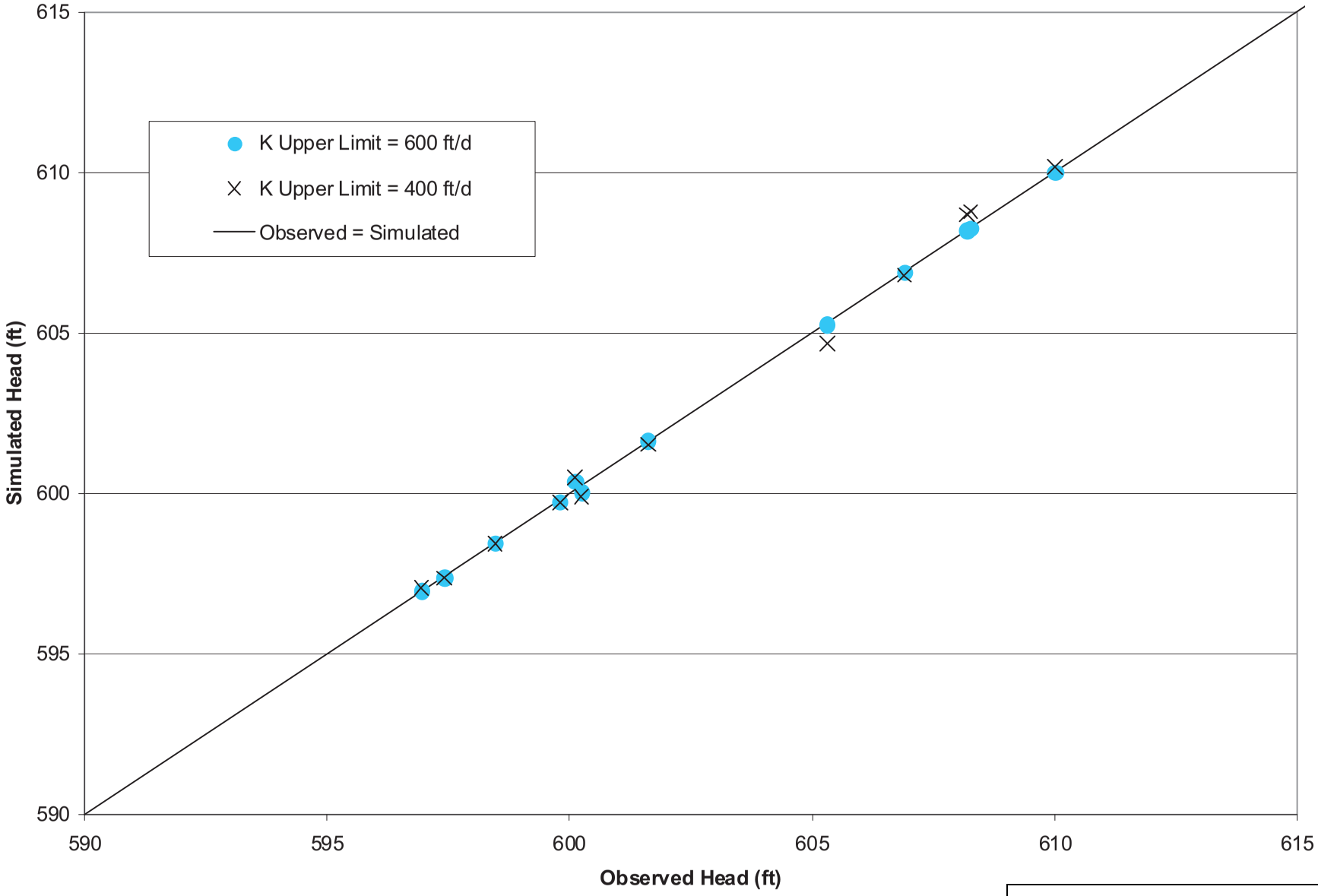


Figure 4-48

Scatter Plot Showing Observed Versus Simulated Groundwater Levels from PEST Simulations

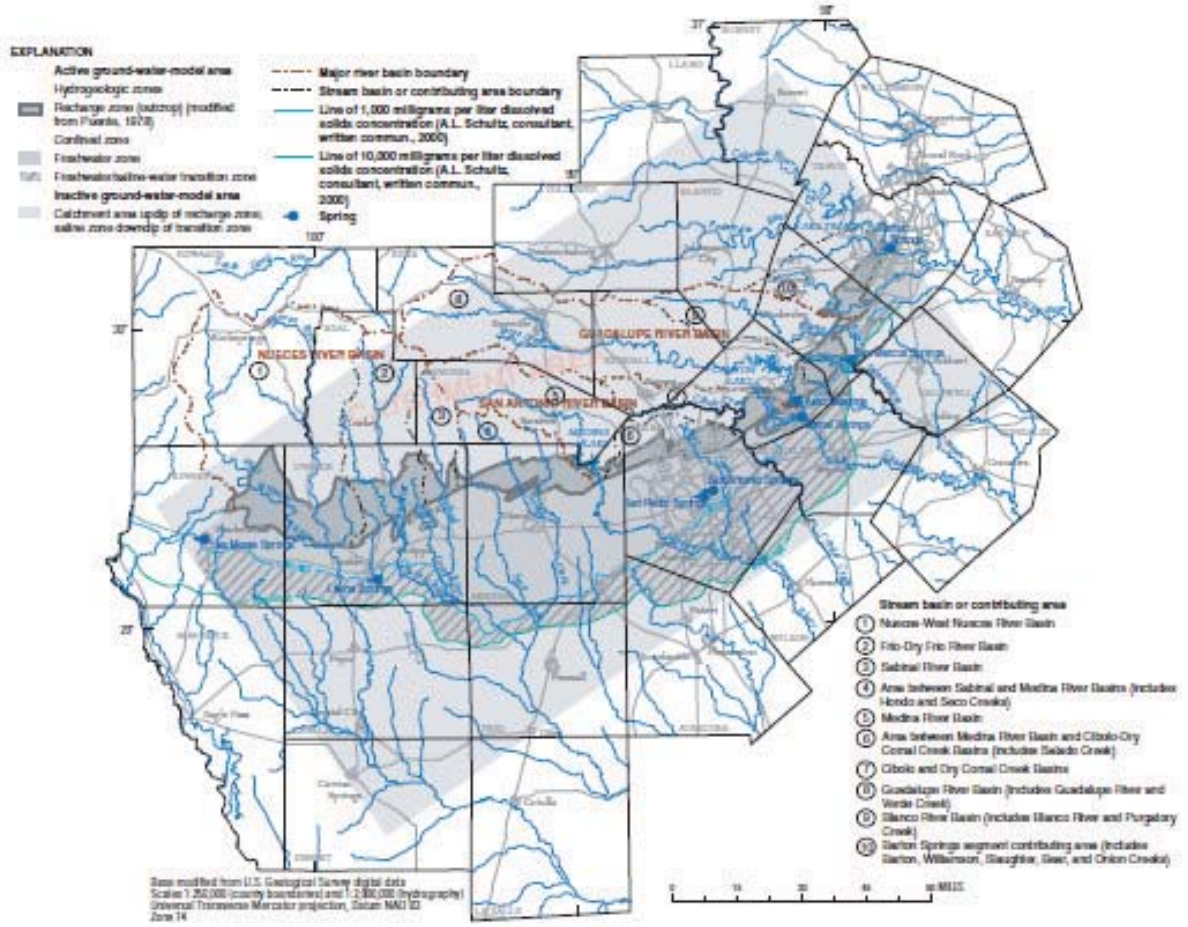


Figure 4-49. Hydrogeologic zones and catchment area (upper parts of stream basins that contribute to recharge) of the Edwards aquifer, San Antonio region, Texas. (from Lindgren et al., 2004)

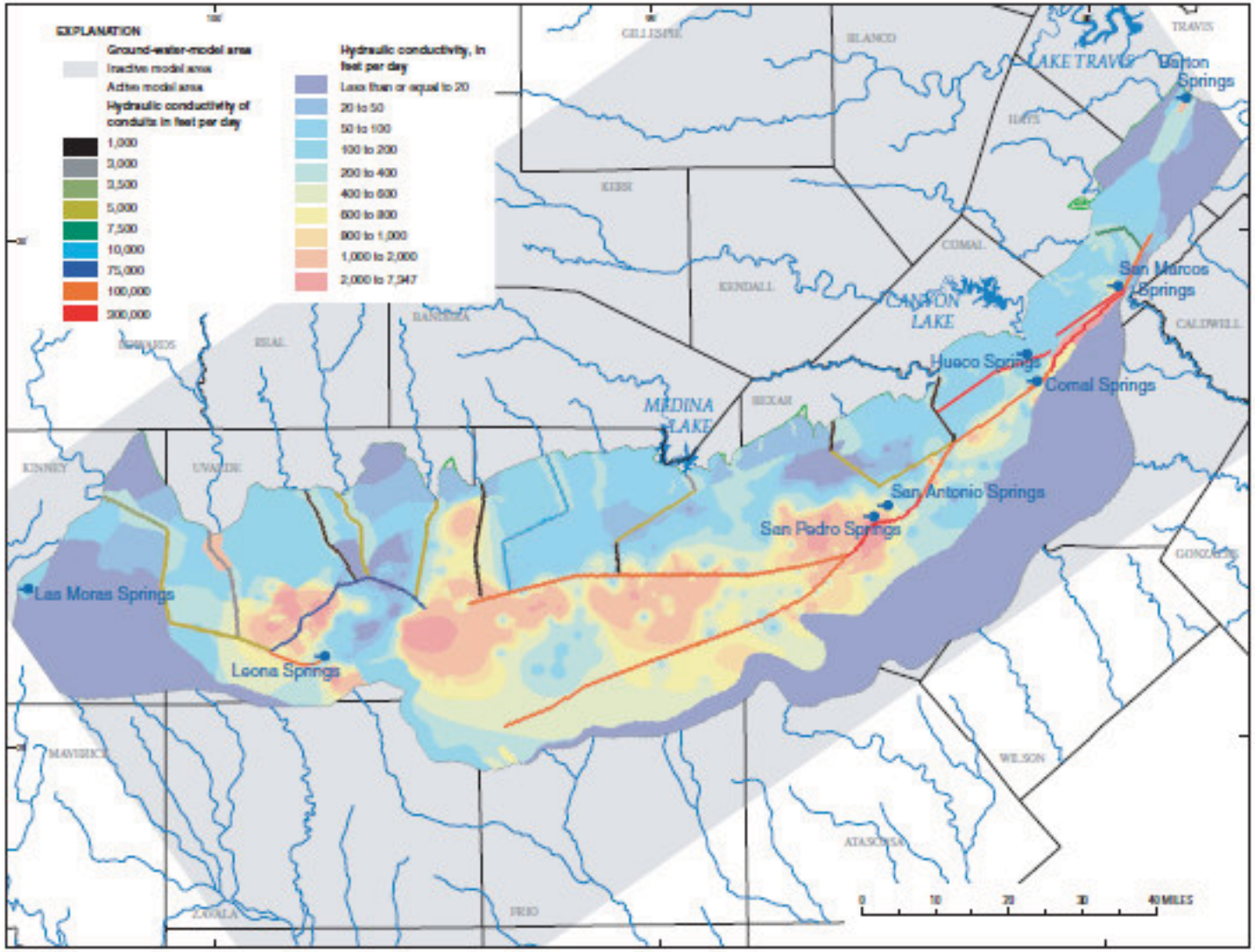


Figure 4-50. Simulated distribution of horizontal hydraulic conductivity for calibrated Edwards aquifer model, San Antonio region, Texas. (from Lindgren et al., 2004)

5.0 References Cited

Bassett, A.M. and D.H. Kupfer. 1964. *A Geologic Reconnaissance in the Southeastern Mojave Desert, California.* California Division of Mines and Geology Special Report 83.

Bassett, A.M., D.H. Kupfer, and F.C. Barstow. 1959. *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California.* US Geological Survey Bulletin 1045-D. pp. 97-138.

Bedford, D.R., Miller, D.M., Phelps, G.A. 2006. *Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California.* U.S. Geological Survey Open-File Report 2006-1165.

Bedinger, M.S., Langer, W.H., and Reed, J.E. 1989. *Ground-water Hydrology, in Bedinger, M.S., Sargent, K.A., and Langer, W.H., eds. Studies of geology and hydrology in the Basin and Range Province, southwestern United States, for isolation of high-level nuclear waste – Characterization of the Death Valley region, Nevada and California*. U.S. Geological Survey, Professional Paper 1370-F. p 49.

Bedinger, M.S., Sargent, K.A., and Langer, W.H., eds. *Studies of Geology and Hydrology in the Basin and Range Province, Southwestern United States, for Isolation of High-Level Nuclear Waste – Characterization of the Death Valley Region, Nevada and California*. U.S. Geological Survey. Professional Paper 1370-F. p 49.

Belcher, W.R., Sweetkind, D.S., and Elliott, P.E. 2002. *Probability Distributions of Hydraulic Conductivity for the Hydrogeologic Units of the Death Valley Regional Ground-Water Flow System, Nevada and California.* U.S. Geological Survey Water-Resources Investigation Report 02-4212. p 18.

Bishop, C.C. 1963. Needles Sheet, Geologic Map of California. California Division of Mines and Geology. Scale 1:250,000.

Burchfiel, B.C. and Davis, G.A. (Davis).1980. "Mojave Desert and Surrounding Environs". *The Geotectonic Development of California*. Ernst, W.G. ed. Prentice-Hall, Englewood CLIFFS. NJ.

California Department of Water Resources (CDWR). 2010. *California's Groundwater.* Bulletin 118 on the world wide web: http://www.water.ca.gov/groundwater/bulletin118/update2003.cfm.

Campbell, G.S. 1985. *Soil Physics with BASIC: Transport models for soil plant systems*. Amsterdam, The Netherlands. Elsevier, Developments in Soil Science, No. 14. p 150.

Czarnecki, J.B. 1997. *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California, with a section on Estimating Evapotranspiration Using the Energy-Budget Eddy-Correlation Technique*. U.S. Geological Survey Water-Supply Paper 2377. 1997.

Davisson, M.L. and Rose, T.P. 2000a. *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*. Lawrence Livermore National Laboratory. UCRL-ID139027. p 15.

Dibblee, T.W., Jr. 1980a. *Pre-Cenozoic Rock Units of the Mojave Desert.* D.L. Fife and A.R. Brown, eds. Geology and Mineral Wealth of the California Desert. South Coast Geological Society. Santa Ana, CA.

Dibblee, T.W. 1980b. *Cenozoic Rock Units of the Mojave Desert*. D.L. Fife and A.R. Brown, eds. Geology and Mineral Wealth of the California Desert. South Coast Geological Society, Santa Ana, CA.

Doherty, J. 2004. PEST Model-Independent Parameter Estimation User Manual. 5th Edition. Watermark Numerical Computing. p 336.

Dokka, R.K. and Travis, C.J. (Dokka). 1990. *Late Cenozoic Strike Slip Faulting in the Mojave Desert, California.* Tectonics, v. 9. No. 2. pp 311-340.

Flint, A. 2009. Personal communications. April 2009.

Freiwald, D.A. 1984. *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California.* US Geological Survey Water Resources Investigation Report 83-4082.

Gale, H.S. 1951. *Geology of the Saline Deposits, Bristol Dry Lake, San Bernardino County, California*. California Division of Mines and Geology Special Report 13.

GAP. 2009. http://www.biogeog.ucsb.edu/projects/gap/data/meta/landcovdd.html. Date Accessed

GEOSCIENCE Support Services, Inc. (GSSI). 1995. *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins*. Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) and Mojave Water District. September 6.

GEOSCIENCE Support Services, Inc. (GSSI). 1999. *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volumes I and II.* Prepared for the Metropolitan Water District of Southern California. November 1999.

GEOSCIENCE Support Services, Inc. (GSSI). 2000. *Cadiz Groundwater Storage and Dry-Year Supply Program – Dry Lake Evapotranspiration Estimates.* Letter from Dennis Williams to Tom Freeman, URS Greiner Woodward-Clyde. March 9, 2000.

Hall, Jr., C.R. 2007. *Introduction to the Geology of Southern California and Its Native Plants*. University of California Press. p 493.

Handford, C.R. 1982. *Sedimentology and Evaporite Genesis in a Holocene Continental Sabkha Playa Basin - Bristol Dry Lake, California.* Sedimentology, Volume 29.

Harbaugh, A.W., Banta, E.R., Hill, M.C. 2000. *MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process.* U.S. Geological Survey Open-File Report 00-92. p 121.

Hazlett, R.W. 1992. "Some Thoughts on the Development of Amboy Crater." *Old Routes to the Colorado.* San Bernardino County Museum Association Special Publication 92-2.

Hazzard, J.C. 1933. *Notes on the Cambrian Rocks or the Eastern Mojave Desert, California.* California University Department of Geology Sciences Bulletin, v. 23, No. 2 Map 1, scale 1:187,500.

Hevesi, J.A., Flint, A.L., and Flint, L.E. 2002. *Preliminary Estimates of Spatially Distributed Net Infiltration and Recharge for the Death Valley Region, Nevada-California*. U.S. Geological Survey Water Resources Investigations Report 02-4010.

Hevesi, J.A., Flint, A.L., and Flint, L.E. 2003. *Simulation of net infiltration and potential recharge using the distributed-parameter watershed model, INFILv3, of the Death Valley Region, Nevada and California.* U.S. Geological Survey Water-Resources Investigations Report 03-4090. p 161.

Hevesi, J.A. 2009. Personal communications. April/May 2009

Howard, K. A. 2002. *Geologic Map of the Sheep Hole Mountains 30'x60' Quadrangle, San Bernardino and Riverside, Counties, California*. U.S. Geological Survey Miscellaneous Field Studies Map MF2344.

Howard, K.A., E.D. Horringa, D.M. Miller and P. Stone. 1989. *Geologic Map of the Eastern Parts of the Cadiz Lake and Cadiz Valley 15-Minute Quadrangles, San Bernardino and Riverside Counties, California.* US Geological Survey Map MF-2086.

Howard, K.A. and D.M. Miller. 1992. "Late Cenozoic Faulting at the Boundary between the Mojave and Sonoran Blocks: Bristol Lake Area, California." S.M. Richard, ed. *Deformation Associated with the Neogene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, California*. San Bernardino County Museums Special Publication 92-1. pp. 37-47.

Hunt, G.S. 1966. *Ground Water Geology of the Bristol and Cadiz Valleys, San Bernardino County, California*. M.S. Dissertation, University of Southern California

Jachens, R.C., and Howard, K.A. 1992. "Bristol Lake Basin – A Deep Sedimentary Basin Along the Bristol-Danby Trough, Mojave Desert." *Old Routes to the Colorado*. San Bernardino County Museums Special Publication 92-2. Redlands, CA. pp 57·59.

Karlstrom. K.E., Miller, C.F., Kingsbury, J.A., and Wooden, J.L. 1993. *Pluton Emplacement Along an Active Ductile Thrust Zone. Piute Mountains. Southeastern California. Interaction Between Deformation and Solidification Processes.* Geological Society of America Bulletin. Vol. 105. p 213-230.

Koehler, J.H. 1983. *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base Baghdag Area*. USGS Water Resources Investigations Report 83·4053. California.

Kupfer, D.H. and A.M. Bassett. 1962. *Geologic Reconnaissance Map of the Southeastern Mojave Desert, California.* US Geological Survey, Field Investigations Map MF-205, Scale 1:125,000.

Laczniak, R.J., J.L. Smith, P. E. Elliot, G.A. DeMeo, and M.A. Chatigny. 2001. *Ground-Water Discharge Determined from Estimates of Evapotranspiration, Death Valley Regional Flow System,*

Nevada and California. US Geological Survey, Water-Resources Investigations Report 01-4195.

Liggett, M.A., 2009a. Personal communication, Powerpoint Presentation containing photos of standing water on Bristol Dry Lake.

Liggett, M.A., 2010. Generalized Geologic Map of Fenner Gap. January 3, 2010.

Lindgren, R.J., Dutton, A.R., Hovorka, S.D., Worthington, S.R.H, and Painter, Scott. 2004. *Conceptualization and Simulation of the Edwards Aquifer, San Antonio Region, Texas: U.S.* Geological Survey Scientific Investigations Report 2004-5277. p 143.

Maas, J. 1994. *Depth to Basement Calculated from Gravity Data.* Proprietary report to Cadiz Land Company, Inc. (Cadiz Inc.)

Maidment, D.R.. 1993. *Handbook of Hydrology.* McGraw-Hill, Inc. p 889.

Mendenhall, W.C. 1909. *Some Desert Water Places in Southern California and Southwestern Nevada.* US Geological Survey, Water-Supply Paper 224.

Metropolitan Water District of Southern California. 1999. *Cadiz Groundwater Storage and Dry-Year Supply Program: Draft Environmental Impact Report/Draft Environmental Impact Statement*. SCH No. 99021039, Report No. 1157.

Metropolitan Water District of Southern California. 2000. *Cadiz Groundwater Storage and Dry-Year Supply Program: Supplement to the Draft Environmental Impact Report/Draft Environmental Impact Statement.* SCH No. 99021039, Report No. 1169.

Metropolitan Water District of Southern California. 2001. *Cadiz Groundwater Storage and Dry-Year Supply Program: Final Environmental Impact Report / Final Environmental Impact Statement*. SCH No. 99021039, Report No. 1174 (in 4 volumes).

Miller, D.A. and R.A. White. 1998: *A Conterminous United States Multi-Layer Soil Characteristics Data Set for Regional Climate and Hydrology Modeling*. Earth Interactions, 2. [Available on-line at http://EarthInteractions.org]

Miller, D.M., Howard, K.A., and John, B.E. 1982. "Preliminary Geology of the Bristol Lake Region, Mojave Desert, California." Cooper, J.D., compiler, *Geologic Excursions in the Mojave Desert, Volume and Guidebook.* Geological Society of America, Cordilleran Section 78th Annual Meeting, Fullerton, California, California State University. pp. 91-100.

Miller, D.M., Miller, R.J., Nielson, J.E., Wilshire, H.G., Howard, K.A. and Stone, P. 1991. *Preliminary Geologic Map of the East Mojave National Scenic Area, California.* U.S. Geological Survey Open-File Report 91-435.

Moyle, W.R. 1967. *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*. California Department of Water Resources Bulletin 91-14.

Moyle, W.R., Langer, W.H., Woolfenden, L.R., and Mulvihill, D.A. 1984. *Maps Showing Ground-Water Levels, Springs, and Depth to Ground-Water, Basin and Range Province, Southern California*. U.S. Geological Survey Water Resources Investigation Report 83-4116-B.

Murbach, D., and Baldwin, J., eds. 1994. *Mojave Desert.* South Coast Geological Society. Santa Ana California, Martin Stout Volume. Fieldtrip Guidebook 22. p 669.

National Oceanic Atmospheric Administration (NOAA). 2009. *CPC US Unified Precipitation data provided by the NOAA/OAR/ESRL PSD*. Climate Data Center, CPC. Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/.

Nishikawa, T., Izbicki, J.A., Hevesi, J.A., Stamos, C.L., and Martin, P. 2004. *Evaluation of Geohydrologic Framework, Recharge Estimates, and Ground-Water Flow of the Joshua Tree Area, San Bernardino County, California.* U.S. Geological Survey Scientific Investigations Report 2004-5267. p 115.

NORCAL Geophysical Consultants, Inc. (NORCAL). 1997. *Seismic Reflection Survey Cadiz Valley, Cadiz, California.* Proprietary report to Cadiz, Inc.

Natural Resources Conservation Service (NRCS). 2009a. http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/history.html.

Natural Resources Conservation Service, United States Department of Agriculture (NRCS). 2009b. STATSGO2. U.S. General Soil Map (STATSGO2) for California. Available online at http://soildatamart.nrcs.usda.gov

Painter, S.L., Woodbury, A.D., Jiang, Y. 2007. *Transmissivity Estimation for Highly Heterogeneous Aquifers: Comparison of Three Methods Applied to the Edwards Aquifer, Texas, USA.* Hydrogeology Journal, No. 15. pp. 315-331.

Parker, R.B. 1963. *Recent Volcanism at Amboy Crater San Bernardino County*. California Division of Mines and Geology Special Report 76. p 22.

Rewis, D.L., Christensen, A.H., Matti, J.C., Hevesi, J.A., Nishikawa, Tracy, and Martin, Peter. 2006. *Geology, Ground-Water Hydrology, Geochemistry, and Ground-Water Simulation of the Beaumont and Banning Storage Units, San Gorgonio Pass Area, Riverside County, California.* U.S. Geological Survey Scientific Investigations Report 2006-5026. p 173.

Rosen, M.R. 1989. *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate.* Ph.D. Dissertation, University of Texas, Austin, Texas. pp 266.

Rosen, M.R. 1992. "The Depositional Environment and Evolution of Bristol Lake Basin, Eastern Mojave Desert, California." *Old Routes to the Colorado.* Special Publication, San Bernardino County Museum Association.

Simpson, R.W., R.C. Bracken, and D.J. Stierman. 1984. *Aeromagnetic, Bouguer Gravity, and Interpretation Maps, Sheep Hole-Cadiz Wildness Study Area, California.* U.S. Geological Survey MF 1615-B, 4 sheets, scale 1:62,500.

Thompson, D.G. 1929. *The Mohave Desert Region, California, A geographic, geologic, and hydrologic reconnaissance.* U.S. Geological Survey Water Supply Paper, 578. pp 795.

U.S. Geological Survey (USGS). 2000. *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources,*

Volumes I and II. Memorandum from James F. Devine to Molly S. Brady, Field Manager, Bureau of Land Management, Needles, California. February 23, 2000.

U.S. Geological Survey (USGS). 2006a. National Elevation Dataset. http://ned.usgs.gov/

U.S. Geological Survey (USGS). 2006b. *Geology and Mineral Resources of the East Mojave National Scenic Area, San Bernardino County, California.* U.S. Geological Survey Bulletin 2160.

U.S. Geological Survey (USGS). 2007. *Geology and Mineral Resources of the East Mojave National Scenic Area, San Bernardino County, California*. U.S. Geological Survey Bulletin 2160.

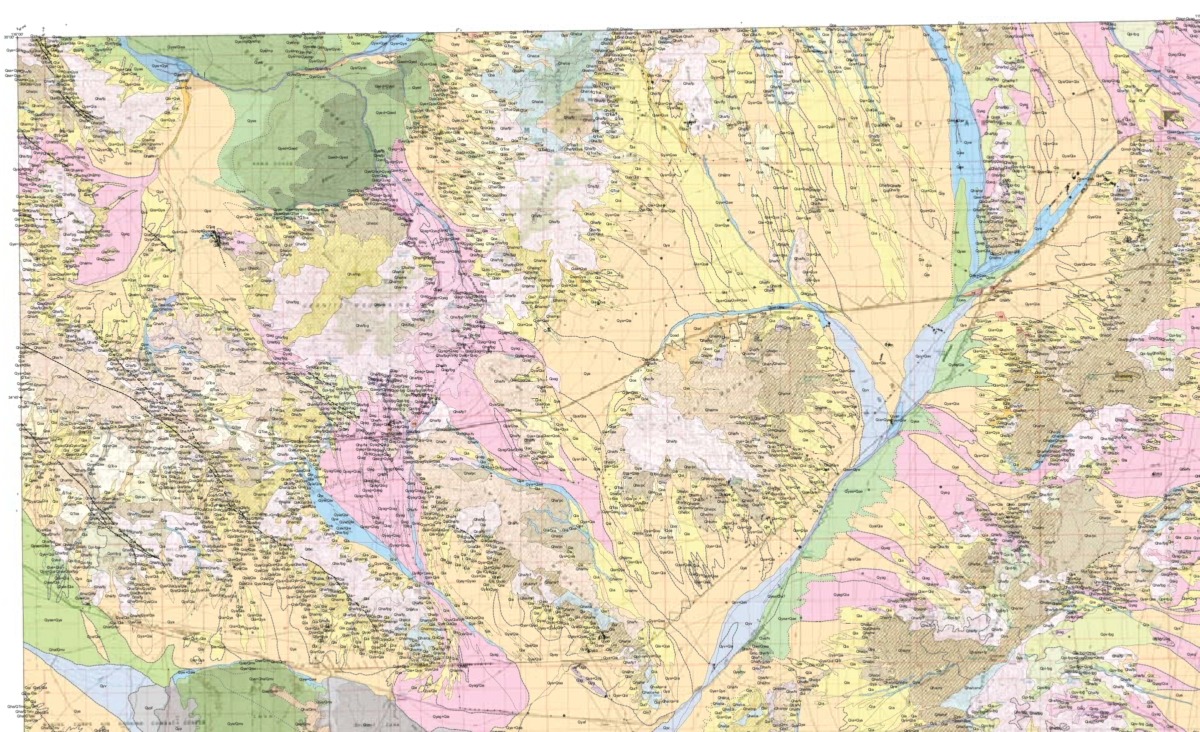
U.S. Geological Survey (USGS). 2008. *Documentation of Computer Program INFIL3.0 – A Distributed-Parameter Watershed Model to Estimate Net Infiltration Below the Root Zone.* U.S. Geological Survey Scientific Investigations Report 2008-5006. p 98. Online only.

U.S. Geological Survey (USGS). 2009. Online Well Database. http://waterdata.usgs.gov/ca/nwis/inventory and http://waterdata.usgs.gov/nwis/gwconstruction.

Appendix A
Field Investigation Report (CD)

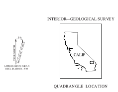
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Open-File Report 2006-1165
Pamphlet accomanies map
Preliminary Surficial Geologic Map Database of the Amboy
30x60 Minute Quadrangle, California
SHEET 1 of 1



Modified base from U. S. Geological Survey, 1985
Projection, zone 11 Universal Transverse Mercator
1927 North American Datum
Contours and elevations in meters

INTERIOR—GEOLOGICAL SURVEY



QUADRANGLE LOCATION

SCALE 1:100 000

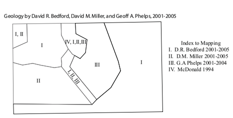
Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California

By

David R Bedford, David M Miller, and Geoff A Phelps

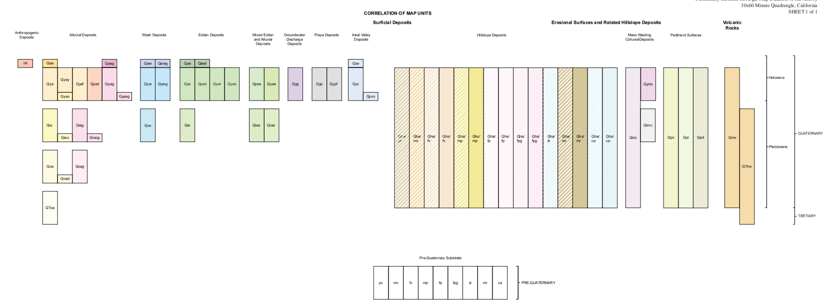
2006

Geology by David R. Bedford, David M. Miller, and Geoff A. Phelps, 2001-2005



Index to Mapping
I. D.R. Bedford 2001-2005
II. D.M. Miller 2001-2005
III. G.A Phelps 2001-2004
IV. McDonald 1994

CORRELATION OF MAP UNITS



Description of Map Units

Surficial Deposits

Erosional Surfaces and Related Hillslope Deposits

Volcanic rocks

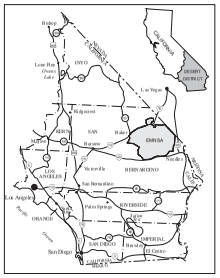
Substrate materials

Explanatory notes

Line Symbols

Point Symbols

USGS U.S. Department of the Interior
U.S. Geological Survey



INDEX MAP SHOWING LOCATION OF EAST MOJAVE NATIONAL SCENIC AREA (EMNSA)

Base from U.S. Geological Survey, 1:100,000, Davis Dam, 1983; Amboy, Iverson, Mesquite Lake, Needles, 1985; Soda Mountains, 1993
Universal Transverse Mercator projection

EXPLANATION

Unit labels—Indicate composition of detritus comprising the alluvial deposits (labels shown in red represent the dominant lithologic component); unit labels refer to units described on Plate 1

Approximate boundaries between areas having crudely homogeneous composition of surface detritus

Topographic range front (as interpreted from aerial photography)

Alluvial deposits exceed 300 m in thickness on hachured side of boundary

Drainage divide

Distribution of mapped geologic units generalized from Plate 1:

- **Quaternary and Tertiary sedimentary rocks and surficial deposits**
- **Quaternary and Tertiary volcanic rocks**
- **Mesozoic plutonic rocks**
- **Mesozoic to Late Proterozoic sedimentary and volcanic rocks**
- **Proterozoic plutonic and metamorphic rocks**

Approximate boundary of East Mojave National Scenic Area (EMNSA, this report)

Approximate boundary of Mojave National Preserve (current as of March 2007)

Geology generalized from Plate 1 of this report
Interpretation of aerial photography by John Dohrenwend and Mary McKittrick, 1986, from photography acquired 1970–1980
Digital database by R.J. Miller
Edited by T.A. Lindquist and J.L. Zigler
Digital cartography by R.D. Koch
Manuscript approved for publication September 11, 1998

SCALE 1:125 000

TOPOGRAPHIC CONTOUR INTERVAL 20 AND 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Digital files of plate 3 are also on MF-2414 file in U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, or call 1-888-ASK-USGS.

Any use of trade, firm, or product names in this publication is for identification purposes only and does not imply endorsement by the U.S. Government.

Estimated Extent of Pediments and Adjacent Areas of Thin Alluvial Cover, Including Generalized Lithologic Content of Piedmont Deposits and Inferred Thickness of Cenozoic Cover in the East Mojave National Scenic Area, California

By
John C. Dohrenwend and Mary A. McKittrick

2007

Thesis here, T. G., et al., 2007, Geologic and mineral resources of the East Mojave National Scenic Area, San Bernardino County, California: U.S. Geological Survey Bulletin 2160

VOLUME 2

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638

VOLUME 3

VOLUME 3:
APPENDICES B-G

Cadiz Groundwater Modeling and Impact Analysis

September 1, 2011

Prepared for: Brownstein Hyatt Farber Schreck, LLP

Prepared by:

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638

CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS

TABLE OF CONTENTS

VOLUME 1 - REPORT

ABBREVIATIONS AND DEFINITIONS 1

1.0 EXECUTIVE SUMMARY 5

2.0 INTRODUCTION 15

2.1. Purpose and Scope 15

2.2. Description of Study Area 16

2.3. Previous Investigations 16

2.4. Recent Supplemental Geohydrologic Investigations 17

2.5. Sources of Data 18

3.0 GEOLOGY 19

3.1. Geologic Setting 19

3.2. Geologic Units 20

3.2.1. Alluvium 21

3.2.2. Tertiary Volcanics and Fanglomerates 21

3.2.3. Archaen and Jurassic Granitic and Metamorphic Bedrock 22

3.3. Geologic Structure 23

3.3.1. Overview of Geologic History and Structure 23

3.3.2. Geologic Structure in Fenner Gap 24

4.0 HYDROLOGY 26

4.1. Precipitation 26

4.2. Groundwater Occurrence and Movement 26
4.3. Aquifer Systems 27
4.4. Groundwater Storage 28
4.5. Groundwater Quality 28

5.0 MODEL DEVELOPMENT AND CONSTRUCTION 30
5.1. Conceptual Model 30
5.2. Computer Code 30
5.3. Model Domain, Grid and Time Discretization 31
5.4. Boundary Conditions 32
5.5. Aquifer Parameters 33
5.5.1. Lithologic Model in the Fenner Gap Area 33
5.5.2. Layer Elevations 34
5.5.3. Effective Porosity and Storativity 35
5.5.4. Hydraulic Conductivity 36
5.5.5. Vertical Leakance 38
5.5.6. Initial Groundwater Elevations 38
5.5.7. Dispersivity 39
5.5.8. Elastic and Inelastic Storage Coefficients 39
5.5.9. Preconsolidation Stress 39
5.6. Recharge and Discharge 40
5.6.1. Natural Recharge and Artificial Recharge 40
5.6.2. Groundwater Pumping 40
5.6.3. Evapotranspiration 41

6.0 MODEL CALIBRATION AND SENSITIVITY ANALYSIS....43

6.1. Model Calibration Approach....43

6.2. Steady State Model Calibration....45

6.3. Transient Model Calibration....46

6.4. Sensitivity Analysis....49

7.0 MODEL PREDICTIVE SCENARIOS....50

7.1. Description of Model Scenarios....50

7.2. Project Pumping....51

7.3. Natural Recharge....51

7.4. Project Extraction Wells....52

7.4.1. Wellfield Configuration....52

7.4.2. Conceptual Drill Site Layout and Wellfield Manifold System....53

7.4.3. Well Cross-Section....54

7.5. Initial conditions....55

8.0 IMPACT ANALYSIS....56

8.1. Groundwater Elevations....56

8.2. Drawdown Analysis....56

8.2.1. Regional Drawdown....56

8.2.2. Drawdown during Dry Year, Wet Year and Average Year Conditions....57

8.3. Depth to Groundwater....59

8.4. Saline Water/Freshwater Interface....60

8.5. Groundwater in Storage....61

8.6. Potential Land Subsidence....62

9.0 FINDINGS 64

10.0 MODEL LIMITATIONS AND UNCERTAINTY 69

11.0 REFERENCES 70

FIGURES, TABLES, APPENDICES (VOLUMES 2 AND 3)

FIGURES

No.	Description
1	General Project Location
2	2009 Groundwater Elevations
3	Total Dissolved Solids Concentrations
4	Cadiz Groundwater Model Boundary
5	Cadiz Groundwater Model Grid
6	Boundary Conditions of the Cadiz Groundwater Model
7	Fenner Gap Lithologic Model Boundary
8a	Lithologic Model Results – Cross Section 3-3’
8b	Lithologic Model Results – Cross Section 3-3’ Legend
9	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 4
10	Zone of Percent Carbonate Distribution for Cadiz Groundwater Model Layer 5
11	Bottom Layer Elevations of the Cadiz Groundwater Model
12	Layer Thickness of the Cadiz Groundwater Model
13	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 32,000 acre-ft/yr
14	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 16,000 acre-ft/yr
15	Hydraulic Conductivity of the Cadiz Groundwater Model – Natural Recharge of 5,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
16	Vertical Leakance of the Cadiz Groundwater Model
17	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 32,000 acre-ft/yr
18	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 16,000 acre-ft/yr
19	Initial Groundwater Elevations for Transient Model Calibration – Natural Recharge of 5,000 acre-ft/yr
20	Inelastic Storage Coefficient and Clay Thickness (ft) of the Cadiz Groundwater Model
21	Areal Distribution of Natural Recharge Rate of 32,000 acre-ft/yr
22	Annual Groundwater Pumping of Cadiz Agricultural Wells
23	PEST Hydraulic Conductivity Pilot Points
24	Location of Wells with Water Level Data Used for Steady State Model Calibration
25	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
26	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr
27	Measured versus Model-Calculated Water Levels – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
28	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 32,000 acre-ft/yr
29	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
30	Spatial Distribution of Water Level Residuals – Steady State Model Calibration for Natural Recharge of 5,000 acre-ft/yr
31	Location of Wells with Water Level Data Used for Transient Model Calibration
32	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
33	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
34	Selected Hydrographs of Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
35	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
36	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
37	Measured versus Model-Calculated Water Levels – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
38	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
39	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
40	Histogram of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
41	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
42	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
43	Spatial Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
44	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 32,000 acre-ft/yr
45	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 16,000 acre-ft/yr
46	Temporal Distribution of Water Level Residuals – Transient Model Calibration for Natural Recharge of 5,000 acre-ft/yr
47	Normalized Sensitivity of Selected Model Parameters
48	Cadiz Conservation Project Scenario Wellfield Configuration A
49	Cadiz Conservation Sensitivity Scenarios Wellfield Configuration B
50	Cadiz Groundwater Conservation and Storage Project Annual Pumping for Project Conservation Scenario
51	Conceptual Drill Site Layout
52	Cadiz Conservation Project Scenario Schematic of Proposed Manifold System
53	Conceptual Well Design Diagram
54	Initial Groundwater Elevations for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
55	Initial Groundwater Elevations for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr

FIGURES (CONTINUED)

No.	Description
56	Initial Groundwater Elevations for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr
57	Initial TDS Concentrations for Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2
58	Model-Calculated Groundwater Elevations at the End of 50 Years – Project Scenario
59	Model-Calculated Groundwater Elevations at the End of 100 Years – Project Scenario
60	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 1
61	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 1
62	Model-Calculated Groundwater Elevations at the End of 50 Years – Sensitivity Scenario 2
63	Model-Calculated Groundwater Elevations at the End of 100 Years – Sensitivity Scenario 2
64	Regional Drawdown at the End of 50 Years – Project Scenario
65	Regional Drawdown at the End of 100 Years – Project Scenario
66	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 1
67	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 1
68	Regional Drawdown at the End of 50 Years – Sensitivity Scenario 2
69	Regional Drawdown at the End of 100 Years – Sensitivity Scenario 2

FIGURES (CONTINUED)

No.	Description
70	Model Calculated Drawdown at Selected Locations
71	Model Calculated Depth to Water at Selected Locations
72	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Project Scenario
73	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 1
74	Model-Generated Saline Water and Freshwater Interface (TDS = 1,000 mg/L) – Sensitivity Scenario 2
75	Model Calculated TDS Concentrations at Selected Locations
76	Cumulative Annual Changes in Groundwater Storage - Conservation Scenarios
77	Model-Calculated Potential Land Subsidence – Project Scenario
78	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 1
79	Model-Calculated Potential Land Subsidence – Sensitivity Scenario 2
80	Model-Calculated Potential Land Subsidence at Selected Locations

TABLES

No.	Description
1	Groundwater Pumping for the Transient Model Calibration – 1986 to 2009
2	Groundwater Budget for Project Scenario – Natural Recharge of 32,000 acre-ft/yr
3	Groundwater Budget for Sensitivity Scenario 1 – Natural Recharge of 16,000 acre-ft/yr
4	Groundwater Budget for Sensitivity Scenario 2 – Natural Recharge of 5,000 acre-ft/yr

APPENDICES

Ltr.	Description

VOLUME 2 – APPENDIX A

A	Cadiz Groundwater Conservation and Storage Project – Prepared by CH2M Hill

VOLUME 3 – APPENDICES B-G

B	Geologic Structural Evaluation of the Fenner Gap Region Located between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. Prepared by Dr. Miles Kenney
C	Geohydrologic Assessment of the Fenner Gap Area. Prepared by GEOSCIENCE Support Services, Inc.
D	Timeline – Chronology for Estimates of Natural Recharge to the Cadiz Project Area
E	Hydrographs for Transient Model Calibration with Natural Recharge of 32,000 acre-ft/yr
F	Hydrographs for Transient Model Calibration with Natural Recharge of 16,000 acre-ft/yr
G	Hydrographs for Transient Model Calibration with Natural Recharge of 5,000 acre-ft/yr

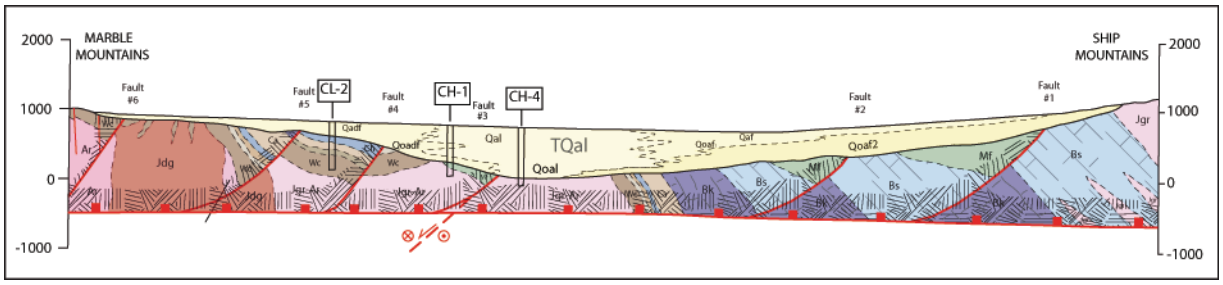
APPENDIX B

Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountians and Ship Mountains, San Bernardino County, California

(Prepared by Dr. Miles Kenney)

GEOSCIENCE

GEOLOGIC STRUCTURAL EVALUATION OF THE FENNER GAP REGION LOCATED BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA



Report Prepared for:

Brownstein Hyatt Farber Schreck, LLP
Mr. Scott Slater
21 East Carrillo Street
Santa Barbara, CA 93101

Report Prepared by:

Kenney GeoScience,
Dr. Miles Kenney, PG
7206 Plaza de la Costa,
Carlsbad, Ca, 92009.

August 31, 2011

Date: August 31, 2011

From: **Miles Kenney PhD, PG**
Kenney GeoScience
7206 Plaza de la Costa,
Carlsbad, Ca, 92009

To: **Mr. Scott Slater**
Brownstein Hyatt Farber Schreck, LLP
21 East Carrillo Street
Santa Barbara, CA 93101

Subject: **Geologic Structural Evaluation of the Fenner Gap region located between the southern Marble Mountains and Ship Mountains, San Bernardino County, California**

Mr. Slater,

Kenney GeoScience (KGS) is pleased to provide you this report providing a geologic structural evaluation of the Fenner Gap region located between the southern tip of the Marble Mountains and northwestern Ship Mountains, eastern San Bernardino County, California. The primary motivation for this work is to provide reasonable geologic structural constraints for groundwater analysis of the Fenner Valley hydrologic basin, which feeds into the Bristol Valley and Cadiz Valley Groundwater Basins through the Fenner Gap. This work was conducted in association with project team members from CH2M Hill and Geoscience Support Services, Inc.

The primary results of this study are provided on a Geologic Map (Plate 2, attached), and eight cross sections that transect the Fenner Gap region (Plates 3 and 4). The geologic map and cross sections were constructed utilizing data obtained from field mapping bedrock exposures within hills and mountain ranges, Google Earth imagery, evaluation of well cores and samples, interpretation of a seismic reflection line, geologic structural principles, and well documented structural characteristics associated with extensional tectonics and igneous intrusions.

This report contains explanatory figures within the text, appendices providing supportive data (publication in progress), and four attached plates (Plate 1 - Regional Geology, Plate 2 - Geologic Map of the Study Area, Plate 3 - Cross Sections 1 through 5, and Plate 4 - Cross Sections A through C).

Dr. Miles D. Kenney PG

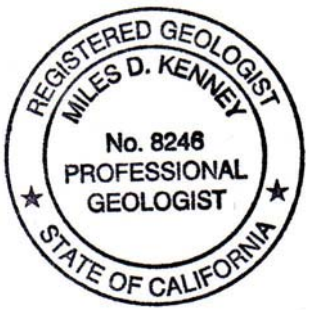


TABLE OF CONTENTS

1.0 PROJECT OBJECTIVESAND PURPOSE **1**

2.0 SITE LOCATION AND DESCRIPTION **1**
2.1 Site topography and geomorphology 2

3.0 REGIONAL PHYSIOGRAPHIC AND GEOLOGIC SETTING **3**

4.0 PROJECT METHODOLOGY **4**
4.1 Field mapping and logging of boring cores, samples and video 4
4.2 Seismic reflection line 4
4.3 Cross sections and maps by Mark Liggett 4
4.4 Google earth imagery 4
4.5 Gravity based basement structure contours 5
4.6 Field and in house discussions with team members 5
4.7 Existing literature 5

5.0 GENERAL REGIONAL GEOLOGIC HISTORY **5**
5.1 Pre-Cambrian (Archean and Proterozoic) through Paleozoic Eras 5
5.2 Mesozoic Era 6
5.3 Cenozoic Era 9

6.0 MECHANISMS OF EXTENSIONAL TECTONICS IN TEHH BASIN AND RANGE **11**
6.1 Detachment faulting 11
6.2 Metamorphic core complexes 12
6.3 High angle normal faults 13
6.4 Extensional volcanism 14
6.5 Common stratigraphy and structure associated with extensional tectonics 14

7.0 FINDINGS 15
7.1 Geology of the Fenner Gap 15
7.1.1 Archean Igneous and Metamorphic Complex 16
7.1.2 Paleozoic sedimentary section 16
7.1.3 Jurassic Igneous and Metamorphic Suite 17
7.1.3.1 Jurassic Granitics 18
7.1.3.2 Jurassic Dioritic Gneiss 18
7.1.3.3 Jurassic and Archean Suite 18
7.1.3.4 Structures produced by Jurassic igneous intrusives 19
7.1.4 Miocene fanglomerates with a note regarding mylonites 19
7.1.5 Miocene volcanics 19

7.1.5.1 Tv (Extrusives) 19
7.1.5.2 Tvi (Hypabyssal) 20
7.1.6 Late Tertiary to Quaternary alluvial deposits (TQal) 21
7.1.6.1 Fenner Valley Axis Deposits 21
7.1.6.2 Distal fluvial fans near the Marble Mountains 21
7.1.6.3 Fluvial and fanglomerates 21
7.1.7 Ancient playa lake and Fenner Valley sill 22

8.0 DEPTH STRUCTURE EVALUATION ACROSS FENNER GAP 22
8.1 Approach and principles 22
8.2 Deformational events 23
8.3 Evidence for Jurassic intrusives in Fenner Gap 24
8.4 Evidence for listric normal faults in Fenner Gap 24
8.5 Evidence for the existence of the detachment fault 25
8.6 Additional structures to convolve 25

9.0 SUMMARY OF MIOCENE FAULT HISTORY 26

10.0 CONCLUSIONS 26

11.0 REFERENCES 28

Attachments:

Plate 1 Regional geologic map of the Fenner Gap area
Plate 2 Geologic map of the Fenner Gap between the southern Marble Mountains and Ship Mountains
Plate 3 Geologic cross sections 1, 2, 3, 4 and 5 across the Fenner Gap between the southern Marble Mountains and Ship Mountains.
Plate 4 Geologic cross sections A, B and C across the Fenner Gap between the southern Marble Mountains and Ship Mountains.

Appendix A:

Providing Supportive Data for Report

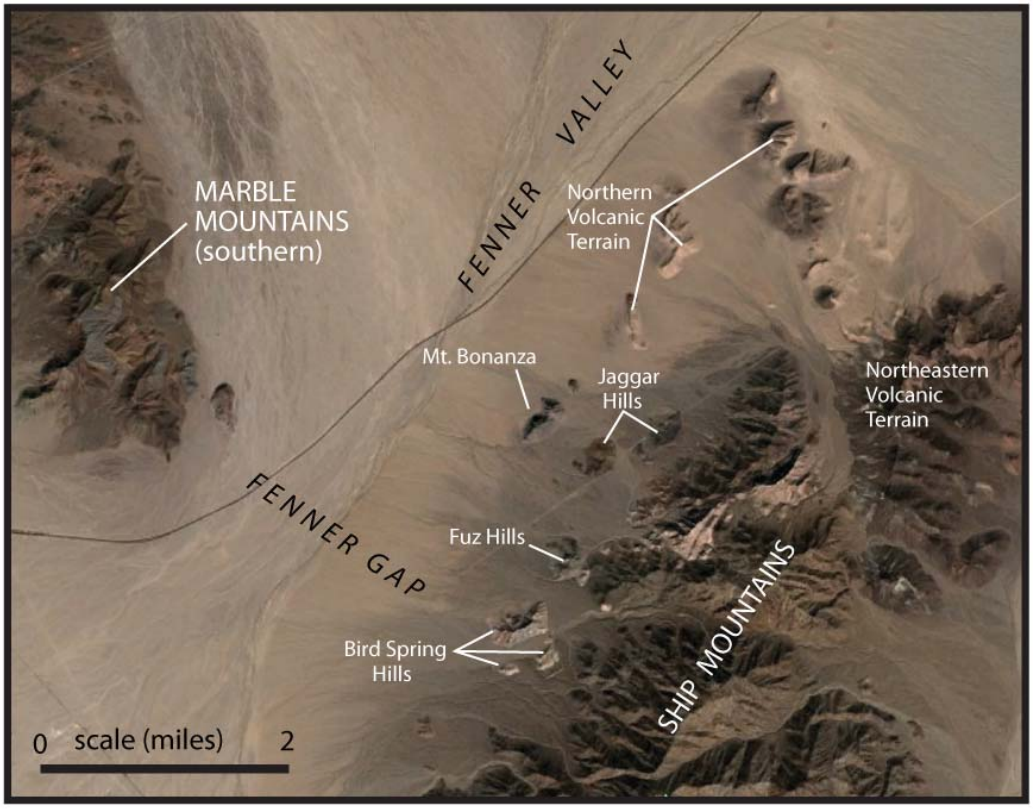
1.0 PROJECT OBJECTIVES AND PURPOSE

The objective of this report is to provide a reasonable and detailed stratigraphic and structural geologic evaluation of the depth structure in the Fenner Gap, which is described herein as the valley between the southern tip of the Marble Mountains and the northern flanks of the Ship Mountains. CH2M Hill and Geoscience Support Services, Inc. will utilized the subsurface structural and stratigraphic data to perform a detailed groundwater conductivity analysis within the Fenner Gap. The center piece of this work are the Geologic Map at a scale of 1:1000' (Plate 1), and eight cross sections transecting the Fenner Gap region provided on Plates 3 and 4.

2.0 SITE LOCATION AND DESCRIPTION

The study area as shown on Plate 1 represents an area encompassing the southern most Marble Mountains, southeastern Fenner Valley and the western to northern Ship Mountains, in San Bernardino County, California. This region is located approximately 17 miles east of Amboy, San Bernardino County, California and a couple of miles south of the Interstate Highway 66. The Fenner Gap is defined as an approximately 2.6 miles wide valley at the southwestern end of the Fenner Valley located between the southern tip of the Marble Mountains and the northwestern most bedrock exposures of the Ship Mountains. The approximate center of the Fenner Gap is located at Latitude 34 31.2N, and Longitude 115 26.7W. Figure 1 below shows the general region of the study area (similar to the geologic map of Plate 2), the Fenner Gap, and a number of designated areas discussed in this report. Names were applied to some bedrock inselbergs (bedrock exposures surrounded by young alluvium) for discussion purposes, which are also shown on Figure 1. These include Bird Spring Hills, Fuz Hills, Mt. Bonanza, Jaggar Hills, northern volcanic terrain, and the northeastern volcanic terrain. These areas are also shown on the Geologic Map (Plate 2) and cross sections (Plates 3 and 4).

Figure 1: Shows the general study area, the Fenner Gap, the southern end of the Fenner Valley, the Marble and Ship Mountains, and designated names for geologic terrains discussed within this report.



2.1 Site topography and geomorphology

Elevations across the Fenner Gap from northwest to southeast vary from a high of ~1,600 feet above mean sea level (msl) in the southern Marble Mountains, 931' msl at the base of the Marble Mounts, ~900 feet in the valley axis, ~1100 feet at the base of the Ship Mountains, to ~3200 along the crest of the Ship Mountains. Alluvial fan sediment aprons (bajadas) surround the deeply incised Marble and Ship Mountain that range in age from late Pleistocene to present. Numerous alluvial fan surfaces near the mountain fronts are latest Pleistocene in age (<25,000 years old) and do not exhibit any identified fault scarps or lineaments suggesting that faulting has not occurred locally since their deposition. In addition, no lineaments were identified associated with the now inactive normal faults that were active during the Miocene extensional tectonic phase of deformation.

Relatively large bedrock inselbergs exist along the northern flanks of the Ship Mountains that include Bird Spring Hills, Fuz Hills, Mt. Bonanza, Jaggar Hills and the volcanic buttes in the Northern Volcanic Terrain (Figure 1). The inselbergs provide critical information regarding the subsurface structure and lithology in the area. The existence of inselbergs along mountain ranges is typical of Basin and Range extensional tectonic regions where they represent elevated bedrock highlands associated with normal faulting that subsequently received alluvial sediments around them once normal faulting ceased. These data provide strong evidence that normal faulting is no longer active in the study area.

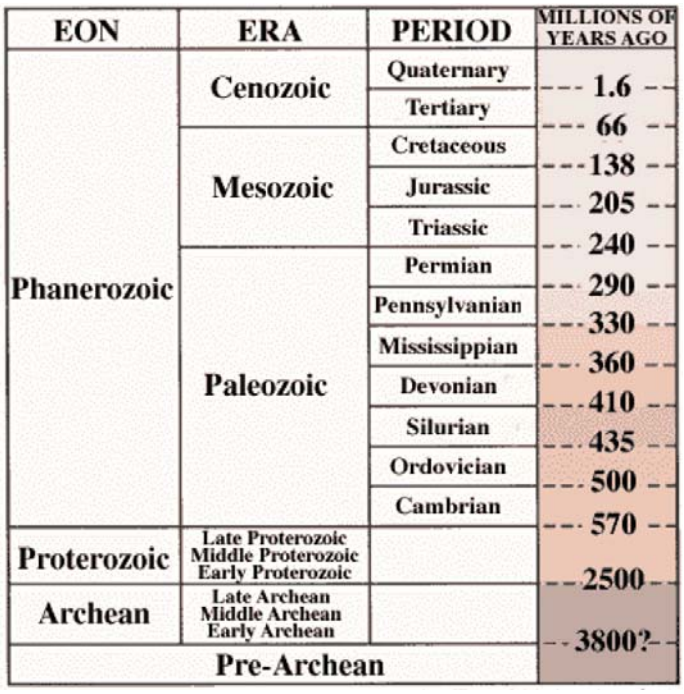
There are a few important inselbergs in the southern Marble Mountains. One of these is located just 400 feet south of the southern tip of the Marble Mountains, which exposes a small low relief outcrop of strongly foliated Jurassic dioritic gneiss that is not identified within the southern Marble Mountains proper (Plate 2). Very similar gneissic rocks occur on the southern side of the Marble Mountains within the Jagger Hills (see Figure 1) indicating that the strongly foliated rocks likely extend across the Fenner Gap.

3.0 REGIONAL PHYSIOGRAPHIC AND GEOLOGIC SETTING

The site is located in the Basin and Range Geomorphic Province (BRGP), which is characterized by a series of structural and topographic basins bounded by relatively linear mountain ranges. The BRGP exists throughout Nevada, eastern and southeastern California, and western to southern Arizona. The alternating mountains and valley topography primarily resulted from extensional (pulling apart) tectonics that occurred during the Miocene (see Wernicke, 1992 for a good review). Most valleys within the BRGP are truly basins in the sense that sediments eroding from the local mountain ranges deposit relatively locally within the immediate valley. Streams remain trapped within the BRGP basins and do not terminate to the Pacific Ocean or Gulf of California (Sea of Cortez). In addition groundwater remains trapped in alluvial valley sediments and upper bedrock units within the basins. Understanding groundwater transport in part requires knowledge of the local subsurface stratigraphy and geologic structure. For example, depth, thicknesses and characteristics of the relatively young basin alluvial sediments and underlying bedrock units, location of faults, and the type of geologic units (i.e. crystalline bedrock, volcanic, carbonates, nonlithified sedimentary). Plate 2 provides a geologic map of the study area, which shows numerous mountain ranges and interconnecting valleys typical of the BRGP.

The age of the rocks in the study area range from Proterozoic (1.4 Billion years old – i.e. Pre-Cambrian) to currently depositing alluvial sediments of Quaternary age (Figure 2). Thus the geologic history as provided by identified rocks in the region involves approximately 1.4 billion years.

Figure 2: Generalized Geologic time scale (USGS website).



4.0 PROJECT METHODOLOGY

Data utilized to evaluate the subsurface geologic structure of the Fenner Gap region included field geologic mapping, logging of boring cores, sample cuttings, photographs and videos, seismic reflection data, cross sections and maps provided by Mark Liggett, Google Earth imagery, gravity based basement structure contours, field and in house discussions with team members, and existing literature. These are discussed below.

4.1 Field mapping and logging of boring cores, samples and video

Field mapping was conducted during approximately 21 days between September 2010 and February 2011. Approximately three of these days were utilized to review onsite cores. Mapping utilized USGS 7.5 minute topographic maps at a scale of 1:1000 (1 inch = 1,000 feet), a hand held GPS unit, and Google Earth imagery on an iPhone. During mapping, a total of 358 individual "sites" were evaluated geologically with recorded data such as latitude and longitude, field cross sections, unit descriptions, strikes and dips of bedding, faults, foliation, fracturing, and the existence of folds, vugs (void spaces within bedrock) or other structures. Fracture density was also noted particularly in bedrock outcrops (rocks of Mesozoic age and older). Rock samples were collected at various sites in addition to photographs. The results of the field mapping are shown on the Geologic Map of Plate 1. Mapping of the southern Marble Mountains was greatly assisted by geology faculty at Cal State Fullerton.

Boring data utilized in this report include PW-1, Well 5/14-13, TH-1, Cl-1, Cl-2, CH-1, CH-2, CH-4, CH-5, MW-5, TW-1, TW-2, TW-2B, TW-3, and DT-1. The locations of the borings are shown on Plate 2 (Geologic Map). Data from the PW-1 boring included verbal communication from team members that crystalline bedrock existed at a particular depth, which was utilized in the cross sections (Plates 3 and 4). Data for Well 5/14-13 and TH-1 consisted of references to these borings in the seismic reflection report by NORCAL (1997) that included brief descriptions of the type and depth of bedrock provided by Mark Liggett. Cores or cuttings were evaluated for borings TW-2B, TW-3, CH-1, CH-4, CH-5, and DT-1. A video of boring TW-1 was also available for review in addition to Field logs produced during drilling for all borings as well. Boring cores and/or cuttings were logged during this study with an emphasis to identify bedding dip, clast assemblage (i.e. proximal carbonates, volcanics, granitics, or distal clasts), fault gouge zone thickness and characteristics, rock unit name (which formation), etc. These data were critical during the construction of the cross sections shown on Plates 3 and 4.

4.2 Seismic reflection data

The NORCAL (1997) report provides data and interpretation of a 2.1-mile long seismic reflection line that extends from the southern tip of the Marble Mountains in the northwest to nearly across the Fenner Gap toward the southeast. The location of the seismic line is shown on Plate 2. The reflection data extends to depths of approximately 1500 feet. The NORCAL data interpretation was conducted utilizing structural models (maps and cross sections) provided by Mark Liggett.

4.3 Cross sections and maps by Mark Liggett

A number of generalized geologic maps, cross sections, and boring log interpretations by Mark Liggett were available for review during preparation of this report. These data greatly assisted KGS in gaining a quick understanding of the local structure and stratigraphy of the region.

4.4 Google earth imagery

Google Earth was utilized during field mapping, to locate field sites with latitude and longitude, and to map areas not physically walked during field mapping. This program was the primary data source to map the alluvial fan surfaces across the sites that were correlated to field mapping sites.

4.5 Gravity based basement structure contours

CH2M Hill provided structure basement contour maps identifying the approximate depth of "bedrock" based on gravity data provided by Dr. John P. Maas whom also assisted NORCAL during their seismic reflection line study.

4.6 Field and in house discussions with team members

Considerable hydrologic, geophysical and geologic work had been conducted for the project prior to KGS involvement. Provided information involving discussions, publications, geologic maps, cross sections, and boring logs provided by team members with CH2M Hill and Geoscience Support Services proved to be a critical component of this study.

4.7 Existing literature

Pertinent scientific publications were obtained for this study as well as utilization of KGS in house l publications and those provided by team members at the beginning of the project. The literature covered topics including age and structure of local and regional faulting and deformation, stratigraphy, and plutonism and volcanism in the region. The literature emphasized understanding Paleozoic sedimentary formations (composition, age, regional thicknesses) and the Miocene extensional tectonic event locally and throughout the southwestern United States. Strangely, no detailed geologic maps were identified for the Fenner Gap region, which motivated the need to conduct detailed geologic mapping during this project.

5.0 GENERAL REGIONAL GEOLOGIC HISTORY

5.1 Pre-Cambrian (Archean and Proterozoic) through Paleozoic Eras

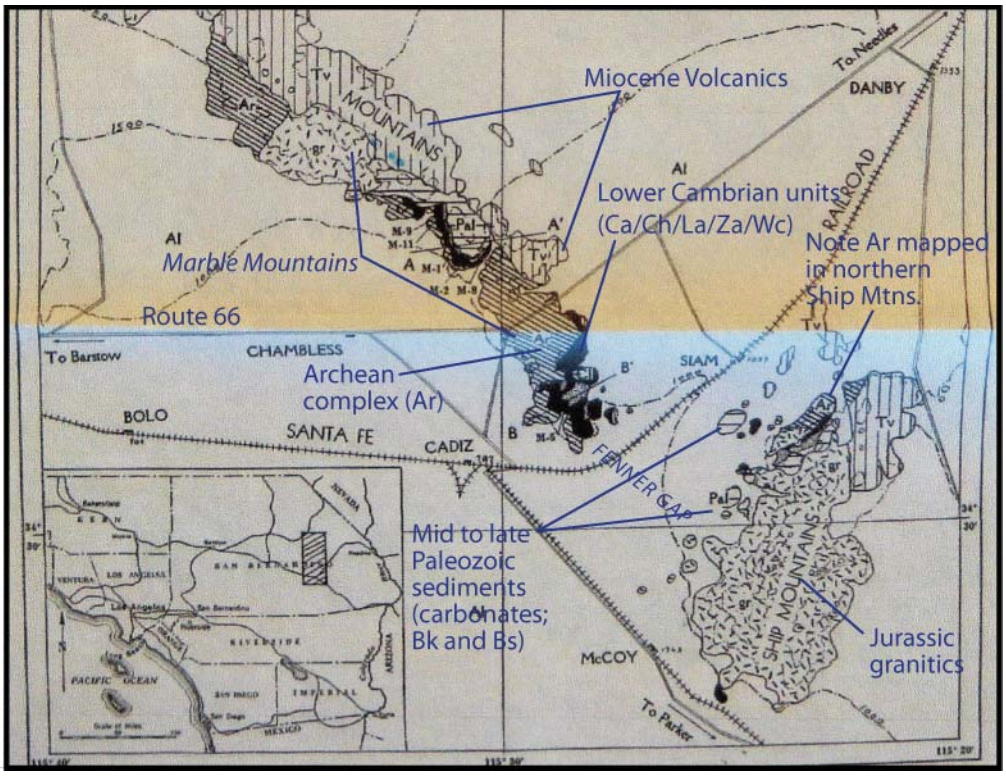
The general geologic history at the site first involved the creation of the pre-Cambrian (Archean to Proterozoic age) craton composed of igneous and metamorphic rocks that extends across most north America. Locally these rocks are approximately 1.4 billion years ago (Plate 1, Silver and McKinney, 1963; Lanphere, 1964). The Archean to Proterzoic age rocks essentially represent the initial continental crust of the North American tectonic plate. These rocks were subsequently eroded to nearly flat across western north America, which provided a platform surface for deposition of a very thick sequence of Paleozoic marine and terrestrial sediments. The contact between the Paleozoic sediments and the underlying Archean and Proterozoic craton rocks represents an unconformity of over 400 million years. This unconformity is referred to as the Great Unconformity and extends over a very large region in western North America and is very well exposed at the base of the Grand Canyon and within the site.

Western North America was tectonically quiet with very little tectonic deformation during most of the Paleozoic. This allowed for the deposition of the thick marine and terrestrial sediments in the region including thousands of feet of Paleozoic deposits within the study area. Locally, these deposits include from oldest to youngest: Wood Canyon (quartzite), Zabriskie Quartzite, Latham Shale, Chambless Limestone, and Bird Spring (carbonates and quartzites) formations (Plate 2). This sequence of sandstones, silts and carbonates were deposited as cratonal platform deposits on top of the Great Unconformity erosion surface. Many of cratonal platform formations are correlated thousands of miles across North America. Selected publications discussing these rocks include Hazard and Crickmay (1933), Hazzard and Mason (1936), Hazzard (1954), Brown, (1981), Miller et al. (1982), Stone et al. (1983), Fedo and Cooper (1989), Montanez and Osleger (1996), Howard (2002), and Stevens and Stone (2007).

It should be noted that the pre-Cambrian igneous and metamorphic complex in the Fenner Gap is referred to herein as Archean (symbol Ar), however its true age is Proterozoic. The map symbol Ar for the unit was utilized herein because Hazard and Crickmay (1933) originally mapped these rocks as Archean

(symbol Ar, Figure 3) and regionally the pre-Cambrian cratonal rocks range in age from Archean to Proterozoic.

Figure 3: Modified geologic map of the study area by Hazard and Crickmay (1933). This represents the first geologic map of the area.



5.2 Mesozoic Era

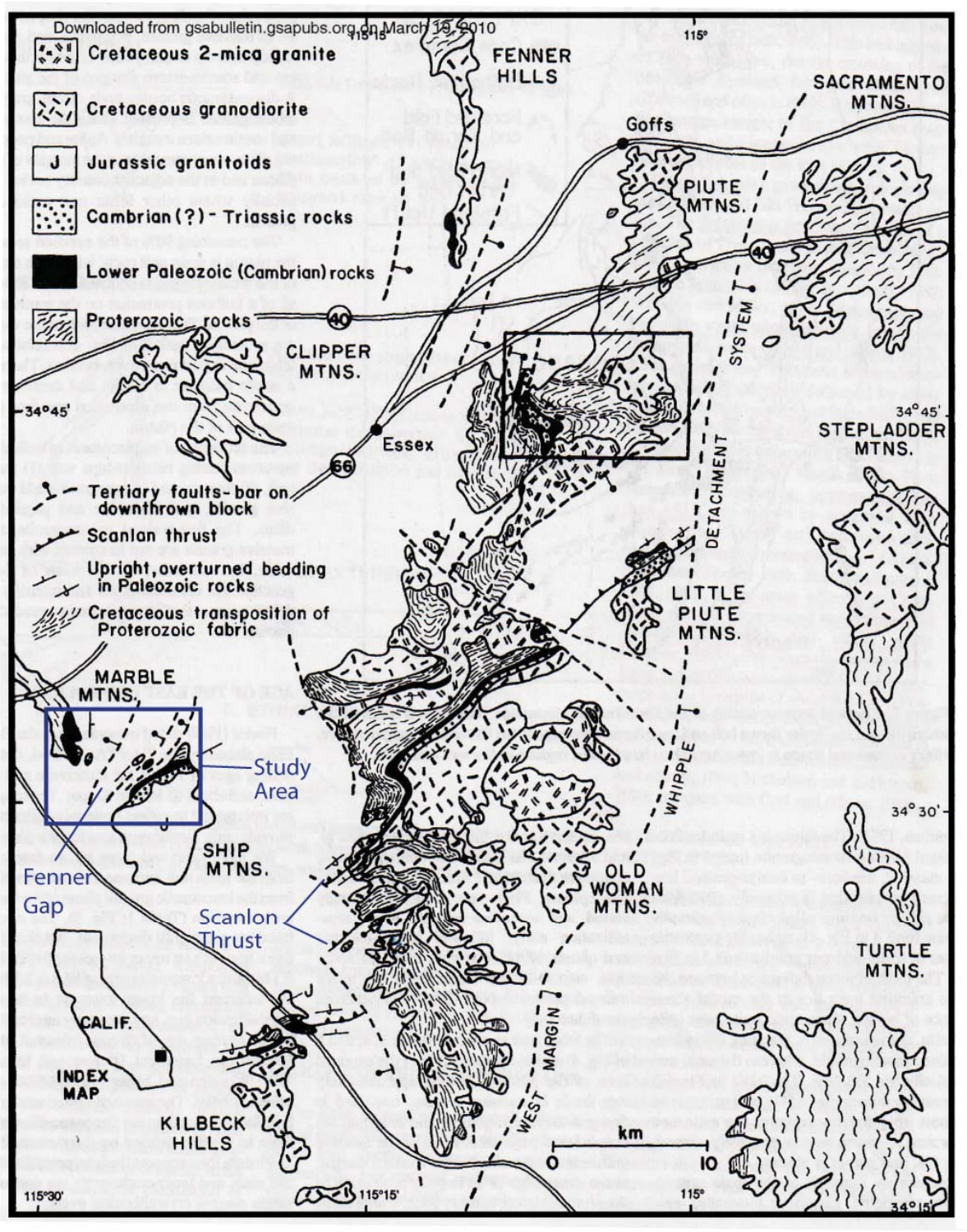
Since the latest Paleozoic, the western margin of the North American Plate become a tectonically active plate margin. Mesozoic to early Cenozoic involved primarily various subducting margin events that caused compressional deformation and extensive igneous activity (magma generation) from the western coast too as far inland as the Rocky Mountains. Jurassic plutonism occurred approximately 167 million years ago (mya) in the Marble Mountains and approximately 151 mya in the Ship Mountains (Bishop, 1963; Calzia and Morton, 1980; also see Miller et al., 1982). The Jurassic intrusive suite in the Fenner Gap region is very similar in composition, depth of emplacement, and temporal compositional variations as those describe by Fox and Miller (1990) in the Bristol, Providence and Colton Hills areas north to northeast of the study area. Powell (1993) provides a good discussion of regional igneous trends of southern California. The local Jurassic intrusive rocks appear to be very consistent with regional mid-Mesozoic igneous rocks as described by Powell (1993). Particularly their quartz poor composition, and ubiquitous chlorite and epidote alteration (secondary mineralization).

Locally, the upper crustal intrusion of the Jurassic plutonic rocks caused deformation and metamorphism to all rocks they intruded into and particularly within hundreds of feet. Most of the Ship Mountains is composed of the Jurassic plutonic intrusives but these rocks also occur buried by Tertiary sediments across the southwestern and central Fenner Gap. The Jurassic intrusive suite metamorphosed and deformed the Archean igneous and metamorphic suite and the Paleozoic cratonal platform deposits in various ways across the site. Metamorphism was dominantly due to increased temperatures (contact metamorphism). Local folding and attenuation (ductile thinning) of the Paleozoic sedimentary formations

occurred in the northern Ship Mountains and across Fenner Gap where the pre-cambrian and Paleozoic sedimentary rocks were completely engulfed by Jurassic intrusives (roof pendants). In addition, emplacement of some Jurassic intrusions was associated with intense shearing and foliation during emplacement of the Jurassic dioritic gneiss member (Jdg), which represents an early phase if not the first phase of Jurassic plutonism locally. Jurassic intrusives also caused local structural uplift causing deep erosion of Paleozoic formations. However, Jurassic and older rocks in the study area as a whole have never been buried deeper that upper crustal levels (2 to 4 kilometers) which has allowed for the Paleozoic sedimentary rocks in the southern Marble Mountains and some inselberg outcrops in the northwestern Ship Mountains to be relatively un-metamorphosed.

Mesozoic compressional tectonics in the form of thrusting and folding occurred in what is called the Mesozoic foreland fold and thrust belt (Howard and others, 1980). Locally, compressional deformation zones associated with this tectonic event are identified to the east in the Old Woman Mountains (Scanlon Thrust System; Figure 4 below; Howard, 2002) and the west in the southern Bristol Mountains (Brown, 1981). However, no direct evidence of local compressional deformation was identified in the study area during this investigation.

Figure 4: Generalized regional geologic map of the study area (modified from Karlstrom et al., 1993). Note that this is the first map identified during this study to show normal faulting in the Fenner Gap along the northern flanks of the Ship Mountains.



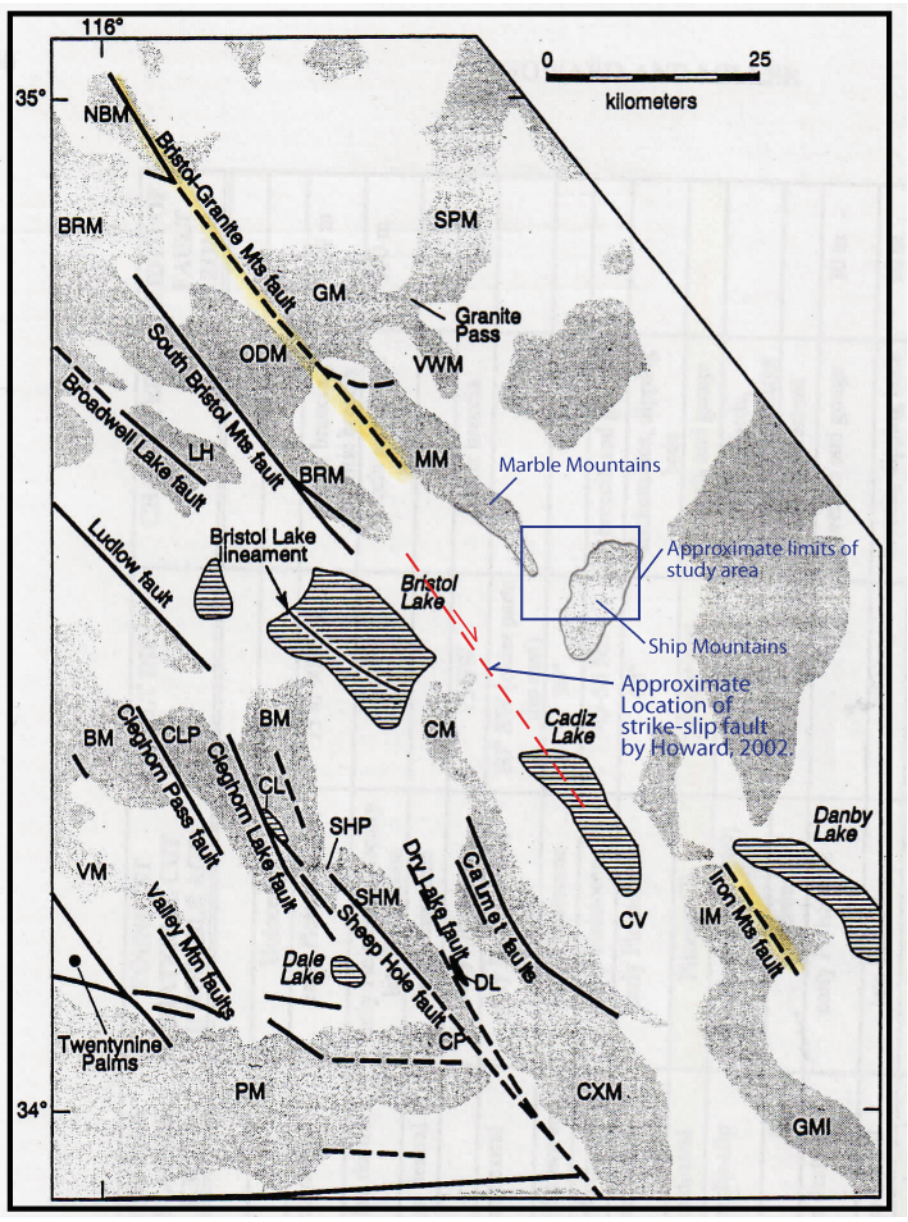
5.3 Cenozoic Era

During the Miocene epoch (~5 to 23 million years ago), large-scale extensional tectonics (pulling apart) occurred throughout western north America including the area of Nevada, eastern and southeastern California, and western and southern Arizona. This extension as discussed earlier is what essentially produced the Basin and Range Geomorphic Province and remains the dominant factor for the regions geomorphology (scattered mountain ranges bounded by internal craton basins, etc) although this tectonic event as essentially ceased in most regions. This phase of deformation is one of the dominating factors regarding understanding the local geologic structure at the site. Due to its importance the Miocene extensional deformational event is discussed in more detail in the next section of this report.

Near the end of the Miocene and continuing today, the western North American Plate transitioned from extensional to transform (strike-slip) style deformation to result in the development of the San Andreas Fault System (Powell, 1993). Dominantly northwest trending strike-slip (horizontal motion) faults within the San Andreas Fault System (Powell, 1993) occur from offshore in the Pacific Ocean to close to the study area although the dominant strike-slip faults occur in western California (i.e. San Andreas Fault proper). These faults allow rocks just west of each northwest trending right-lateral strike-slip fault to move toward the northwest.

There is evidence of Quaternary age active strike-slip faults in the general region of the study area that are part of the San Andreas Fault System and essentially represent the eastern limits of this fault system. In particular the mapped Bristol-Granite Mountains fault along the western margin of the Granite and northern Marble Mountains (Howard and Miller, 1992). Figure 5 by Howard and Miller (1992) shows Quaternary age faults based on geomorphic evidence of potentially offset Quaternary age deposits, most of which are preserved latest Pleistocene to Holocene (past ~11,000 years) alluvial fan surfaces. Their map shows the South Bristol Mountains and Bristol-Granite Mountains fault trending toward the eastern Bristol Lake and Cadiz Lake basins and may connect with the Iron Mountain Fault to the southeast. Supportive evidence for this is a mapped strike-slip fault along the eastern Bristol Lake region by Howard (2002) based on well core evaluation within Bristol Lake. Figure 5 shows the approximate location of the buried (concealed) northwest trending strike-slip fault in the eastern Bristol Lake area proposed by Howard (2002). Also note on Figure 5 the paucity of mapped Quaternary age faults in the study area, which is consistent with a State of California fault map by Jennings (1994) and aerial photo and field mapping conducted during this study.

Figure 5: Modified figure from Howard and Miller (1992) showing faults that likely offset Quaternary age sediments in the Bristol Lake region (black lines). Therefore these faults are likely active. The red fault is from Howard (2002) that occurs within axis of the Bristol and Cadiz valleys.



During the late Cenozoic and cessation of basin and range extensional tectonics the dominant geologic processes locally have involved erosion of the local ancestral mountain ranges and sediment infilling of the local basins (i.e. Fenner, Bristol, and Cadiz Valleys). Of note, Jennings (1994) indicates that the Amboy cinder cone involving primarily basalt flows occurred approximately 6,000 years ago. This volcanic area is located about 20 miles west of Fenner Gap.

6.0 MECHANISMS OF EXTENSIONAL TECTONICS IN THE BASIN AND RANGE

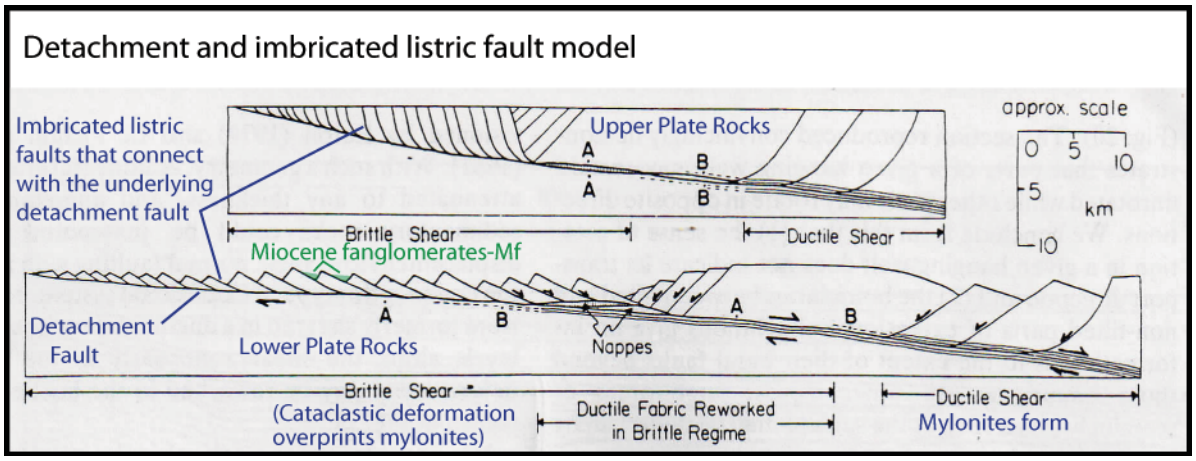
During most of the Miocene Epoch (mid-Tertiary) western North America experienced large magnitude extensional tectonics where in some places the Earths crust (lithosphere in reality) was extended over 100 percent. This occurred throughout Nevada, eastern and southeastern California, western and southern Arizona and northern Mexico (Sonoran Desert). Good summary publications regarding the age and style of deformation is found in Frost and Martin (1982), Wernicke and Burchfiel (1982), Wernicke et al. (1987), Spencer and Reynolds (1989), Wernicke (1992), and Stewart (1998). The extension is believed to have resulted from gravity collapse of the over thickened continental lithosphere produced during Mesozoic compressional tectonics believed associated with a low angle subduction zone during the late Cretaceous to early Cenozoic. The over thickened crust occurred from the coast all the way to the eastern Rocky Mountains. Once compression ceased just prior to the Miocene, the over thickened continental lithosphere simply collapsed under its own weight allowing the entire region to extend. Essentially, it was a form of gravity collapse very similar to landslides.

6.1 Detachment faulting

The mechanisms of extensional tectonics in western North America involved low angle detachment faults that provided essentially a basal slide ramp for the overlying crust to slip laterally over. Detachment faults are regional and extend over hundreds of miles in all directions. The detachment faults initially formed at mid-crustal levels (8 to 15 km) and deformed ductily across mylonitic shear zones hundreds of feet thick. Over time and continued extension, the crustal rocks above the detachment fault (upper plate) rose closer to the surface and cooler geothermal temperatures. This cause the style of shearing along the detachment fault to change. Namely, from ductile at deeper depths where temperatures were sufficiently high to produce mylonitic foliation, to brittle-cataclastic deformation in the upper crust where temperatures were much lower. Thus, typical characteristics of detachment faults include a thick (over 100 feet typically) mylonitic fabric zone that is subsequently overprinted by a relatively thinner and well defined brittle (cataclastic) shear zone. The mylonitic foliation appears essentially like an igneous plutonic gneissic rock where coarse-grained silicate minerals are smeared out and elongated. The cataclastic gouge zones that over print the mylonitic shear fabric are generally composed of ground up rock with extensive secondary mineralization and thus typically exhibit a wide variety of colors (reds, orange, yellow, black, etc).

The rocks above and below the detachment fault are referred to as upper plate and lower plate rocks respectively. Total motion across detachment faults can be on the order of tens of kilometers and generally speaking, once a detachment fault is exposed on the surface the upper plate rocks are typically quite different than those in the footwall rocks. For example, lower plate rocks can be the result of mid to deep crustal levels whereas the upper plate rocks may never have been deeper than just a couple of kilometers. Thus upper and lower plate rocks typically show a large contrast in metamorphic regimes. A series of imbricated faults and associated crustal blocks were typically produced in the upper plate, which individually connect to the underlying detachment fault. These types of faults are called listric and they gradually exhibit less steep dips with depth while they are active, but also, as the entire system is active, the listric faults themselves rotate over time to shallower dips (Figure 6). The half graben valleys associated with each listric fault fill with sediments (fanglomerates typically) and volcanic igneous rocks during deformation. Thus, the bedding dips of the half grabens sediments generally trend from steep to shallow from the base of the formation to stratigraphic upper levels respectively.

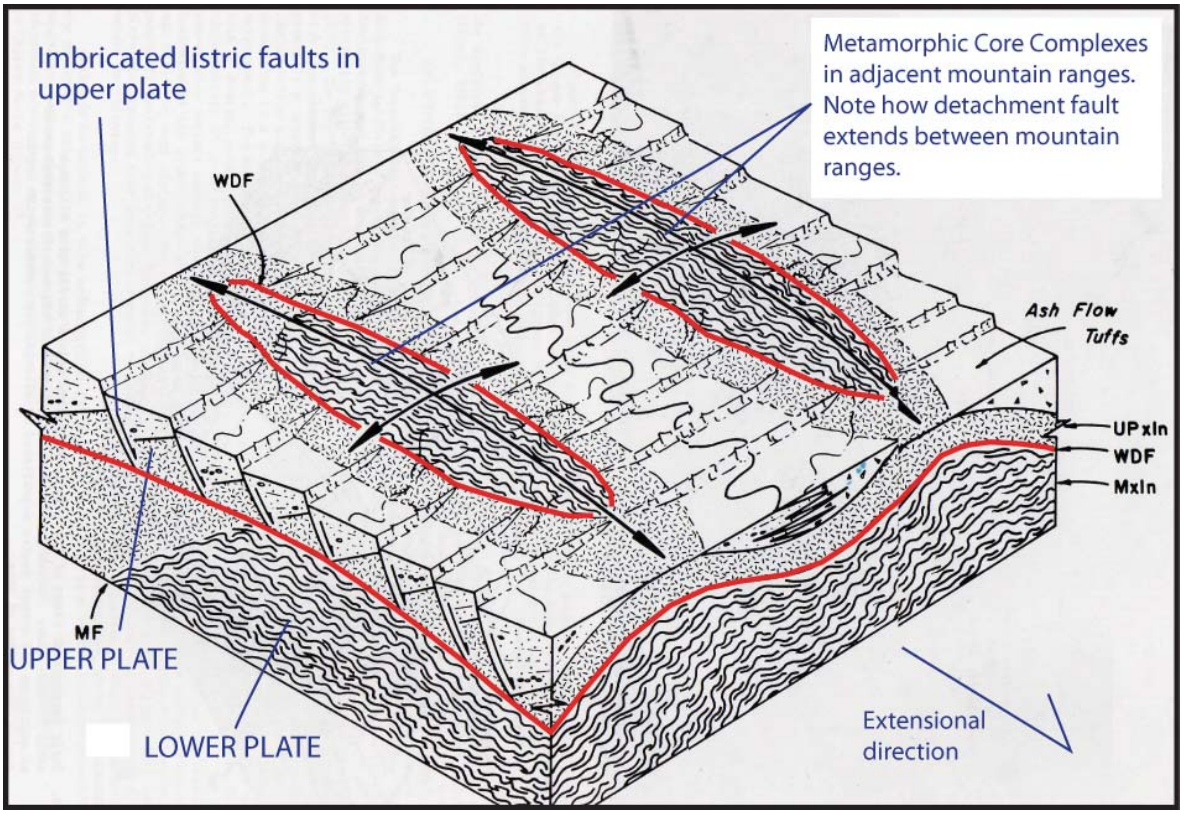
Figure 6: Generalized cross section of many of primary characteristics of extensional tectonics (Modified from Wernicke and Burchfiel (1982).



6.2 Metamorphic core complexes

One of the very interesting structures identified in the southwestern United States associated with extensional tectonics are metamorphic core complexes (Hamilton, 1981). Figure 7 shows a cartoon drawing depicting how they form. Metamorphic core complexes develop in regions that have undergone a very high magnitude of crustal extension to the point where the rising detachment fault reaches the surface. In other words, extension was sufficient where all the upper plate rocks essentially slipped off the top of the detachment fault. It is in these areas that lower plate rocks are exposed. Metamorphic core complexes occur in the central Mojave Desert (Glazner et al., 1989; Fletcher et al., 1995), the Big Maria Mountains (Hamilton, 1982), Whipple Mountains (Davis et al., 1982; Teel and Frost, 1982), numerous ranges in southwestern Arizona (Spencer and Reynolds, 1989) and in the northern Sonoran Desert in Mexico (Nourse et al., 1994). However, no metamorphic core complexes are known to exist in the area of the site. The western limit of the development of metamorphic complexes is currently mapped just east of the Old Woman Mountains as shown on Figure 4 as the *West Margin Whipple Detachment System*. The western limit of known detachment faulting is also shown on Howard (2002) as the *Breakaway fault for Colorado River extensional corridor*. This western limit of detachment faulting represents where the regional detachment fault to the east reaches the surface thus suggesting that detachment faulting does not occur further west. However, a detachment fault was identified in the Ship Mountains during this study and one is mapped by Howard (2002) in the Calumet Hills just 13.5 miles southwest of Fenner Gap on the western side of Bristol Lake. These data indicate that either multiple stacked detachment faults may have occurred in the region, or that the detachment fault associated with the mapped *Breakaway fault for Colorado River extensional corridor* (Karlstrom et al. 1993 and Howard, 2002) may have actually continued further west under the Old Woman Mountains to be exposed in the northern volcanic terrain (Figure 1) of northern Ship Mountains when it was offset by late stage basin and range high angle normal faulting.

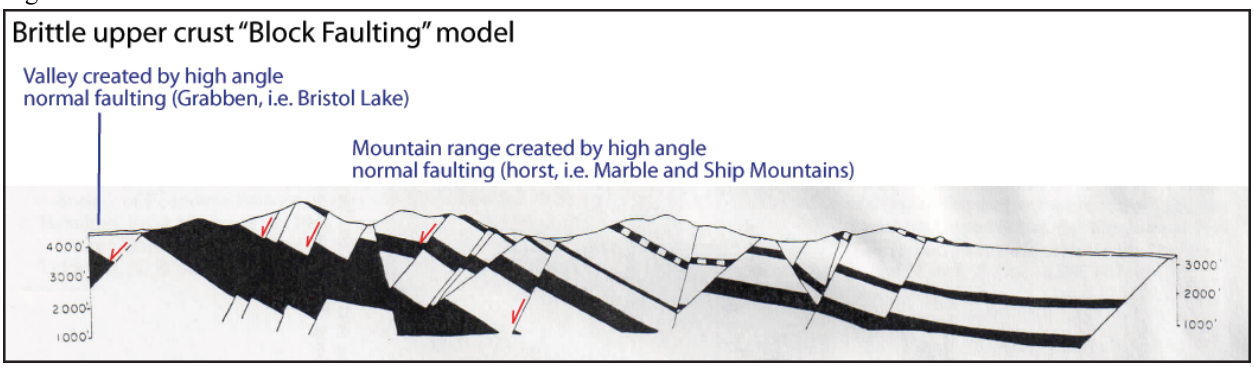
Figure 7: Generalized oblique cross section showing how metamorphic core complexes develop (Modified from Teel and Frost, 1982).



6.3 High angle normal faults

In many regions of the Basin and Range extensional terrain, high angle normal faults occurred subsequent to the imbricated listric and low angle detachment fault phase of faulting (Otton, 1981; Dokka, 1981; Stewart, 1998). The high angle faults often cut through the detachment fault to produce surface exposures of these faults with an absence of a metamorphic complex. It is unknown whether or not these high angle faults connect with a second and deeper detachment fault (stacked detachment faults) but it seems reasonable that this would occur. Regardless, the high angle normal faults appear to represent in many areas the final stages of extensional tectonics that terminated during the late Miocene. Figure 8 provides a generalized cross section showing the complexity (various dip angles and offset magnitudes, and fault block rotations) that resulted from high angle normal faulting.

Figure 8: Generalized cross section of



The high angle block faults often occur on a sufficient scale to allow for large valley basins (grabens) and mountain ranges (horsts) to form. A good local example include the Ship and Marble Mountains that likely were elevated as a combined unit relative to the Bristol and Cadiz Valley by a late stage northwest trending high angle normal fault along the western margins of these ranges. This normal fault is postulated to have allowed the Marble and Ship Mountains to rise relative to the Bristol and Cadiz Valleys. Thus, the current mountain range and valley topography may be dominated by block faulting near the later stages of regional tectonics similar to that proposed for the northern Sonoran Desert (Steward, 1998). It should be pointed out that many geologists understand that normal faults exist along most Basin and Range mountain fronts but these faults are quite often not shown on Geologic maps because they are buried by younger undeformed sediments (concealed).

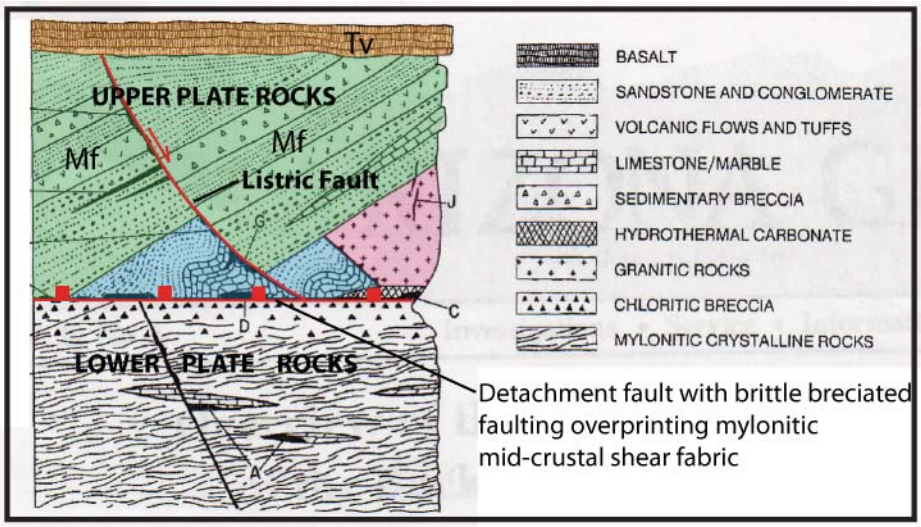
6.4 Extensional volcanism

Volcanism is well documented during extensional tectonism throughout the Basin and Range Province. This volcanism is considered pressure release type associated with thinning of the lithosphere. The volcanic rock compositions vary from Rhyolite (high in silica and low in iron and magnesium) to Basalt (low in silica and high in iron and magnesium). However, there is a general compositional trend during extension volcanism from primarily rhyolitic to basaltic over time in many extended areas including the deserts of southeastern California, and western and southern Arizona. Literature evaluated during this study regarding Miocene age volcanism include: May et al., (1981), McCurry (1981), Suneson and Lucchitta (1981), Dahm and Hankins (1982), Davis et al. (1982), Hamilton (1982), Frost and Martin (1982), Hillhouse and Wells (1999), Calderone et al. (1990), Wernicke (1997), Stewart (1998).

6.5 Common stratigraphy and structure associated with extensional tectonics

Common stratigraphic and structural relationships occur associated with extensional tectonics. For example, imbricated listric faults, tilted sediments within half grabens associated with listric faults that exhibit near source fanglomerates and interbedded volcanic rocks, detachment fault zones exhibiting a cataclastic shear zone over printing a thick mylonitic shear fabric, and capping volcanic rocks (typically basalts) that show progressively shallower dips up section. Many of these general characteristics are shown on Figure 9.

Figure 9: Generalized stratigraphy and structure associated with extensional tectonics (Modified from Spencer and Reynolds, 1989). Mf – Miocene fanglomerates (same symbol as on Plates 3 and 4).



7.0 FINDINGS

The stratigraphy and structures observed in the Fenner Gap region including the southern Marble Mountains, the southeastern end of Fenner Valley and the Ship Mountains are typical of the geologic history of the Basin and Range Province. The region exhibits Paleozoic sedimentary craton platform deposits overlying pre-Cambrian igneous and metamorphic cratonal rocks. These rocks were then intruded by Mesozoic age igneous plutonic rocks, and then extended in the Miocene during regional extension. Since the Miocene, the region has been relatively tectonically inactive with the exception of relatively minor right-lateral strike-slip faulting due to the San Andreas Fault System. For the most part, since the Miocene the dominating geologic processes have involved erosion of the local mountains and sediment infilling of the adjacent basins.

7.1 Geology of the Fenner Gap

Detailed descriptions of the identified geologic units are provided in Appendix A and on the Geologic Map of Plate 2. This section provides information regarding the structural and stratigraphic importance of each of the units regarding understanding the geologic history of the site. The general stratigraphy and rock types at the site from youngest to oldest include:

TQal TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits)
Subunits: Qal, Qoal, Qadf, Qoadf, Qoaf1, Qoaf2 and Qoaf3.

Tv and Tvi TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)
Tv Volcanic Rocks
Tvi Hypabyssal Volcanic Rocks (cooled near surface)

Mf MIOCENE FANGLOMERATES

Kgr CRETACEOUS LEUCOCRATIC GRANITE (possibly 2-mica granite)

Jgr	JURASSIC IGNEOUS SUITE (U-Pb >150 Ma - middle or Late Jurassic)	
	Jgr	Jurassic Granitics
	Jdg	Jurassic Dioritic Gneiss
	Jgr-Ar	Jurassic Granitics - Archean Complex.
Bs	PENNSYLVANIAN TO PERMIAN BIRDSPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)	
Bk	MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)	
	Bku	UPPER MEMBER
	Bkm	MIDDLE MEMBER - SILVER KING DOLOMITE
	Bkl	LOWER MEMBER
Ca	LOWER CAMBRIAN CADIZ FORMATION	
Ch	LOWER CAMBRIAN CHAMBLESS LIMESTONE	
La	LOWER CAMBRIAN LATHAM SHALE	
Za	LOWER CAMBRIAN ZABRISKIE QUARTZITE	
Wc	LOWER CAMBRIAN WOODCANYON FORMATION	
Ar	ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX (unit locally is actually Proterozoic in age).	

7.1.1 Archean Igneous and Metamorphic Complex

The Archean igneous and metamorphic complex (unit Ar) are the oldest rocks in the study area (Figure 3 and Plate 1). These rocks are approximately 1.4 to 1.5 billion years old (Silver and McKinney, 1963; Lanphere, 1964). As discussed earlier, locally these rocks are actually Proterozoic in age but the map symbol and name designation provided originally by Hazzard and Crickmay (1933) were maintained for this study. After an erosion event of approximately 1 billion years, a sequence of lower Cambrian to upper Paleozoic sediments were deposited on top of the Archean cratonal rocks. These units include from oldest to youngest, the Wood Canyon (Wc – primarily quartzite), Zabriskie Quartzite (Za), Latham Shale (La), Chambless Limestone (Ch), Bonanza King Dolomite (Bk), and the Bird Spring Limestone (Bs).

7.1.2 Paleozoic Sedimentary Section

Units Wc, Za, La and Ch are referred to as the Lower Cambrian Section within this report. This suite of rocks are cumulatively approximately 1,100 feet thick and provide excellent stratigraphic and structural markers in the region. The stratigraphic thicknesses and composition of all the Paleozoic deposits locally are described in Hazard and Crickmay (1933), Hazard and Mason (1936), and Hazard (1954). It is possible that the Monte Cristo and Sultan limestones may also occur in the area stratigraphically between units Bk and Bs but they were not positively identified. However the Monte Cristo and Sultan limestones were identified in the southern Bristol Mountains west of the study area near the town of Amboy (Brown, 1981) and thus may occur in the study area within the northern Ship Mountains, and potentially at depth in the eastern Fenner Gap.

The regionally identified Cambrian age Bonanza King formation is primarily composed of dolomite, which is a magnesium carbonate mineral. This formation exhibits a stratigraphic thickness of 2,000 feet in areas where it has not been eroded or attenuated by metamorphism. The upper Paleozoic Bird Spring formation overlies the Bonanza King formation and is primarily composed of marble (carbonates) but

does contain numerous interbedded members of fine grained silty and slaty marls and quartzites. The Bird Spring formation has a regional stratigraphic thickness of approximately 4,000 feet. Thus, regionally, there is the potential for a carbonate dominated Paleozoic stratigraphic section of over 6,000 feet associated with the combined Bonanza King and Bird Spring formations.

The lower Paleozoic sequence of sedimentary rocks is very well preserved in the southern Marble Mountains where these rocks are not metamorphosed and only weakly folded and tilted. However, the Bird Spring formation (upper Paleozoic) is not well exposed in the southern most Marble Mountains. Fossils are common particularly in the Latham Shale and Chambless Limestone (Hazard and Crickmay, 1933; Hazard and Mason, 1936; and Hazard, 1954). The Paleozoic section in the southern Marble Mountains generally strike toward the north and dip approximately 30 degrees toward the east and are weakly folded and exhibit numerous normal (extensional) faults.

The Paleozoic sequence of sedimentary rocks exhibit various degrees of metamorphism and deformation in the study area primarily produced during emplacement of the Jurassic igneous suite described below. The rocks are strongly fractured, in places had undergone contact metamorphism, attenuation (thinning) due to ductile flow, and were folded and tilted. Small scale faults also occur in these rocks. The transition from the non-metamorphosed Paleozoic sedimentary rocks in the Marble Mountains to deformed and metamorphosed in the Ship Mountains primarily occurs across Fenner Gap and generally in the region of unit Jdg described below. However, this transition is moderately well exposed on the surface between the relatively unmetamorphosed Bonanza King Formation on Mt. Bonanza, and highly deformed and attenuated Wood Canyon Formation in the Jaggar Hills (Figure 1, Plate 2).

All units dominated by carbonates (Ch, Bk, and Bs) exhibited karst weathering (dissolution) with the development of caves (large vugs). Large vugs were also identified in the video of boring TW-1 within the Bonanza King formation and minor dissolution features were identified within carbonate members of the Cadiz formation in the southern Marble Mountains. All of the Paleozoic rocks exhibit very strong fracturing and jointing throughout the site.

7.1.3 Jurassic Igneous and Metamorphic Suite

The next youngest rocks in the study area is the Jurassic Igneous and Metamorphic Suite that is approximately 151 and 167 million years old in the northern Marble Mountains and throughout the Ship Mountains respectively (Miller, et al., 1982). In terms of the study area, the site is dominated by the 167 million year old intrusions that are the primary rock in the Ship Mountains and extend beneath basin infill sediments across the southern and southwestern Fenner Gap. The Jurassic intrusive suite has been subdivided into three concordant units in this study herein called the Doritic Gneiss (symbol Jdg), the mixed Jurassic intrusives with older bedrock units (Jgr-Ar), and a member that consists of nearly pure Jurassic intrusives (Jgr). This suite of rocks exhibits abundant epidote secondary mineralization that likely were produced by the alteration of hornblende and biotite. This type of secondary mineralization, which gives these rocks a greenish hue, is typical of Jurassic age plutonic rocks as described within the Eastern Plutonic Belt of Powell (1993). In addition, rocks of the Jurassic igneous and metamorphic suite exhibit a high density of fracturing (joints with small displacements) and joints. Field mapping data indicates that on average, 4 to 12 joints would occur in a square foot area.

Contacts between members Jgr, Jdg and Jgr-Ar of the Jurassic igneous and metamorphic suite are dominantly concordant and trend east-west from the northern Ship Mountains across Fenner Gap. Structurally across the study area, unit Jdg represents a relatively tabular east-west trending body along the northern limits of the Jurassic igneous and metamorphic suite. The northern boundary of unit Jdg grades into progressively less metamorphosed and deformed rocks consisting of the Archean igneous and metamorphic complex and Paleozoic sedimentary formations similar to bedrock exposures in the southern

Marble Mountains. The transition zone between unit Jdg and relatively undeformed Archean through Paleozoic rocks can occur across a horizontal distance of less than 400 feet as demonstrated by rocks exposed in the southern most Marble Mountains (Plate 2). Unit Jdg grades into unit Jgr-Ar along its southern boundary with gradually increasing relative abundances of unit Jgr toward the south. Thus, the general stratigraphy of the Jurassic igneous and metamorphic suite is Jdg along the northern boundary (Jaggar Hills), grading into unit Jgr-Ar toward the south (northern Ship Mountains), which grades into unit Jgr further to the south within the central Ship Mountains.

7.1.3.1 Jurassic granitics (Jgr)

The type section of unit Jgr is exposed in the Central Ship Mountains. Unit Jgr consists of medium to fine grained biotite quartz syenite, syenogranite, quartz monzonite, and fine grained hypabyssal equivalents. The unit exhibits a paucity of quartz and salmon color orthoclase feldspar is common. The unit is typically not ductilly foliated but does exhibit considerable jointing and fracturing throughout suggesting some stress and strain at upper crustal levels. Penetrative epidote secondary mineralization is very common. Relatively small to very large roof pendants of older bedrock units and sills are common. This intrusive suite likely correlates well in terms of general age, time transgressive composition variations from mafic to more felsic, occurrence of aplite dikes and emplacement at relatively shallow crustal depths as described by Fox and Miller, 1990 evaluating similar rocks in the southern Bristol, southern Providence Mountains and Colton Hills. This unit intruded and deformed all relatively older units, which has led to a change in structure across the Fenner Gap between the relatively un-intruded Marble Mountains and strong intrusions within the Ship Mountains. The contact between these two structural terrains occurs within Fenner Gap. Aplite dikes are also common within this unit. Dikes of unit Jgr occur in the southern Marble Mountains indicating that the unit occurs at depth below the range.

7.1.3.2 Jurassic dioritic gneiss (Jdg)

The type section of the Jurassic dioritic gneiss is exposed in the Jagger Hills (Figure 1) and a small inselberg outcrop located approximately 400 feet south of the southern tip of the Marble Mountains. The Jurassic dioritic gneiss (Jdg) represents the relatively oldest member of the Jurassic igneous and metamorphic suite. This unit exhibits strong nearly vertical foliation and intercalated older rocks (Wc typically). This rock unit was originally mapped as Archean (Hazard and Crickmay, 1933) but is considered here as representing the initial intrusion and along the northern limits of the Jurassic igneous and metamorphic suite. The evidence for this is the intercalated members of the Lower Cambrian suite within unit Jdg and the concordant contact between units Jdg and Jgr-Ar. Unit Jdg exhibits strong east west and nearly vertical foliation. It is an approximately 2,000 feet thick tabular body located along the northern limits of the Jurassic igneous and metamorphic suite and extends from the Jaggar Hills across Fenner Valley to just south of the southern tip of the Marble Mountains (Plate 2). This member is more mafic than the typical Jurassic intrusives (i.e. Jgr) observed throughout most of the Ship Mountains. Emplacement of unit Jdg involved intense shearing and relative vertical uplift of the rocks south of the unit relative to the north causing local erosion of Paleozoic and pre-Cambrian rocks.

7.1.3.3 Jurassic granitics and Archean complex (Jgr-Ar)

Unit Jgr-Ar is characterized by coarse grained, non-foliated to moderately foliated Jurassic igneous intrusives intercalated primarily with Archean igneous and metamorphic rocks, but also exhibits roof pendants and slivers of Paleozoic sedimentary rocks ranging in thickness from just a few feet to over 1,000 feet (i.e. near the Vulcan Mine, Plate 2). Member Jgr-Ar represents later stages of plutonic emplacement where Jurassic intrusives entered a region parallel to and south of the initial Jdg intrusions causing additional relative vertical uplift of the older rocks (Ar through Bs) but emplacement was not sufficient to "destroy" the pre-existing rocks in terms of metamorphism and volume of intrusion. Member Jgr was emplaced just to the south of member Jgr-Ar and essentially consists of nearly pure Jgr intrusive rocks.

7.1.3.4 Structures produced by Jurassic igneous intrusives

The emplacement of the Jurassic igneous suite produced an antiform and synform structure identified by exposures of the Paleozoic rocks from the northern Ship Mountains across Fenner Gap. These structures are shown on Plate 2 and strike roughly parallel with member contacts within the Jurassic igneous suite. The implication of the antiform produced by large vertical movements of magma during emplacement of Jgr was to essentially allow for the erosion of most of the Paleozoic rocks along the crest of the antiform.

7.1.4 Miocene Fanglomerates (Mf) with a note regarding mylonites

The next youngest rocks identified at the site are coarse-grained Miocene age fanglomerates (unit Mf) deposited within early Miocene age half grabens produced by imbricated listric faults. These sediments are exposed in the northeastern Ship Mountains within the area delineated as the northeastern volcanic terrain on Figure 2. Unit Mf is at least 1,000 feet thick and defined herein as sediments deposited just prior to and during local Miocene extension. Basal members of unit Mf were likely deposited either just before or during early stages of regional extension based on exotic and well rounded clasts (conglomerates), very well sorted sedimentary members, and a paucity of volcanic deposits or clasts. The history of extensional tectonics within unit Mf is stratigraphically and structurally recorded by compositional and structural changes from the basal to upper members within the section. For example, an increase in proximal clasts, interbedded volcanic members, increase in grain size, grain angularity (conglomerate to breccia) and progressively shallower dips from the basal to upper members due to listric fault rotations. Unit Mf is also identified in a number of the borings within Fenner Valley (Plates 2, 3, and 4).

Clast compositions within unit Mf vary across the site associated with variations in proximal bedrock exposures. For example, upper members of unit Mf in the northeastern volcanic terrain are dominated by mylonitic cobbles and boulders eroded from the nearby exposed detachment fault, and within borings in Fenner Gap, some clasts in unit Mf consist of locally derived bedrock exposures (i.e. units Bk, Bs, volcanics, etc).

In most places it is likely that erosion occurred in unit Mf prior to deposition of the upper Cenozoic valley infill deposits (unit TQal); however this does not need to be the case. At the cessation of Miocene extension, it is possible that unit Mf simply continues to be deposited into undeformed (horizontal bedding) sediments. However, for this study and as discussed earlier, Mf is defined as the sedimentary unit deposited primarily during or possibly beginning just before Miocene age extensional tectonics.

As a side note regarding Miocene age rocks, the mylonitic fabric associated with the exposed detachment fault in the northeastern volcanic terrain was likely developed and/or reactivated during the Miocene. The mylonitic fabric likely overprinted older rocks and may have originally formed during late Cretaceous to early Tertiary compressional tectonics. Based on the evaluation of all the existing data, it is likely that mylonites identified in the study area have a minimum age of Miocene and developed during extensional tectonics. The locally identified mylonites provide the only exposures of lower plate rocks associated with detachment fault structure.

7.1.5 Miocene Volcanics (Tv and Tvi).

7.1.5.1 Tv (extrusives)

A sequence of local igneous volcanic rocks (unit Tv) was deposited in the study area after deposition of unit Mf; however, some distal volcanic deposits do occur in the upper members of unit Mf. These rocks are well exposed in the southeastern Marble Mountains, and the northern Ship Mountains in the areas referred to as the northern and northeastern volcanic terrains (Figure 2). A small outcrop of unit Tv was identified near Bird Spring Hills along the western flanks of the Ship Mountains (Plate 2). In the northern Ship Mountains, Tv deposits are approximately 1,100 feet thick and represent many individual volcanic

eruptive members. Although not mapped in detail, it appears that for the most part, the thick volcanic sequence of rocks are conformable with relatively minor deformation occurring during deposition.

The Tv deposits generally strike to the north to northeast with dips between 10 to 25 degrees toward the east. In the northern volcanic terrain (Figure 1), a series of volcanic outcrops bounded by younger alluvium occur that are tilted and exhibit repeat of section (see members A, B and C on Plate 2 and discussed below). These data indicate that normal faults likely exist in this area that strike roughly parallel to the strike of the volcanic layers. These faults are shown as cross faults on Plate 2.

Local Tv rocks are composed of numerous distal (tuffs and ashes) and proximal (basalt and pyroclastic flows) volcanic deposits. Based on mapping in the northeastern volcanic terrain, the lower half of unit Tv consists primarily of distal volcanic deposits (tuffs and ashes) with the upper half composed of proximal basalts and pyroclastic flows. The transition from early silicic magmas (distal) to later state mafic magmas (proximal) is commonly observed throughout the southwestern United States extensional terrain (May et al., 1981; McCurry, 1981; see papers in Frost and Martin, 1982). Proximal upper members of unit Tv dominate exposures of unit Tv in the southern Marble Mountains, northern volcanic terrain, and near the Bird Spring Hills. Although not mapped in detail, the exposed upper members of unit Tv were subdivided into three members (A, B and C on Plate 2) to assist in understanding the local structure. These members were correlated across various outcrops in the northern volcanic terrain and across Fenner Gap in the southern Marble Mountains.

The upper proximal members of local unit Tv represent primarily mafic flows of basalt and pyroclastic deposits. Similar mafic igneous extrusives in terms of structural and stratigraphic position in the Miocene series occur in the Whipple Mountains located 57 miles southeast-east of the study area and the Clipper Mountains located northeast of the study area (Plate 1). These deposits have reported ages of ~16 mya (million years ago; Davis et al., 1982) and 17 mya (Calderone et al., 1990) in the Clipper and Whipple Mountains respectively. In the Ojo Range in south central Arizona, upper stratigraphic basalt flows are 16 to 14 mya and underlying rhyolitic deposits are 18 to 16 mya old respectively (May et al., 1981).

The Peach Springs tuff represents a regional rhyolitic tuff deposit that has been identified throughout the region from the Colorado Plateau region all the way to the central Mojave Desert (Wells and Hillhouse, 1989). This tuff was formed from a single cooling event approximately 18 to 19 mya (Wells and Hillhouse, 1989). Although this tuff was not positively identified (correlated) in the study area, it is presumed to exist within the local Tv sequence, and likely occurs in the distal lower members of mapped Tv.

The dates provided above indicate that unit Tv was likely deposited locally during a period of time between 19 and 16 mya. Based on the provided data, the lower member distal and overly lying proximal volcanic deposits are likely 19 to 16 mya (silicic) and 14 to 16 mya (mafic) old respectively.

7.1.5.2 Tvi (Hypabyssal)

In a few places, fine grained igneous rocks were identified that likely cooled very close to the surface (hypabyssal). The best outcrop of these rocks is along Fault No.1 within the Fuz Hills but was also identified in a small wash in the Bird Spring Hills area (Plate 2). There, a salmon (likely silicic) colored igneous rock with small phenocrysts occur that exhibits a strong jointing system parallel to the mapped orientation of the fault (northeast strike). It is postulated here that this unit may have been injected along the fault shear zone and due to a paucity of shear structures, may have been emplaced once the fault was inactive as a listric fault. A correlation of unit Tvi with the relatively silicic lower member of unit Tv is possible.

7.1.6 Late Tertiary to Quaternary alluvial deposits (TQal)

Valley fill sediments (unit TQal) represent coarse-grained alluvial deposits produced by the erosion of the local and regional mountain ranges that by definition herein were deposited after local Miocene extension ceased. Unit TQal represents distal fluvial well-sorted sands and gravels, and coarse-grained fanglomerates near the mountain fronts (alluvial fans). Bedding of unit TQal is undeformed and is thus typically less than 3 to 4 degrees common for alluvial fan depositional environments. Member units of TQal were not mapped or evaluated in detail during this study but observations of their general characteristics were observed during field mapping. The aerial extent of these units shown on Plate 2 was determined from field mapping and utilizing Google earth. In addition, a fairly quick attempt was made to review the boring data (logs, cores, cuttings) to assist in mapping the units at depth (cross sections).

Unit TQal is subdivided as follows into surface and subsurface members as shown on Plates 2, 3 and 4:

7.1.6.1 *Fenner Valley axis deposits*

Qal Quaternary alluvium of the Fenner Valley axis. These surficial deposits are composed of relatively well sorted fluvial sands with small gravel and minor silt and are loose.

Qoaf Quaternary older alluvim of the Fenner Valley Axis. These deposits represent older and thus deeper members of unit Qal to reflect an increase in density with depth. An increase in secondary mineralization primarily composed of carbonate occurs.

7.1.6.2 Distal fluvial fans near the Marble Mountains

Qadf Quaternary alluvial distal fans. These deposits are composed moderately well sorted fluvial sands, and small to medium size gravel (pebbles, cobbles with occasional small boulder) and are loose. The unit primarily occurs on the northern side of Fenner Gap flanking the Marble Mountains.

Qoadf Quaternary older distal fans. This unit represents older members of distal fan deposits similar to unit Qadf but unit density is likely medium dense to dense.

7.1.6.4 Fluvial and fanglomerates fans near Ship Mountains

Qaf Quaternary alluvial fan deposits. These deposits are composed of fluvial and fanglomerates (debris flows) sands and gravels (pebbles, cobbles and small boulders) and range from loose to medium dense. The unit exhibits weak bar and swale topography and soil profiles on the bars contain silts and clays that are medium dense. These deposits represent medial fan sediments within the bajadas of the western Ship Mountains and overlies unit Qoaf.

Qoaf1 Quaternary older alluvial fan deposits. These sediments represent older equivalents of unit Qaf and thus are deeper and thus become progressively more dense with depth. Secondary carbonate occurs concentrated in some gravel dominated layers that are associated with paleosols (buried soils) and/or groundwater weathering and recrystallization. Upper members of this unit are certainly late Pleistocene in age.

Qoaf2 Quaternary older alluvial fan deposits. These deposits represent proximal alluvial fan deposits that are a combination of fluvial and fanglomerates (debris flows). The unit is composed of sand and abundant gravels much of which are cobble to medium boulder in size. Grain size increases upslope considerably near the base of the Ship Mountains. A preliminary analysis of exposed soils on preserved fan surfaces

indicate that unit Qoaf2 was deposited during the latest Pleistocene with a minimum age of approximately 12 to 15 thousand years. However, unit Qoaf2 exhibits many terrace surfaces of varying ages some of which are likely over 35,000 years old based on preliminary soil evaluation (including desert varnish, desert pavement, rubification under clasts, soil hue, amount of secondary silts and carbonates) and terrace stratigraphic position. These ages are consistent with regional alluvial fan ages discussed in Dohrenwend et al. (1991). This unit exhibits numerous buried soil horizons that are generally two to four feet thick containing secondary silts, clays and carbonate.

Qoaf3 Quaternary older alluvial fan deposits. These deposits occur along the flanks of the elevated volcanic units in the northeastern Ship Mountains. The unit is composed almost exclusively of volcanic boulders some of which are three to four feet in diameter. The unit represents proximal debris flows to the local volcanic highlands. Soil profiles in this unit are a minimum of four to five feet thick as exposed in some mining related trenches that exhibit a minimum of Stage III to possibly state IV carbonate as defined in Machette (1985).

7.1.7 Ancient playa lake and Fenner Valley sill

TQal members deeper than approximately 700 feet just northeast of the Fenner Gap and at the southwest end of Fenner Valley exhibit some fine-grained fat clay deposits suggesting that the Fenner Gap bedrock sill (the spill over elevation for a basin) had not yet been breached by the Fenner Valley drainage system. This implies that TQal sediments deeper than approximately 700 feet may have been deposited in a playa lake environment, which is shown on the cross sections of Plates 3 and 4. Sediments shallower than a depth of 700 feet in the Fenner Valley drainage system would have had the potential to be transported all the way to Bristol and Cadiz Valleys once the bedrock sill was overcome. These deposits were likely deposited sometime between latest Miocene through the Pliocene.

This paleo-depositional and geomorphic model suggests that currently buried bedrock formations in Fenner Gap were a bedrock ridge exposed to erosion processes. This model provides a reasonable explanation for the paucity of preserved volcanic deposits and thick sequences of unit Mf within the Fenner Gap region at depth (Plates 3 and 4). Unit Mf and Tv collectively can be 2000 feet thick and a lack of these deposits, especially the volcanic units that are presumably deposited across a landscape strongly suggests that relatively deep erosion occurred in Fenner Gap. This erosion may have occurred once Miocene extension had ceased or possibly during the block faulting later stages of extensional tectonics as the Marble and Ship Mountains were uplifted collectively respective of the Bristol and Cadiz Valleys.

8.0 DEPTH STRUCTURE EVALUATION ACROSS FENNER GAP

8.1 Approach and Principles

The evaluation of the relative ages of geologic units and structures (i.e. is one structure relatively younger or older than another?) is critical in the structural evaluation of an area. Another key aspect to determining structure is to simply understand the mechanism of how geologic units are created which allow for assumptions to be made regarding original structure prior to deformation. For example, one of the laws of geology is the assumption that sedimentary (bedding) and volcanic deposits (flows, or ash deposits) were originally deposited close to horizontal. Thus, if sedimentary layers are tilted or folded, then it can be assumed that these rocks were deformed after deposition. Other examples include magma (igneous) intrusions, which by their nature can intrude into any unit in nearly every way imaginable and can also destroy intruded units. However, by utilizing the law of cross cutting relationships (any structure cutting across another structure must be younger) the relative age of the intrusive plutonic rock can be

determined. The same evaluation occurs with faulting where all the units and structures that a fault cuts across must be older than the time the fault was active.

Utilizing these types of observations, the geologic history of a site can be evaluated. These site observations are combined with the existing knowledge of the region based on published work which is critical because in general, it is very rare to obtain good field examples in any one area of all cross cutting, stratigraphic and structural relationships needed to figure out the local geology and history perfectly. With this in mind, some assumptions will nearly always have to be made regarding evaluating a site geologic history.

Based on evaluation of the existing data, eight cross sections were constructed for this study across and within the Fenner Gap region. Data utilized for the cross sections included mapping bedrock exposures, understanding the local stratigraphy, reviewing previous work in the region (namely cross sections and geologic maps by Mark Liggett), identifying individual members and their deformational role of the Jurassic metamorphic suite, review of the seismic reflection line, an understanding of regional extensional tectonic structures and stratigraphy, and evaluation of the well data (logs, cores and cuttings).

All the geologic units identified in the cross sections (Plates 3 and 4) currently buried by young sediments (TQal) were identified somewhere in the field at the surface with the exception of the rocks below the detachment fault shear/mylonitic zone. Therefore, all upper plate rocks shown in the cross sections were exposed somewhere in the field, but the rocks of the lower plate were not identified in the field with the exception of the mylonitic fabric just below the cataclastic shear zone in the northeastern volcanic terrain.

8.2 Deformational Events

The two primary deformational events that affected the original and fairly simple structure of relatively flat Paleozoic cratonal platform deposits overlying Archean cratonal crust (referred herein as the original system) was emplacement of the Jurassic intrusive suite and Miocene extension.

The local geology exposed in the Marble and Ship Mountains provided excellent examples to evaluate these two deformational events separately. In the Marble Mountains, the original system is fairly intact where the Paleozoic suite of sedimentary rocks are unmetamorphosed and only moderately folded and faulted. Only in a few places were igneous dikes associated with the Jurassic igneous suite identified. The Paleozoic sedimentary units on average strike northward and dip approximately 30 degrees to the east. In this area, the primary deformational event was Miocene age normal faulting (Plate 2). The normal faults in this area range from low angle to steeply dipping with various orientations. Some of the normal faults offset older normal faults, which provide key cross cutting relationships to determine their relative ages. Based on these observations, north-south striking low angle normal faults dipping toward the east were active prior to a set of northeast-southwest trending imbricated high angle northward dipping normal faults (see Faults No. 7, 8, and 9 on Plate 2).

The northern and northeastern volcanic terrains also provide good evidence of the Miocene extensional event. The repeat of volcanic members A, B and in places C provides strong evidence of normal faulting in the area after deposition. In addition, the Miocene fanglomerates in the northeastern volcanic terrain exhibit many characteristics diagnostic of imbricated half graben extensional faulting.

In contrast, most of the Ship Mountains are dominated by intrusions of the Jurassic Igneous and Metamorphic Suite and provide excellent exposures to evaluate their deformational affect on the original system (Paleozoic sediments overlying pre-cambrian rocks). In the Ship Mountains, the Paleozoic suite of rocks are uplifted, metamorphosed, replaced, attenuated, eroded away, and/or folded by the Jurassic igneous intrusions. Roof pendants are common. The largest structures produced by the Jurassic

intrusives include a synform and antiform pair that strike northeast-east to southwest-west in the northern Ship Mountains and trends toward the axis of Fenner Gap (pink fold lines on Plate 2). The antiformal structure is of key importance because it caused local erosion of most of the Paleozoic suite along the axis (top) of the fold. For example, in the Jaggar Hills (Figure 1), all of units Bs and Bk have been eroded away which potentially were up to 6,000 feet thick. However, just a couple of thousand feet away from the axis of the intrusive antiform, thick sequences of nearly the entire Bk section are preserved at Mt. Bonanza (Plate 2).

It was also observed that within hundreds of feet of the Jurassic intrusive rocks, that the level of metamorphism was considerably diminished. This is observed in the Bird Spring Hills where the Bird Spring formation is weakly metamorphosed and contains recognizable fossils (Miller et al., 1982; Stevens and Stone, 2007) and at Mt. Bonanza where the Bonanza King formation is weakly metamorphosed. As a side note, this is one of the lines of evidence that the Jurassic intrusives were emplaced at shallow crustal levels.

8.3 Evidence for Jurassic Intrusives in Fenner Gap

There is very strong evidence that Jurassic intrusives occur buried across the Fenner Gap. This includes the identification of a small outcrop of the Jurassic dioritic gneiss (Jdg) member just approximately 400 feet south of the southern tip of the Marble Mountains and identification of Jurassic intrusives in numerous boring cores and cutting samples. Member Jdg occurs along the northern limits of the Jurassic igneous suite, which implies that members Jgr-Ar and Jgr occur immediately south of the Jdg exposure below the surface within Fenner Gap.

8.4 Evidence for Listric Normal Faults in Fenner Gap

One of the key steps to evaluating the subsurface structure in Fenner Gap was determining whether or not similar normal faulting as observed in the southern Marble Mountains occur buried by alluvial sediments to the south. Evidence for normal faulting in the Fenner Gap include:

- The identification of northwest dipping, northeast-southwest trending normal faults along the northwestern flank of the Ship Mountains (Fault No. 1 and 2 on Plate 2) that are relatively younger than the Jurassic intrusives and very similar to faults of the Marble Mountains (Fault No. 7, 8 and 9).

- The correlation of well exposed Miocene fanglomerates in the northeastern volcanic terrain that are very diagnostic of documented extensional tectonic stratigraphy in the southwestern United States that are also very similar to deposits identified in the Fenner Gap borings (unit Mf). In other words, Miocene fanglomerates formed in half grabens exist buried in the Fenner Gap.

- Normal faults were identified in the NORCAL (1997) seismic reflection line.

- In TW-3, a 45 to 50 foot thick cataclastic shear zone was identified that exhibits an average 41 degree dip, which projects to the surface very close to the projection of Fault No.2 and is consistent with a fault identified in the NORCAL (1997) seismic line. Thus Fault No. 2 was identified on the surface in the Jaggar Hills, in TW-3, and further to the southwest along the seismic reflection line along Cross Section 1-1' (Plates 2 and 3).

- A well developed shear-gouge zone a minimum of 100 feet thick was identified along Fault No.1 at latitude 34 31.201W, longitude 115 24.353W (shown on Plate 2). This shear zone dips approximately 40 degrees to the north, exhibits strong secondary mineralization (epidote, chlorite), cataclastic shear fabric, and contains huge boulders (50x20-feet) of Bird Spring

formation in the shear zone of the hanging wall rocks (just above the fault zone). In addition, a nearby outcrop of Bird Spring formation clearly in the hanging wall rocks likely correlates to Bird Spring formation to the southeast within the Ship Mountains. In both places the sediments dip toward the southeast.

Within the cross sections provided on Plates 3 and 4, most of Faults No. 1 through 9 are shown to exhibit an average vertical separation of approximately 1,000-feet; however, the magnitude of offset across these faults is currently unknown.

8.5 Evidence for the Existence of the Detachment Fault

The last primary structure to include in the model is whether or not a detachment fault occurs at depth in the Fenner Gap. A detachment fault was identified in the northeastern volcanic terrain (Figure 2) located in the northeastern most Ship Mountains (Plate 2). This fault zone, which is well exposed along a number of mines openings, exhibits a cataclastic fault gouge zone with strong mineralization that is at least 50 feet thick overprinting a strong mylonitic shear fabric. The cataclastic gouge zone is developed parallel to the mylonitic fabric with dips between 35 to 45 degrees to the east. The second line of evidence is a strong relatively strong reflecting layer identified in the NORCAL geophysical report (NORCAL, 1997) along Cross Section 1-1' (Plate 2). They identified a relatively horizontal reflector along the entire length of the seismic line (2.1 miles long) at depths ranging from 1050 to 1200 feet. The NORCAL report indicated that its lithologic correlation is unknown but speculated that the reflector may correlate with sub-horizontal foliation or jointing in the pre-Cambrian granitic and metamorphic complex (Ar in this report). It is proposed here that the reflector represents a detachment fault, and the same detachment fault as is exposed in the northeastern most Ship Mountains. It is also possible that the same detachment fault may be exposed approximately 13 miles southwest of Fenner Gap in the Calumet Hills based on mapping by Howard (2002). It is good to keep in mind that detachment faults are well documented to be regional structures that extend for hundreds of miles and beneath mountain ranges and valleys.

The detachment fault and associated upper plate listric faults (Faults No. 1 through 9) locally may have been active between 25 to 17 mya based on work conducted on the Whipple Mountains detachment fault located 57 miles southeast of the study area (Davis et al., 1982). Stewart (1998) indicates that detachment faulting in the general region of southeastern California and near the site was likely active between 20 to 18 mya.

8.6 Additional Structures to Convolve

It is clear from field mapping that additional structures exist in the study area that contributed to the understanding the current geologic structure. These structures are primarily associated with the complex faulting history in the area during the Miocene. The study area exhibits a series of multi-modal normal fault systems that were in part produced by variations in stress regimes over time or transtension (forces that both pull apart and cause horizontal sliding to occur). The region exhibits a series of north-dipping, northeast-southwest striking normal faults (Faults No. 1 through 9 on Plate 2), and a series of dominantly north-south striking faults that primarily dip to the west (Cross Faults CF-A through CF-L on Plate 2). In addition, there are some north-south striking faults in the Marble Mountains that dip to the east that are older than (offset by) the north-dipping, northeast-southwest striking normal faults (i.e. Fault No.7).

Cross Faults CF-A through CF-L (Plate 2) clearly postdate (offset) the Miocene volcanics (Tv) and the detachment fault itself. Due to a paucity of volcanic members in the Miocene fanglomerates (Mf) it seems likely that Faults No 1 through 9 were active prior to local deposition of unit Tv and presumed in the model presented here to have been active during detachment faulting. Thus, Faults No. 1 through 9 were likely active prior to Cross Faults CF-A through CF-L. This model is presuming that Faults No. 1

through 9 do in fact connect with a detachment fault at depth in the Fenner Gap, which has yet to be proven.

The transition from activity of Faults No. 1 through 9 to Cross Faults CF-A through CF-L was likely associated with a change in 'tectonic' stress direction. Specifically, Faults No. 1 through 9 were active during early stages of extension associated with a north-northwest to south-southeast extensional stress direction that transitioned during later stages to an extensional stress direction in the dominantly southwest to northeast direction to produce the Cross Faults. However, it is believed that at least Fault No.3 remained active after the stress direction change within the central axis of the Valley (and possibly Faults No.4, 5, and 6). During this transition, Fault No.3 cut through the detachment fault as did the Cross Faults. Thus, the change in stress directions in the area may closely correlate in time with cessation of activity of the detachment fault. Keep in mind that Cross Fault CF-L offsets the detachment fault in the northeastern volcanic terrain.

9.0 SUMMARY OF MIOCENE FAULT HISTORY

The structure model proposed here indicates that Faults No.1 through 9 were initially active as a series of imbricated listric faults during early stages of extension that connected to the underlying detachment fault. This style of faulting may have occurred between 25 to 17 mya but likely in the range of 20 to 18 mya. This stage is consistent with the model shown in Figure 6. Between approximately 19 to 16 mya most of the local volcanic rocks were deposited. Sometime during deposition of the local volcanics, faulting transitioned into a period of high angle block faulting, possibly left-lateral transtensional, involving Cross Faults CF-A through CF-L and possibly Faults No. 3 through 6 in the Fenner Gap all of which cut through the now inactive detachment fault. Similar high angle block faulting was identified during the later stages of Miocene extension in the Sonoran Desert (northern Mexico) that was dated between 15 to 10 mya (Nourse, et al., 1994). This stage of faulting is similar to that shown in Figure 8. During this stage of block faulting, large-scale block faults may have allowed for the Marble and Ship Mountains to rise collectively relative to Bristol and Cadiz Valleys and thus create the current topography observed today. Since the end of extension, the area has been relatively tectonically stable allowing for the deposition of late Tertiary alluvial deposits (unit TQal).

10.0 CONCLUSIONS

The primary conclusions of this study are provided on the Geologic Map (Plate 1) and on the eight cross sections across Fenner Gap (Plates 3 and 4). The existing geologic data utilized to create the cross sections provided on Plates 3 and 4 do not provide a unique solution. Assumptions had to be made especially considering the random nature associated with Jurassic intrusive igneous rocks but also regarding the complex history of various modes of normal faulting during the Miocene. For example, the volume of Jurassic intrusives into the Bird Spring and Bonanza King formation in the southern Fenner Gap region is unknown. However, a relatively low volume of igneous intrusives is shown into these rocks in southern Fenner Gap primarily due to the lack of metamorphism exhibited in the Bird Spring Hills. It is also evident that some additional normal faulting associated with various cross faults likely occur across Fenner Gap. These faults were evaluated within the cross sections in the regions where surface data suggested or indicated their presence. This is the case in the southern Marble Mountains, area of Mt. Bonanza and the northern volcanic terrain. However, there is little evidence regarding the location of various cross faults within the central region of the Fenner Gap. These types of faults likely do occur across Fenner Gap because they occur in bedrock exposures on both the north and south sides of the Fenner Gap.

Good exposures of all the rocks shown in the cross sections were mapped on the surface, which provided key structural and stratigraphic relationships and unit characteristics assisting in their occurrence at depth.

Examples of this include the nearly vertical foliation and consistent strike of unit Jdg across Fenner Gap, and identification of the antiform structure in unit Jgr-Ar that trended from the northern Ship Mountains into Fenner Gap where it is buried. Other examples include the well defined stratigraphy of the Paleozoic section that provided fantastic structural markers, particularly for the lower Cambrian suite that exhibit a very distinct stratigraphic section. Identification of the detachment fault in the northern volcanic terrain also provided a very important component to understanding the local structure.

Completion of the cross sections within Fenner Gap would have proven extremely difficult without the current boring data shown on Plate 2. Additional boring data would likely change the cross sections as well, however they would likely only shift geologic contacts and/or fault locations on the scale of less than 500 feet. This value was determined during the study by evaluating new boring data and applying that data to the previously constructed interim cross sections. In some instances, the anticipated (predicted) geologic units and/or structures encountered in new borings were only off by less than 200 feet.

It can be assumed that all the rocks, faults and other structures buried within the Fenner Gap are not shown exactly where they truly exist, however, the average cross sectional area of the various rock types likely are fairly accurate. It can also be assumed that in general, the interpreted buried geologic structure shown on the cross sections of Plates 3 and 4 are a simplification of reality. The largest error that may exist within the provided sections likely involves additional normal faults similar to the identified cross faults, which likely exist across the entire Fenner Gap.

Miles Kenney
Kenney GeoScience

11.0 REFERENCES

Acton, G.D., Butler, R.F., Calderone, G.J., 1990, Paleomagnetism of Middle Miocene Volcanic rocks in the Mojave-Sonora desert region of western Arizona and southeastern California; Journal of Geophysical Research, v. 95, no. B1, pp. 625-647.

Anderson, J.L., Armstrong, R.L., Davis, G.A., Frost, E.G., Krummenacher, D., Martin, D.L., 1982, Geologic and Geochronologic relations in the lower plate of the Whipple detachment fault, Whipple mountains, southeastern California: A progress report; p. 409, pp. 426-431, *in* Frost, E.G., Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; Anderson-Hamilton volume.

Anderson, J.L., Howard, K.A., Miller, D.M., 1981, Mylonitic gneiss related to emplacement of a cretaceous batholiths, Iron mountains, southern California; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 73-75.

Anderson, D.L., Kanamori, H., 1975, Theoretical basis of some empirical relations in seismology; Bulletin of the Seismological Society of America, Vol. 65, No. 5, pp. 1073-1095.

Baldwin, J., Murbach, D., Mojave Desert; pp. 19-36, *in* Howard, K.A., John, B.E., Miller, D.A., GSA 1982 Cord. Sec. Guidebook, Preliminary Geology of the Bristol Lake region, Mojave Desert, California.

Bartley, J.M., Fletcher, J.M., Glazner, A.F., Martin, M.W., Walker, J.D., 1995, Large-magnitude continental extension: An example from the central Mojave metamorphic core complex; GSA Bulletin, v. 107; no. 12; p. 1468-1483.

Bartley, J.M., Glazner, A.F., 1994, Eruption of alkali basalts during crustal shortening in southern California; Tectonics, v. 13, no. 2, pp. 493-498.

Bartley, J.M., Glazner, A.F., Walker, J.D., 1989, Magnitude and significance of Miocene crustal extension in the central Mojave desert, California; Geology, v. 17, p. 50-53.

Bishop, C.C., 1963, Compiler, Geologic Map of California, Needles Sheet: California Divisions of Mines and Geology (now the California Geological Survey), scale 1:250,000.

Brandon, A.D., Chacko, T., Creaser, R.A., Constraints on rates of granitic magma transport from epidote dissolution kinetics; Department of Geology, University of Alberta, p. 1-18.

Brown, H., 1981, Stratigraphic and structure of a portion of the Bristol Mountains, San Bernardino County, California; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 10-11.

Burchfiel, B.C., Wernicke, B., 1982, Modes of extensional tectonics; Journal of Structural Geology, v. 4, no. 2, pp. 105-115.

Calzia, J.P., Morton, J.L., 1980, Compilation of isotopic ages within the Needles 1 by 2 degree quadrangle, California and Arizona: U.S. Geol. Survey Open-File Report 80-1303, scale 1:250,000.

Carr, M.D., Howard, K.A., Miller, D.A., 1981, Tectonic framework of the Mojave and Sonoran deserts, California and Arizona; United States Department of the Interior Geological Survey, Open-file Report 81-503.

Cooper, J.D., Fedo, C.M., 1990, Braided fluvial to marine transition: the basal lower Cambrian Wood Canyon formation, southern Marble mountains, Mojave desert, California: Journal of sedimentary petrology, v. 60, no. 2, pp. 220-234.

Crickmay, C.H., Hazzard, J.C., 1993, Notes on the Cambrian rocks of the eastern Mojave desert, California; University of California Publ. Bull. Dept. Geol. Sci., v. 23 p. 57-79.

Dahm, J.B., Hankins, D.D., 1982, Preliminary Geology of a portion of the southern Kofa mountains, Yuma County, Arizona; *in* Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume, pp. 459-468.

Davis, C.A., Anderson, J.L, Martin, D.L., Krummenacher, D., Frost, E.G., Armstrong, R.L., 1982; Geologic and Geochronologic relations in the lower plate of the Whipple Detachment fault, Whipple Mountains, southeastern California: A progress report; *in* Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume, pp. 409-431.

Dawes, R.L., Evans, B.W., 1991, Mineralogy and geothermobarometry of magmatic epidote-bearing dikes, Front Range, Colorado; Geological Society of America Bulletin, v. 103, pp. 1017-1031.

Dokka, R.K., 1980, Early Miocene detachment faulting in the central Mojave desert, California; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 29-31.

Dohrenwend, J.C., Bull, W. B., McFadden, L. D., Smith, G. I., Smith, R. S. U., Wells, S. G.; 1991; Quaternary geology of the Basin and Range Province in California; *in* The Geology of North America Vol. K-2, Quaternary Nonglacial Geology: Conteminous U.S.; The Geological Society of America, Chapter 11, p. 321-352.

Fowler, E., Kooser, M.A., Sadler, P.M., Webster, M., 2003, Combining stratigraphic sections and museum collections to increase biostratigraphic resolution, Application to lower Cambrian trilobites from southern California; Approaches in high-resolution stratigraphic paleontology, edited by Peter J. Harries, chapter 3, pp. 95-99.

Fox, L.K., Miller, D.M., 1990, Jurassic granitoids and related rocks of the southern Bristol mountains, southern Providence mountains, and Colton Hills, Mojave Desert, California *in* Anderson, J.L., ed., The nature and origin of Cordilleran magmatism: Boulder, Colorado, Geological Society of America Memoir 174.

Frost, E. G., Martin D.L. (editors), 1982; Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume; pp.608, includes 51 articles.

Geologic Map of California, 1964, Needles Sheet; Division of Mines and Geology.

Glazner, A.F., 1990, Recycling of continental crust in Miocene volcanic rocks from the Mojave block, southern California; *in* Anderson, J.L., ed., The nature and origin of Cordilleran magmatism: Boulder, Colorado, Geological Society of America, Memoir 174.

Glazner, A.F., Miller, J.S., 1995, Jurassic plutonism and crustal evolution in the central Mojave Desert, California; Contrib Mineral Petrol v. 118: pp. 379-395.

Hagadorn, J.W., Waggoner, B., 2005, Conical fossils from the lower Cambrian of eastern California; University of California Museum of Paleontology, http://www3.amherst.edu/~jwhagadorn/publications/PaleoBios.pdf, PaleoBios 25 (1):1-10.

Hamilton, W.B., 1980, Core complexes of the Cordillera; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; p. 41.

Hamilton, W., 1982; Structural Evolution of the Big Maria Mountain, northeastern Riverside County, southeastern California; in Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume; pp. 1-25.

Hamilton, W., Howard, K.A., Stone, P., 1983, Correlation of metamorphosed Paleozoic strata of the southeastern Mojave desert region, California and Arizona; Geological Society of America Bulletin, v. 94, pp. 1135-1147.

Hammarstrom, J.M., Zen, E., 1984, Magmatic epidote and its petrologic significance; Geology, v. 12, p. 515-518.

Hazzard, J.C., Mason, J.F., 1936, Middle Cambrian formations of the providence and Marble mountains, California; Bulletin of the Geological Society of America, v. 47, pp. 229-240.

Hazzard, J.C., 1954, Rocks and structure of the northern Providence Mountains, San Bernardino County, California; Geology of southern California Bulletin 170, chapter 4, pp. 27-35.

Hillhouse, J.W., Wells, R.E., 1989, Paleomagnetism and tectonic rotation of the lower Miocene Peach Springs Tuff: Colorado Plateau, Arizona, to Barstow, California; U.S. Geological Survey, GSA Bulletin*;* June 1989; v. 101; no. 6; p. 846-863.

Horringa, E.D., Howard, K.A., Miller, D.A., Stone, P., 1989, Geologic map of the eastern parts of the Cadiz lake and Cadiz valley 15-minute quadrangles, San Bernardino and Riverside counties, California; Department of the Interior U.S. Geological Survey, Map MF-2086.

Howard, K.A., Miller, C.F., and Stone, P., 1980, Mesozoic thrusting in the eastern Mojave Desert, California: Geological Society of America Abstracts with Programs, v. 12, p. 112.

Howard, K.A., Miller, D.M., and John, B.E., 1982, Regional character of mylonitic gneiss in the Cadiz valley area, southeastern California; *in* Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume, pp. 441-447;

Howard, K.A., Miller, D.M., 1992, Late Cenozoic Faulting at the boundary between the Mojave and Sonoran blocks: Bristol Lake Area, California, *in* Richard, S.M., ed., Deformation associated with the Neogene Eastern California Shear Zone, southwestern Arizona and southeastern California: Redlands, Calif., San Bernardino County Museum Special Publication, p. 37-47.

Howard, K.A., 2002; Geologic map of the Sheep Hole Mountains 30' by 60' Quadrangle, San Bernardino and Riverside Counties, California; USGS Miscellaneous Field Studies MF-2344, Sheets 1 and 2.

Jennings, C.W., 1994, Fault activity map of California and adjacent areas with location and ages of recent volcanic eruptions; Division of Mines and Geology (California Geological Survey), Geologic Data Map No.6.

John, B.E., 1981, Reconnaissance study of Mesozoic plutonic rocks in the Mojave desert region; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; p. 48-50.

Karlstrom, K.E., Kingsbury, J.A., Miller, C.F., Wooden, J.L., 1993, Pluton emplacement along an active ductile thrust zone, Piute mountains, southeastern California: Interaction between deformational and solidification processes; Geological Society of America bulletin, v. 105, pp. 213-230.

Lanphere, M.A, 1964, Geochronolgic studies in the eastern Mojave Desert, California: Journal of Geology, v.72, p.281-399.

LeVeque, R.A., May, D.J., Miller, R.J., Peterson, D.W., Tosdal, R.M., 1981, Miocene volcanic rocks of the Ajo range, south-central Arizona; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 65-66.

Lucchitta, I., 1981, Observations and speculations regarding the relations and origins of mylonitic gneiss and associated detachment faults near the Colorado plateau boundary in western Arizona; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 53-55.

Machette, M.N. 1985, Calcic soils of the southwestern United States; Geological Society of America Special Paper 203, pp 1-21.

May, D.J., Peterson, D.W., Tosdal, R.M., LeVeque, R.A., Miller, R.J., 1981; Miocene volcanic rocks of the Ajo Range, south-central Arizona; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 65-66.

McCurry, M., 1981, The structure and stratigraphy of Miocene volcanic rocks in the Woods mountains area, eastern Mojave desert, San Bernardino county, California; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 67-69.

Miller, C.F., 1981, Cordilleran peraluminous granites: an ancient quartofeldspathic source; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 70-72.

Miller, D.M., Howard, K.A., John, B.E., 1982, Preliminary geology of the Bristol Lake region, Mojave Desert, California; Geological Society of America 1982 Cordilleran Section Guidebook, pp.128-137.

Montañez, I.P., Osleger, D.A., 1996, Contrasting sequence boundary zones developed within cyclic carbonates of the Bonanza King formation, middle to late Cambrian, southern Great Basin, in Witzke, B.J., Ludvigson, G.A., and Day, J., eds., Paleozoic Sequence Stratigraphy: Views from the north American Craton: Boulder, Colorado, Geological Society of America Special Paper 306.

McSween Jr., H.Y., Speer, J.A., Vyhnal, C.R., 1991, Hornblende chemistry in southern Appalachian granitoids: Implications for aluminum hornblende thermobarometry and magmatic epidote stability; American Mineralogist, v. 76, pp. 176-188.

Powell, R.E., 1993; Balanced palinspastic reconstruction of Pre-Late Cenozoic paleogeology, southern California: Geologic and kinematic constraints on evolution of the San Andreas System; in The San Andreas Fault System: Displacement, Palinspastic Reconstruction and Geologic Evolution, edited by Powell, R.E., Weldon, R.J. and Matti, J.C., Geological Society of America, Memoir 178, pages 1-106.

NORCAL Geophysical Consultants, Inc, 1997, Seismic Survey Cadiz Valley, Cadiz, California; report prepared for Cadiz Land Company, NORCAL Job No.95-386.01, report dated October 17, 1997.

Nourse, J.A., Anderson, T.H., Silver, L.T., 1994, Tertiary metamorphic core complexes in Sonora northwestern Mexico; Tectonics, Vol. 13, No.5, pp.1161-1182.

Otton, J.K., 1981, Structural Geology of the Date creek basin area, west-central Arizona; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; p. 82-83.

Reynolds, S.J., Spencer, J.E., 1989, Overview of the Geology and mineral resources of the Buckskin and Rawhide Mountains; Arizona Geological Survey, v. 19, no. 2, p.5-10.

Silver, L.T., McKinney, 1963, U-Pb isotopic age studies of a Precambrian granite, Marble Mountains, San Bernardino County, California; (abs): Geological Society of America Special Paper 73, p.65.

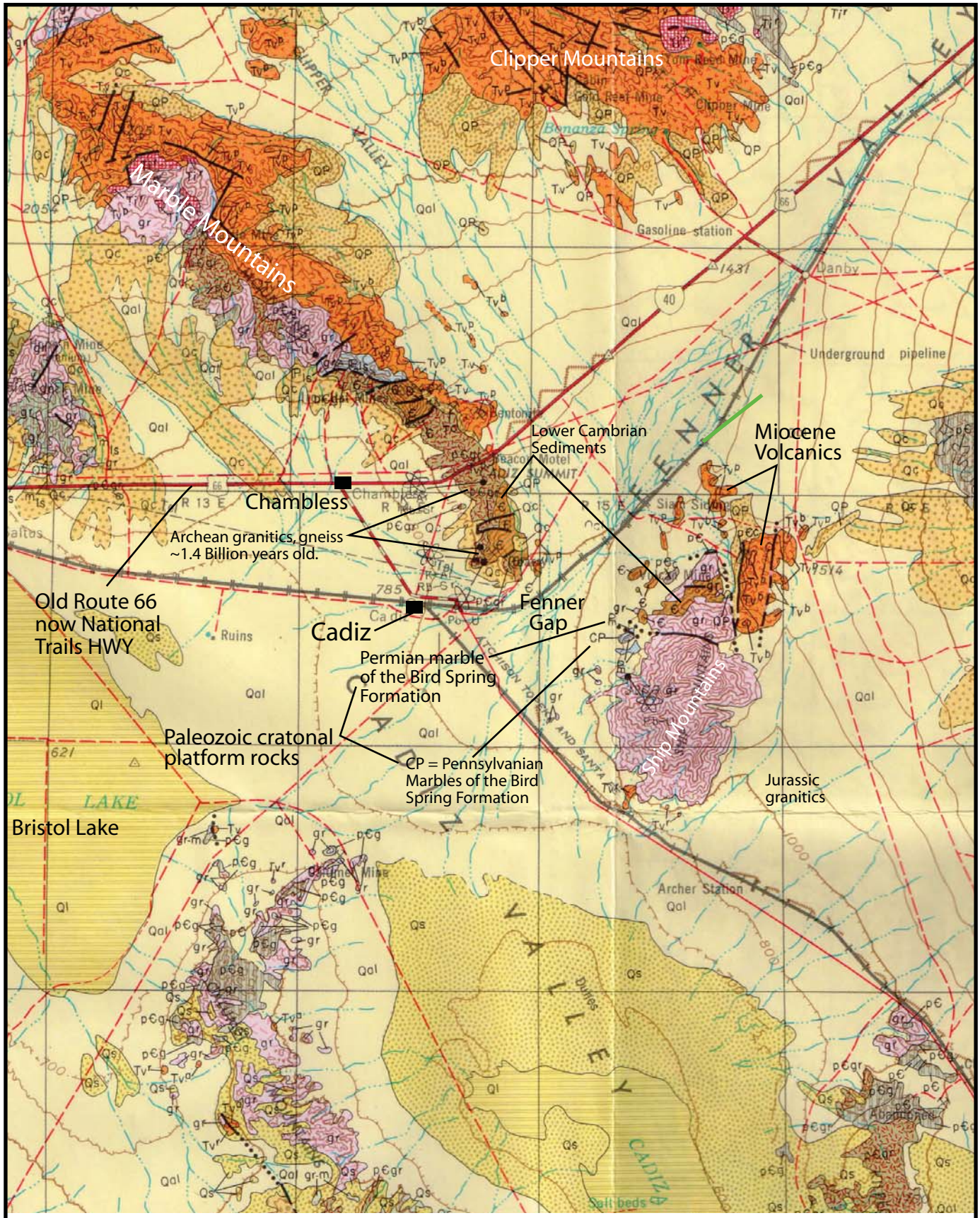
Stewart, J.H., 1998, Regional characteristics, tilt domains, and extensional history of the late Cenozoic Basin and Range province, western North America, *in* Faulds, J.E., Stewart, J.H., eds., Accommodation Zones and Transfer Zones: The Regional Segmentation of the Basin and Range Province: Boulder, Colorado, Geological Society of America Special Paper 323.

Stevens, C.H., Stone, P., 2007, The Pennsylvanian-Early Permian Bird spring carbonate shelf, southeastern California: Fusulind biostratigraphy, paleogeographic evolution, and tectonic implications; Geological society of America special paper 429.

Suneson N., Luccitta, I., 1981, The origin of a Miocene basalt-rhyolite suite, southern Basin and Range Province, western Arizona; *in* Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona, Abstracts from a conference held by the USGS, 1980, edited by Howard, K.A., Carr, M.D., and Miller D.M.; pp. 107-109.

Teel, D.B., Frost E.G., 1982, Synorogenic evolution of the Copper Basin Formation in the eastern Whipple Mountains, San Bernardo County, California; *in* Mesozoic-Cenozoic tectonic evolution of the Colorado river region, California, Arizona, and Nevada; edited by Frost, E.G., Martin, D.L., Anderson-Hamilton Volume, pp. 275-285.

Wells, R.E., Hillhouse, J.W., 1989, Paleomagnetism and tectonic rotation of the lower Miocene Peach Springs Tuff: Colorado Plateau, Arizona, to Barstow, California; GSA Bulletin, v.101, no. 6, pp. 846-863.

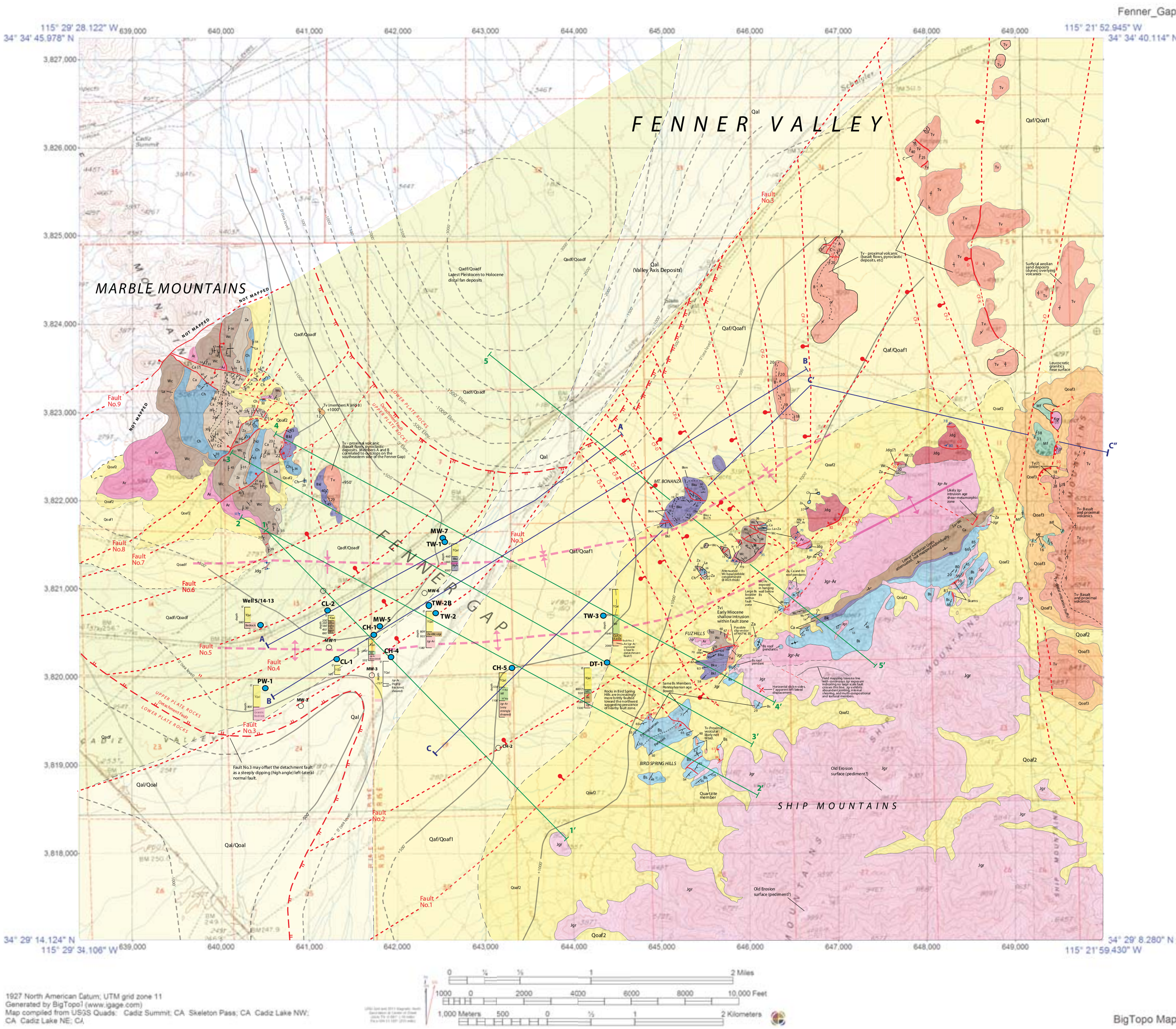


0 5

Scale (miles)

N

CADIZ GROUNDWATER PROJECT		JN 716-10
REGIONAL GEOLOGIC MAP OF THE FENNER GAP AREA	DRAFT	MDK 06/2011
	Kenney GeoScience	Plate 1



1927 North American Datum; UTM grid zone 11
Generated by BigTopo1 (www.igage.com)
Map compiled from USGS Quads: Cadiz Summit, CA Skeleton Pass, CA Cadiz Lake NW, CA Cadiz Lake NE, CA

STRATIGTAPHIC SECTION

Basin & Range Extensional Tectonics

TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits)
Primarily composed of silty sand and gravels deposited by fluvial processes post early Miocene Basin and Range extension. By definition within this report, TQal exhibits horizontal to nearly horizontal bedding (2-3 degree dips typical of alluvial fans), a paucity of fractures or joints and thus is relatively undeformed suggesting it post dates Miocene extensional tectonics. However at depth, unit TQal could and likely is comformable with underlying unit Mf in some places. The unit exhibits fine beds of silty fine to medium sand, some thin silt beds, and occassional carbonate zones that likely represent paleosols or conglomerate layers with post depositional groundwater flow. Conglomerate members contain local clasts (volcanics, carbonates, igneous plutonic). This unit has been subdivided into various alluvial units based on relative age and depositional environment (Qal, Qadf, Qoaf1, Qoaf2 and Qoaf3). Unit Qal represents valley axis sediments from distal sources. There is a general coarsening from unit Qal to unit Qoaf3 primarily associated with sediment transport distances.

Uncomformity in most exposed localities

Tv & Tvi - Tv and Tvi- TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)
Andesitic or dacitic tuffs including crystal-vitric, crystal-lithic, and vitri-lithic types. Tv and Tvi represent volcanic and hypabyssal (cooled and crystalized-emplaced near the surface) rocks. Colors range from dark gray to white and dark to light reddish brown. Partly massive and well bedded. Andesitic and basaltic flows comprise 1/4 of section. Limestone cobbles occur in lowestmember derived from local basement exposures in Fenner Valley & Wild Horse. Likely 1100 to 1200 feet thick locally and exhibit primarily distal tuffs and pyroclastic flows in the lower members which transition up section into primarily more proximal rhyolite tuffs and basalt flows. Unit Tv is mapped separate from unit Mf (below) however, interbedding of Tv and Mf particularly in the upper members of unit Mf is possible as both are associated with stages of Miocene extensional tectonics. Type section for intrusive unit Tvi occurs along Fault No. 1 in the Fuz Hills. Crude correlated stratigraphy of Tv exposures includes layers A (vesicular ash tuff 20 feet thick)/B (salmon colored tuff with blue iridesence sanidine 10 feet thick)/C (vesicular basalt 75 to 100' thick).

Mf - MIOCENE FANGLOMERATES
This unit represents a coarsening upward sequence of sediments composed of well bedded silty fine to medium sands (base of unit), to well bedded gravely sands with exotic well rounded clasts, to cobble conglomerate with rounded exotic and subangular to angular local clasts, to conglomerate-breccia composed of local mylonitic or other local subangular to angular clasts (upper members). The unit generally dips between 10 to 30 degrees to the east, is fractured, very dense, and well cemented. Mf is interpreted to represent deposition and deformation associated with local Basin and Range extensional tectonics during the early Miocene; however, basal members exposed in the northeastern Ship Mountains exhibit fluvial deposits with exotic clasts indicating possible deposition prior to local early Miocene extenstion. No purely volcanic layers were identified in unit Mf however volcanic clasts were identified at the base of unit Mf in some cores.

Kgr - CRETACEOUS LEUCOCRATIC GRANITE
Leucocratic granite (Late Cretaceous ?). Fine to coarse grained 2-mica granite. Zones of weak mylonitic texture where in close proximity to detachment fault to non foliated. Unit only identified in hanging wall rocks where detachment fault is exposed on the surface in the northeastern Ship Mountains. Unit may correlate to leucocratic 2-mica granites in the Old Woman Mountains described by Howard, 2002 and Howard et al, 1989 (units Kl and Kmg), and Karlstrom et al., 1993.

JURASSIC IGNEOUS AND METAMORPHIC SUITE (U-Pb ~167 Ma)

Jurassic Igneous and Metamorphic Suite

Jgr - Jurassic Granitics
Medium to fine grained biotite quartz syenite, syenogranite, quartz monzonite, and fine grained hypabyssal equivalents. The unit exhibits a paucity of quartz and salmon color orthoclase feldspar is common. The unit is typically not ductilly foliated but does exhibit considerable jointing and fracturing throughout suggesting some stress at upper crustal levels. Penetrative epidote secondary mineralization is very common. Relatively small to very large roof pendants of older bedrock units and sills are common. This intrusive suite likely correlates well in terms of general age, time transgressive composition variations from mafic to more felsic, occurence of aplite dikes and emplacement at relatively shallow crustal depths as described by Fox and Miller, 1990 evaluating similar rocks in the southern Bristol, southern Providence Mountains and Colton Hills. This unit intruded and deformed all relatively older units which has led to a change in structure across the Fenner Gap between the relatively unintruded Marble Mountains and strong intrusions within the Ship Mountains. The contact between these two structural terrains occurs within Fenner Gap. Aplite dikes are also common within this unit.

Jdg - Jurassic Dioritic Gneiss
This unit represents dioritic intrusives with zones of a banded gneiss with minor zones exhibiting weak mylonitic fabric. The unit is primarily dioritic but contains felsic zones. Intercalated zones of lower Cambrian units, particularly Wood Canyon and possibly Zabriskie Quartzite occur within the unit indicating that Jdg is not pre-Cambrian in age. Foliation of the unit likely occured during emplacement into Archean igneous and metamorphic suite and lower Cambrian stratigraphic units described below. Foliation is nearly vertical and strikes generally east-west. Fine grained aplite dikes and aphanitic rhyolitic injections parallel to the gneiss foliation occur. This newly discovered unit which was mapped as Pre-Cambrian by earlier studies is conidered here to represent part of the Jurrassic igneous suite of rocks associated with early stages of emplacment of unit Jgr. Secondary epidote is common but cannot rule out magmatic crystallization. Aphanitic dikes parallel to foliation are consistent with upper crustal emplacement similar to unit Jgr. Based on currentmapping data, unit Jdg may have been emplaced as a tabular body trending approximately east west through the Fenner Gap, then later intrusions associated with unit Jgr primarily occured south of the Jdg tabular body with unit Jdg representing the northern boundary of unit Jgr. Within this model considerable shearing occured within unit Jdg as magma associated with uint Jgr was emplaced causing vertical uplift and formation of an antiformal structure to pre-existing rocks. May correlate with unit Jqd of Howard et al., 1989 identified in the northern Kilbeck Hills.

Jgr-Ar - Jurrasic Granitics - Archean Complex
This unit represent regions where Jurrassic plutonism (primarily Jgr) intruded into pre-existing Archean Igneous and Metamorphic Complex (Ar) and Paleozoic rocks (Wc, Za, La, Ch, Ca, Bk, Bs).

Note: The Jurrassic Igneous and Metamorphic Suite is considered part of the Eastern Plutonic Belt by Powell, 1993.

Bs (2000 to 4000 feet) - PENNSYLVANIAN TO PERMIAN BIRDSPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)
Regionally can be 4000 feet thick. Permian basal member 20 feet thick contains small black chert pebbles within sandy limestone (LS) interbeds with cross beds. About 75 feet above is a massive 70 foot light gray LS. As a unit the lower 750 feet of beds consists of dark and light gray LS in beds up to 10 feet thick. Platy to shaly, in partly sandy, fossiliferous, chert rich zones separate some of the massive beds. The upper 1380 feet of section is medium to light gray, sparingly fossiliferous LS in beds up to 5 feet thick. Minor chert and sandstone occur. Includes rocks of Wolfcamp and Leonard age. Bird Spring Fm. exists in upper Pennsylvanian to lower Permian section. Regionally, an additional ~1600 feet of LS units (Monte Cristo & Sultan Fm) exist from Devonian to Mississippian. Miller et. al (1982) indicate that metamorphosed Bird Spring containing early Pennsylvanian conodonts also occurs in the Marble Mtns and an unmetamorphosed section ~ 2500 feet thick (750 meters) crops out in the Ship Mountains. Monte Cristo Formation occurs in some places at the base of the Bird Spring Formation - vitreous, nearly pure, typically massive marble which may occur within the northern Ship Mountains. Marbles (metamorphosed) associated with the Sultan Limestone may also occur locally in the Ship Mountains although this has not be verified. The Bird Spring Formation in the northern Ship Mountains is attenuated due to emplacement of unit Jgr.

Uncomformity

Bk (2000 feet thick) - MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)

Bku: UPPER MEMBER: Light creamy gray dolomite, 200 - 250 feet thick:

Bkm: MIDDLE MEMBER - SILVER KING DOLOMITE: Very dark smoky gray to nearly black dolomite, 200 to 250 feet thick.

Bkl: LOWER MEMBER Dark smoky gray dolomite and partially dolomitized LS, locally cherty and sandy. Intraformational pebble and cobble conglomerates occur. 1500 - 1800 feet thick. Individual beds 3 to 6 feet thick.

Uncomformity

LOWER CAMBRIAN SEDIMENTARY SUITE

Lower Cambrian Sedimentary Section (total thickness is ~1,100 feet)

Ca - LOWER CAMBRIAN CADIZ FORMATION (EARLY PALEOZOIC)
Buff and gray muddy limestone, purplish and reddish platy shale, greenish gray platy shale and platy to massive quartzite. Unit is ~375 feet thick. (114 meters). Coarse grained marls exhibit distinctive herringbone structures.

Ch - LOWER CAMBRIAN CHAMBLESS LIMESTONE (EARLY PALEOZOIC)
Massive weathering, light to primarily dark gray limestone in beds 1 to 10 feet thick. Algal nodules and distinctive red blotches of unkown cause occur throughout the unit. Locally a 10 to 15 foot zone of platy fossiliferous limestone occurs a little above the middle. 85 to 155 feet thick (26 to 47 meters). Locally may be as thick as 200 feet.

La - LOWER CAMBRIAN LATHAM SHALE (EARLY PALEOZOIC) - Correlates with Bright Angel Shale. Fossiliferous greenish gray platy shale which weathers to platy and paperthin fragments. Thin buff weathering sandy limestone layers are present. Famous Trilobite fossil beds. ~ 82 feet thick (25 meters). Also referred to as the Carrara Formation.

Za - LOWER CAMBRIAN ZABRISKIE QUARTZITE (PALEOZOIC) -Correlates with Tapeats Sandstone. Massive brownish weathering white to grayish white quartzite with beds 2 - 6 feet thick. Unit is 50 to 75 feet thick.

Wc - LOWER CAMBRIAN WOODCANYON FORMATION (PALEOZOIC)
Unit described by Hazard, 1954) as Fine grained dark greenish gray shaly to platy quartzite; fine grained reddish brown weathering white quartzite in beds 6-inches to 2 feet thick that can be friable with crossbedding and pebble lenses (thick unit); fine grained dark greenish gray platy quartzite; light gray to reddish brown weathering limestone, locally dolomitized; fine grained greenish black shaly quartzite with local pebble lenses occur a few feet above the base. Unit is 300 to 425 feet thick. Unit is dominantly quartzite.
UPPER MEMBER: Alternating siltstone, quartzite and carbonate (Fedo and Cooper, 1990)
MIDDLE MEMBER: Dark colored cross stratified quartzite
LOWER MEMBER: Alternating siltstone, quartzite and carbonate.

~~~~ *Erosion Surface (correlates with the Great Unconformity in the Grand Canyon)*

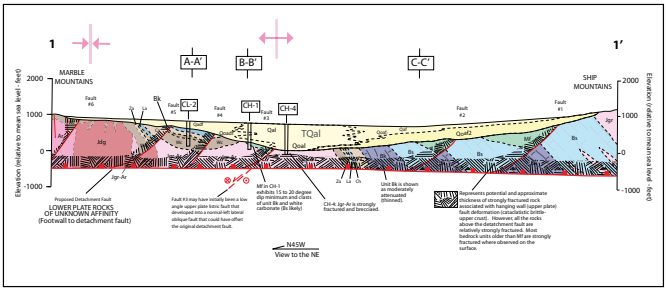
Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX
This unit consists of granite, gneiss, and schist. Granite portions range from leucocratic to pale orange. Relatively large pheonocrysts of plagioclase distinguish this unit from Jgr. 1.4 to 1.5 B.y. in the Marble Mountains (Silver and McKinney 1963; Lanphere, 1964).

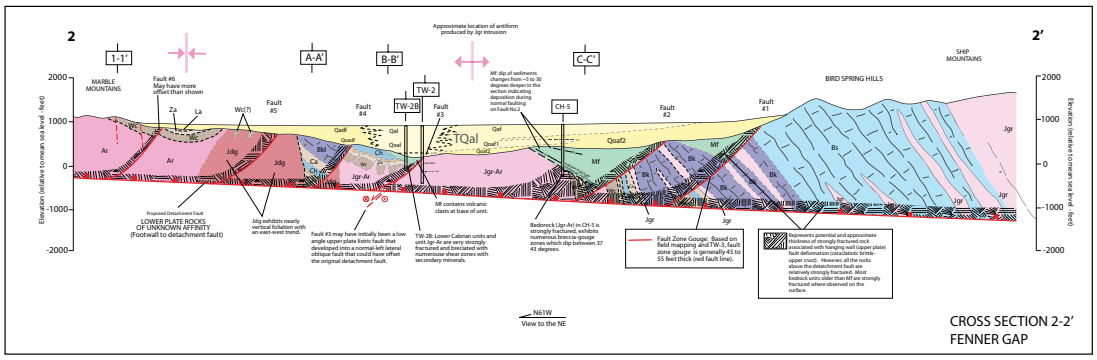
Jdg Jgr

SYMBOL DESSCRIPTIONS

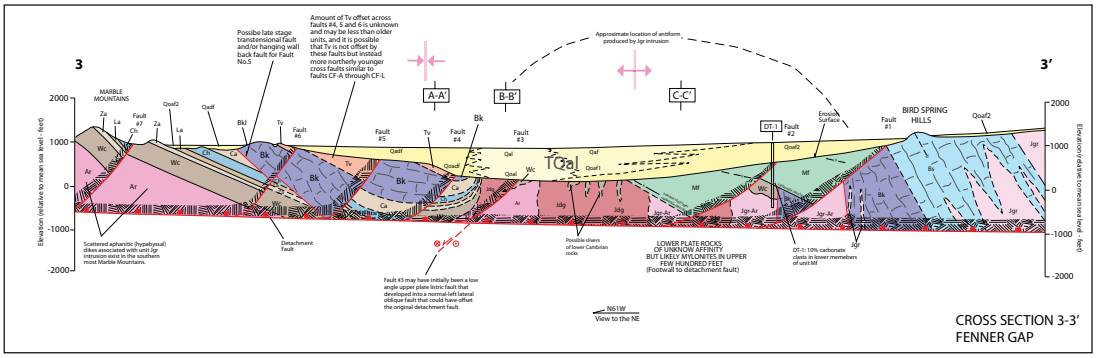
Symbol	Description
56	Strike and dip of bedding or lava flows
	Generalized strike and dip estimated from far field or Google Earth
	Strike of vertically dipping foliation which primarily occurs in unit Jdg
65	Strike and dip of foliation which primarily occurs in unit Jdg
67	Stike and dip of fault plane most of which are associated with Miocene extensional tectonics
Fault No.9	Approximate location of fault. Ball indicates down dip direction; solid line where fault is exposed at the surface; dashed lines where concealed by younger typically non-offset deposits (primarily unit TQal). The subsurface locations of Faults No. 1 through 9 are shown at evaluated depths of unfaulted deposits and thus are shown at the upper most exposure of the fault beneath unfaulted TQal deposits.
	Detachment fault where exposed either at the surface or near the surface beneath alluvim, tick marks on down dip side.
	Detachment fault where postulated to exist at depth and is exposed at the base of unfaulted unit TQal .
-1000' Elev.	Approximate depth in elevation of basement rock below neogene sediments estimated from gravity data (CH2M Hill), boring data, and cross sections.
TW-3 (0', TQal, 950', Mf, 1640', Ca/Ch/La/Za, Fault No. 2, 2000', Ar/Jgr-Ar/mylonite (close to detatchment fault?), depth)	Approximate location of exploratory boring (well). Generalized stratigraphic section of the boring is provided with depths below the surface.
5 — 5'	Approximate location of cross sections 1, 2, 3 4 5, A, B and C.
	Approximate location of synform and antiform structure produced during emplacement of Jurassic intrustions (units Jdg and Jgr). The synform resulted from shearing along the contact with unit Jdg during emplacement and the antiform associated with relatively large volumes of Jgr intrusion. The folding involves all units older than mid-Mesozoic. Pink line is solid where fold is exposed on the surface and dashed where concealed by unfolded Tertiary sediments.

CADIZ GROUNDWATER STORAGE PROJECT		JN 716-10	
GEOLOGIC MAP OF THE FENNER GAP BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS	Mapped by M.D. Kenney, T.J. Hawks	MDK	08/2011
	Kenney GeoScience	Plate 2	
~~~~

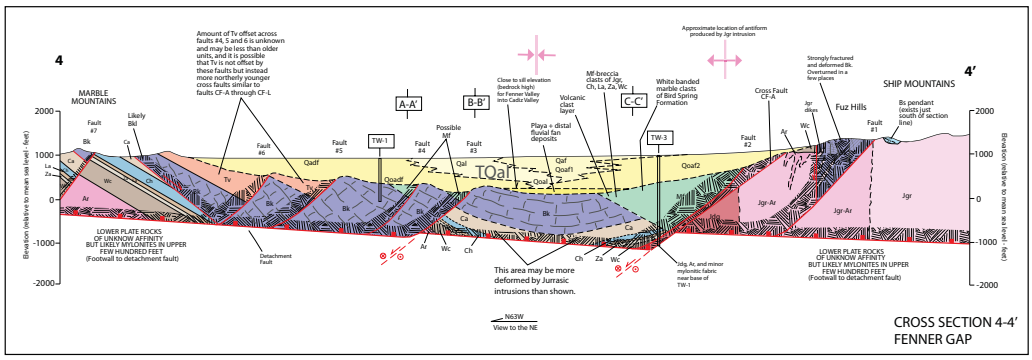




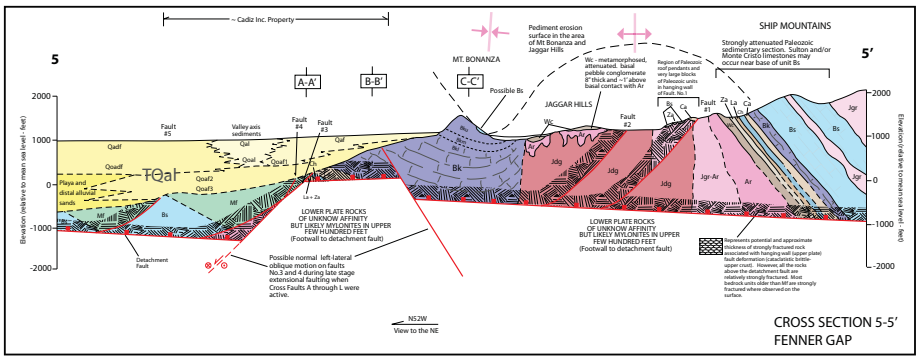
CROSS SECTION 2-2′
FENNER GAP



CROSS SECTION 3-3′
FENNER GAP



CROSS SECTION 4-4′
FENNER GAP



CROSS SECTION 5-5′
FENNER GAP

STRATIGRAPHIC SECTION

Basin & Range Basaltic Volcanics

TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits) Subunits: Qal, Qoal, Qadf, Qoadf, Qoaf1, Qoaf2 and Qoaf3.

Tv and Tvs- TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)

Mf - MIOCENE FANGLOMERATES

Kgr - CRETACEOUS LEUCOCRATIC GRANITE

JURASSIC IGNEOUS AND METAMORPHIC SUITE (U-Pb ~167 Ma)

- **Jgr** Jurassic Granitics
- **Jdg** Jurassic Dioritic Gneiss
- **Jgr-Ar** JuraSic Granitics - Archean Complex.

Bs - PENNSYLVANIAN TO PERMIAN BIRDSPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)

2000 to 4000 feet

Bk - MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)

- Bku: UPPER MEMBER: 200 - 250 feet thick
- Bkm: MIDDLE MEMBER - SILVER KING DOLOMITE: 200 to 250 feet thick
- Bkl: LOWER MEMBER: 1500 - 1800 feet thick

2000 feet thick

LOWER CAMBRIAN BLUE SPRING LIMESTONE

- **Ca** - LOWER CAMBRIAN CADIZ FORMATION
- **Ch** - LOWER CAMBRIAN CHAMBLESS LIMESTONE
- **La** - LOWER CAMBRIAN LATHAM SHALE
- **Za** - LOWER CAMBRIAN ZABRISKIE QUARTZITE
- **Wc** - LOWER CAMBRIAN WOODCANYON FORMATION

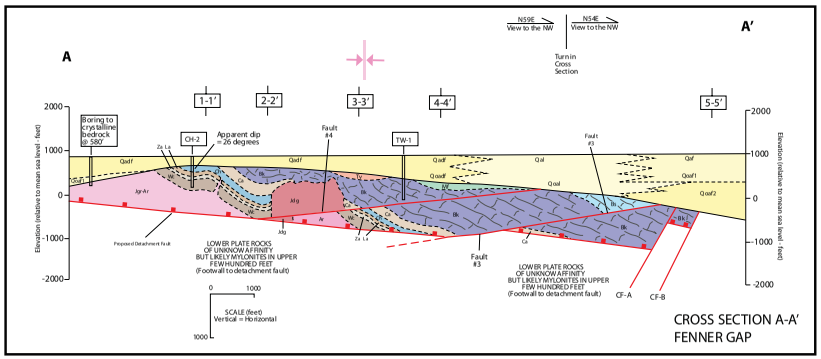
Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX (locally these rocks are Proterozoic).

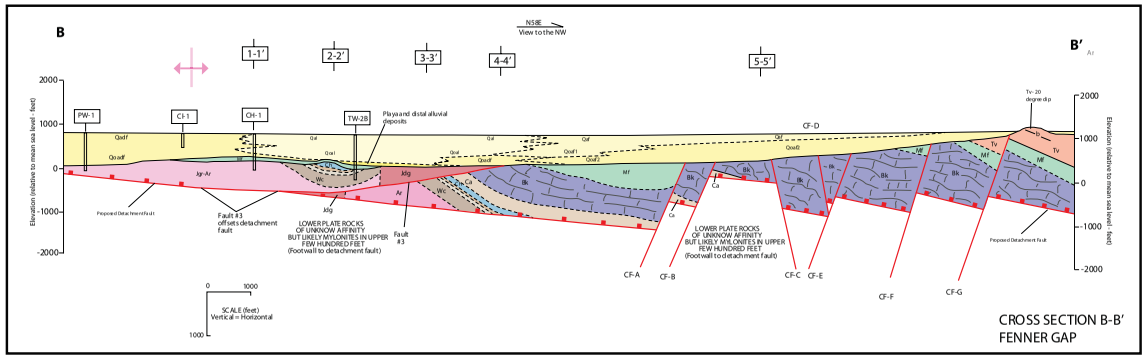
Note: Cross Sections aligned along Fault No.1

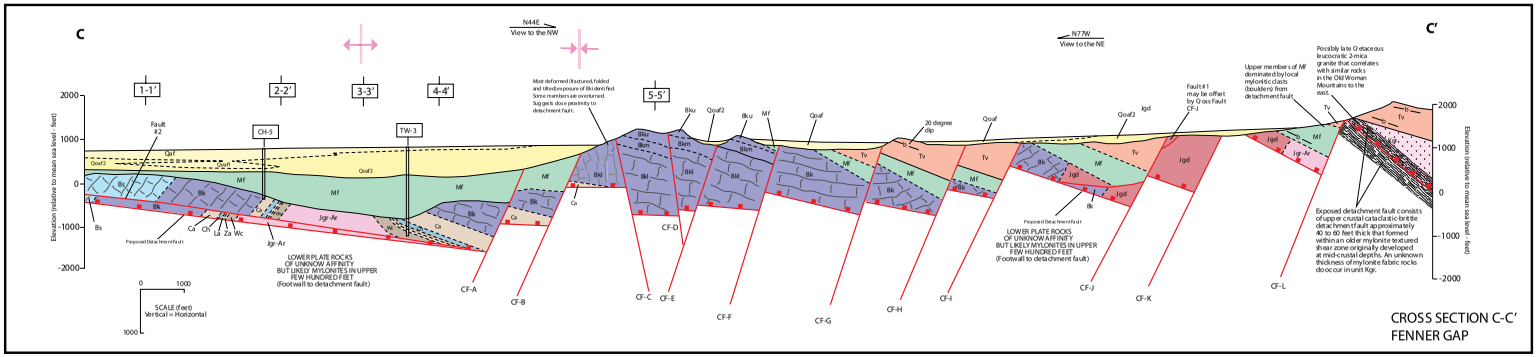
Cross section evaluation based on geologic field work conducted from September 2010 throuth April 2011.

SCALE (feet)
Vertical = Horizontal
0 1000
1000

CADIZ GROUNDWATER STORAGE PROJECT		JN 716-10
GEOLOGIC CROSS SECTIONS 1, 2, 3, 4, & 5 ACROSS THE FENNER GAP BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS	Contructed by M.D.Kenney PhD, PG	MDK 08/2011
	Kenney GeoScience	Plate 3







STRATIGRAPHIC SECTION

Basin & Range Extensional Tectonics

TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits) Subunits: Qal, Qaal, Qaalf, Qoalf, Qoaf1, Qoaf2 and Qoaf3.

Tv and Tvl- TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)

Mf - MIOCENE FANGLOMERATES

Kgr - CRETACEOUS LEUCOCRATIC GRANITE

JURASSIC IGNEOUS AND METAMORPHIC SUITE (U-Pb ~ 167 Ma)

- **Jgr** Jurassic Granitics
- **Jdg** Jurassic Diorit ic Gneiss
- **Jgr-Ar** Jurassic Granitics - Archean Complex.

2000 to 4000 feet

Bs - PENNSYLVANIAN TO PERMIAN BIRD SPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)

2000 feet thick

Bk - MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)

- **Bku**: UPPER MEMBER: 200 - 250 feet thick
- **Bkm**: MIDDLE MEMBER - SILVER KING DOLOMITE: 200 to 250 feet thick
- **Bkl**: LOWER MEMBER: 1500 - 1800 feet thick

LOWER CAMBRIAN SEDIMENTARY SUITE

- **Ca** - LOWER CAMBRIAN CADIZ FORMATION
- **Ch** - LOWER CAMBRIAN CHAMBLESS LIMESTONE
- **La** - LOWER CAMBRIAN LATHAM SHALE
- **Za** - LOWER CAMBRIAN ZABRISKIE QUARTZITE
- **Wc** - LOWER CAMBRIAN WOODCANYON FORMATION

Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX (locally these rocks are Proterozoic).

Notes:

Cross sections alinged along the intersection of Cross Section 1-1'.
Cross section evaluation based on geologic field work conducted from September 2010 throuth April 2011.

Brecciated and fractured zones are similar in thickness and structural position relative to faults as shown on Cross Sections 1 thgrough 5 on Plate 3.

CADIZ GROUNDWATER STORAGE PROJECT		JN 716-10
GEOLOGIC CROSS SECTIONS A, B and C ACROSS THE FENNER GAP BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS	Contracted by M.D.Kenney PhD,PG Kenney GeoScience	MDK 08/2011 Plate 4

APPENDIX A

GEOLOGIC STRUCTURAL EVALUATION OF THE FENNER GAP REGION LOCATED BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA

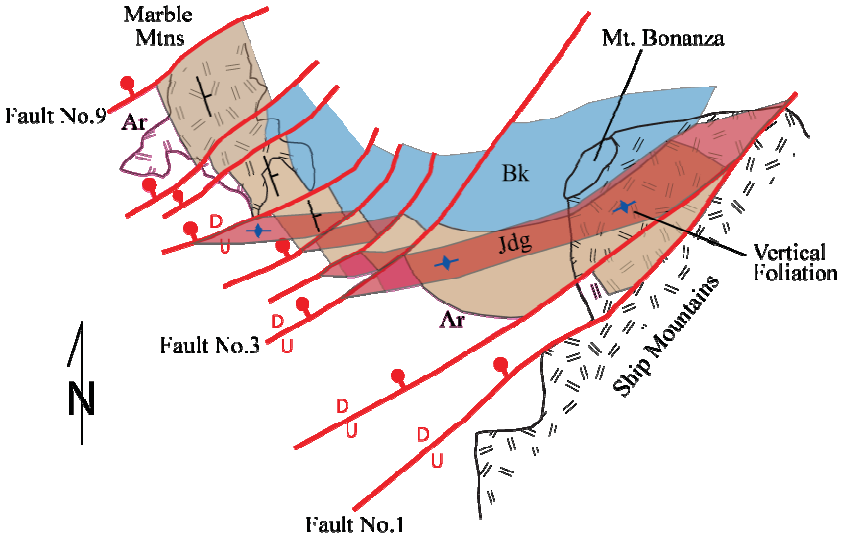
(PREPARED BY DR. MILES KENNEY)

Kenney GeoScience

APPENDIX A -
PROVIDING SUPPORTIVE DATA FOR REPORT:

GEOLOGIC STRUCTURAL EVALUATION OF THE FENNER GAP REGION LOCATED BETWEEN THE SOUTHERN MARBLE MOUNTAINS AND SHIP MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA,

REPORT DATED AUGUST 31, 2011
KENNEY GEOSCIENCE JN 716-10



Prepared for:

Brownstein Hyatt Farber Schreck, LLP
Mr. Scott Slater
21 East Carrillo Street
Santa Barbara, CA 93101

Prepared by:

Kenney GeoScience,
Dr. Miles Kenney, PG
7206 Plaza de la Costa,
Carlsbad, Ca, 92009.

September 19, 2011

TABLE OF CONTENTS

SITE LOCATION OF NAMES OF AREA A-1

LOCAL STRATIGRAPHY AND GEOLOGIC UNIT DESCRIPTIONS A-2
TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits) A-3

Tv and Tvi - TERTIARY VOLCANICS - PEACH SPRINGS TUFF
AND BASALT FLOWS (EARLY MIOCENE ~17 MY) A-3

Mf - MIOCENE FANGLOMERATES A-3

Kgr - CRETACEOUS LEUCOCRATIC GRANITE A-4

Jgr - JURASSIC IGNEOUS AND METAMORPHIC SUITE (U-Pb ~167 Ma) A-4
Jgr - Jurassic Granitics A-4
Jdg - Jurassic Dioritic Gneiss A-5
Jgr-Ar - Jurassic Granitics - Archean Complex A-5

Bs - PENNSYLVANIAN TO PERMIAN BIRD SPRING AND OTHER
LIMESTONE FORMATIONS A-5
Bird Spring Formation Stratigraphic Section A-7

Bk - MIDDLE CAMBRIAN BONANZA KING DOLOMITE A-8

LOWER CAMBRIAN SEDIMENTARY SUITE A-8
Ca - Cadiz Formation A-8
Cadiz Formation Stratigraphic Section A-10
Ch – Chambless Limestone A-11
La - Latham Shale A-11
Za - Zabriskie Quartzite A-11
Wc - Wood Canyon Formation A-11
Wood Canyon Stratigraphic Section A-13

Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX A-14

PHOTOGRAPHS OF SITE GEOLOGIC UNITS AND SETTING A-15

LOCATION AND PHOTOGRAPHS OF VUGS WITHIN CARBONATES A-30

BORING LOG DESCRIPTIONS WITHIN FENNER GAP A-36
TW-1, TW-2B, TW-3, CH-1, CH-4, CH-5, Cl-2, DT-1

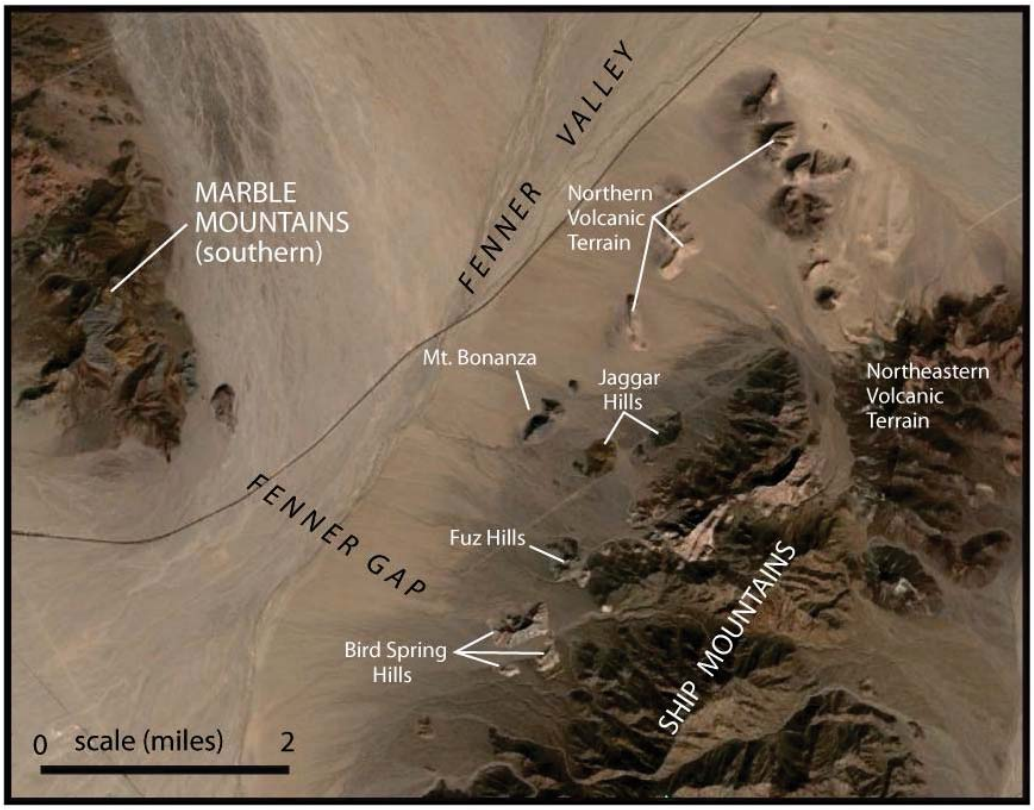
DESCRIPTIONS OF KEY DEFORMATIONAL STRUCTURES A-45
The Original System A-45
The Original System Deformed by Jurassic Intrusives A-46
Offset by Miocene Normal Faults A-47
Apparent Left-Lateral Offset of Original System A-47
Apparent Right-Lateral Offset of Vertically Dipping Jurassic Diorite Gneiss A-48
Convolving Apparent Left-Lateral offset of Original System and Right-Lateral offset of Jurassic Diorite Gneiss A-49

SITE LOCATION OF NAMES OF AREA

The study area as shown on Plate 1 represents an area encompassing the southern Marble Mountains, southeastern Fenner Valley and the western to northern Ship Mountains, in San Bernardino County, California. This region is located approximately 17 miles east of Amboy, San Bernardino County, California and a couple of miles south of the Interstate Highway 66. The Fenner Gap is defined as the valley approximately 2.6 miles wide located at the southwestern end of the Fenner Valley between the southern tip of the Marble Mountains and the northwestern most bedrock exposures of the Ship Mountains. The approximate center of the Fenner Gap is located at Latitude 34 31.2N and Longitude 115 26.7W.

Figure A1 below shows the general region of the study area (similar to the geologic map of Plate 2), the Fenner Gap, and a number of designated areas discussed in this report. Names of the designated areas were applied to some bedrock inselbergs (bedrock exposures surrounded by young alluvium) for discussion purposes. These include Bird Spring Hills, Fuz Hills, Mt. Bonanza, Jaggar Hills, northern volcanic terrain, and the northeastern volcanic terrain. These areas are also shown on a geologic map (Plate 2) and cross sections (Plates 3 and 4) of this report.

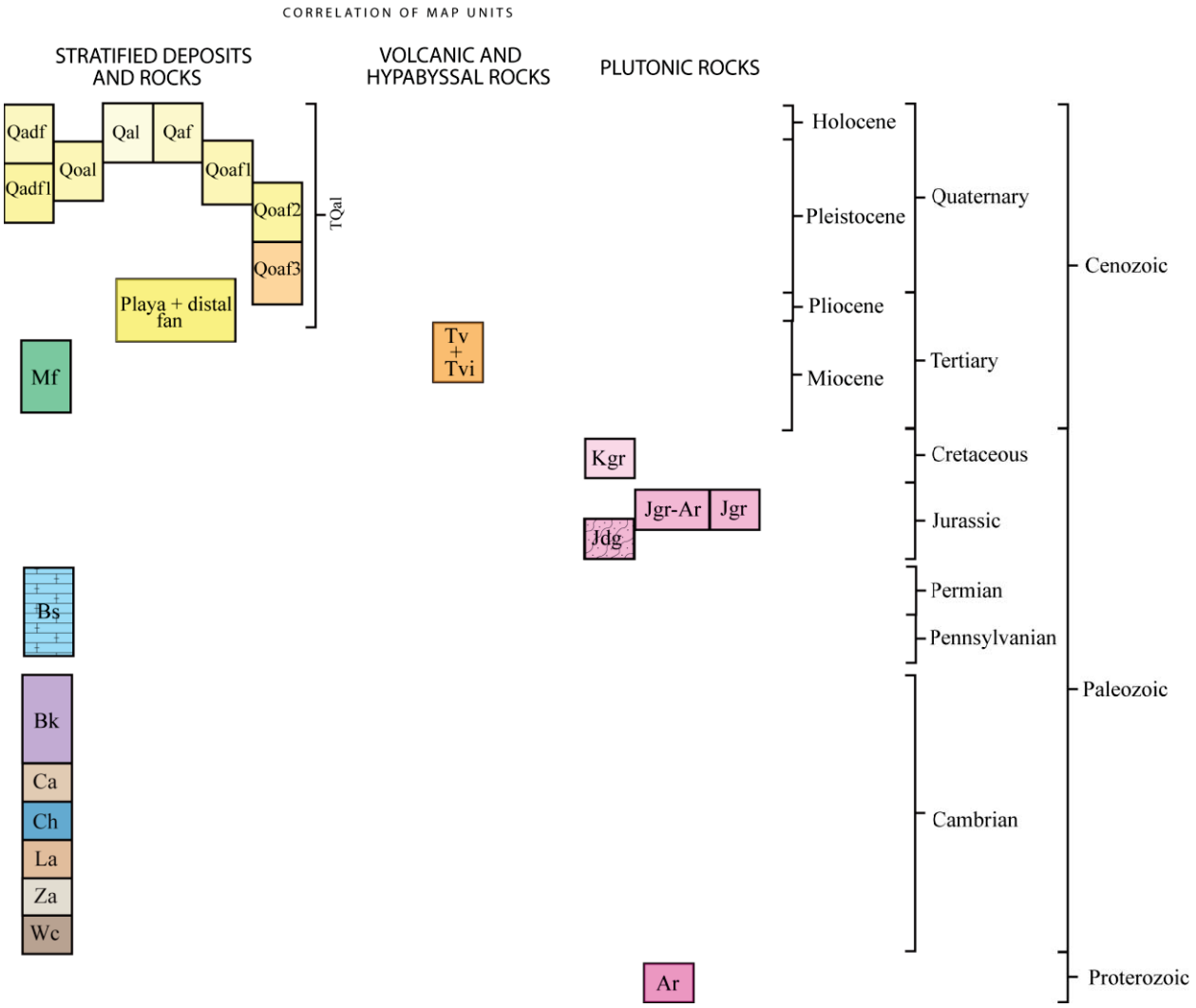
Figure A1: Shows the general study area, the Fenner Gap, the southern end of the Fenner Valley, the Marble and Ship Mountains, and designated names for geologic terrains discussed within this report.



LOCAL STRATIGRAPHY AND GEOLOGIC UNIT DESCRIPTIONS

Geologic rock and sedimentary units within the study area range in age from Proterozoic (1.4 billion years) to Historical. Rock types include igneous intrusive and extrusive, metamorphic, metasedimentary (weakly metamorphosed rocks that retain some original sedimentary structures, which include marble, dolomite, marls, quartzites, and slates), alluvial fan, debris flows, fanglomerates, and lacustrine. Figure A2 below provides the correlation of map units in terms of when the units were created.

Figure A2: Correlation of mapped units.



Geologic units identified within the study area are described below from youngest to oldest.

TQal - TERTIARY TO QUATERNARY ALLUVIUM (Neogene deposits)

Primarily composed of silty sand and gravels deposited by fluvial processes post early Miocene Basin and Range extension. By definition within this report, TQal exhibits horizontal to nearly horizontal bedding (2 to 3 degree dips typical of alluvial fans), a paucity of fractures or joints, and thus is relatively undeformed, suggesting it post dates Miocene extensional tectonics. However, at depth, unit TQal could and likely is comformable with underlying unit Mf in some places. TQal exhibits fine beds of silty fine to medium sand, some thin silt beds, and occasional carbonate zones that likely represent paleosols or conglomerate layers with post depositional groundwater flow. Conglomerate members contain local clasts (volcanics, carbonates, and igneous plutonic). This unit has been subdivided into various alluvial units based on relative age and depositional environment (Qal, Qadf, Qoaf1, Qoaf2 and Qoaf3). Unit Qal represents valley axis sediments from distal sources. There is a general coarsening from unit Qal to unit Qoaf, which is primarily associated with sediment transport distances and climate.

Tv and Tvi- TERTIARY VOLCANICS - PEACH SPRINGS TUFF AND BASALT FLOWS (EARLY MIOCENE ~17 MY)

Andesitic or dacitic tuffs including crystal-vitric, crystal-lithic, and vitri-lithic types. Tv and Tvi represent volcanic and hypabyssal (cooled and crystalized-emplaced near the surface) rocks. Colors range from dark gray to white and dark to light reddish brown. Various members are massive to well bedded and andesitic and basaltic flows comprise 1/4 of section. Limestone cobbles occur in the lowest member, and are derived from local basement exposures in Fenner Valley amd Wild Horse. Likely 1,100 to 1,200 feet thick locally and exhibit primarily distal tuffs and pyroclastic flows in the lower members which transition up section into primarily more proximal rhyolite tuffs and basalt flows. Unit Tv is mapped separate from unit Mf (below); however, interbedding of Tv and Mf particularly in the upper members of unit Mf is possible as both are associated with stages of Miocene extensional tectonics. Type section for intrusive unit Tvi occurs along Fault No. 1 in the Fuz Hills, and small isolated outcrops in the southern Birds Spring Hills. Crudely correlated stratigraphy of Tv exposures from youngest to oldest includes layers A (vesicular ash tuff 20 feet thick), B (salmon colored tuff with blue iridescence sanidine 10 feet thick), C (vesicular basalt 75 to 100' thick).

Mf - MIOCENE FANGLOMERATES

This unit represents a coarsening upward sequence of sediments composed of (from base of units to upper members): (1) well bedded silty fine to medium sands and possible igneous tuffs (base of unit), (2) to well bedded gravely sands with exotic well rounded clasts, (3) to cobble conglomerate with rounded exotic and subangular to angular local clasts, and (4) to conglomerate-breccia composed of local mylonitic or other local subangular to angular clasts (upper members). The unit generally dips between 10 to 30 degrees to the east-northeast, is fractured, very dense, and well cemented. Relatively older members are tilted more than younger members suggesting syntectonic rotation during deposition. Mf is interpreted to represent deposition and deformation associated with local Basin and Range extensional tectonics during the early Miocene; however, basal members exposed in the northeastern Ship Mountains exhibit fluvial deposits with exotic clasts indicating possible deposition prior to local Miocene extension. Minor volcanic layers were identified in the lower and upper most members of unit Mf and volcanic clasts were identified at the base of unit Mf in some cores. This suggests some volcanism in the region during deposition of the unit;

however, based on thick volcanic deposits in the northeastern terrain, most volcanics were likely deposited locally after deposition of Mf. Unit Mf may be conformable with overlying members of unit TQal.

Kgr - CRETACEOUS LEUCOCRATIC GRANITE

Leucocratic fine to medium coarse grained biotite-muscovite (2-mica) granite to possibly tonalite. Unit exhibits zones of moderately strong mylonitic texture where in close proximity to the detachment fault, to non-foliated in other small outcrops within a few hundred feet of the mylonitic zones. Mylonite members of unit Kgr exhibit a paucity of micas. Relatively unfoliated Kgr injections exist subparallel and cross cutting the mylonitic fabric, indicating that unit Kgr is relatively younger than the more mafic mylonite deformation. It is possible that unit Kgr represents a series of injections exhibiting various levels of deformation that may correlate and/or post date with the age of the mylonitic fabric. Unit identified in apparently the hanging wall rocks of the detachment fault (upper plate) in the northern Ship Mountains; however, unidentified high angle faults could have moved Kgr from an underplate position to the surface in the area of the exposed detachment fault. It should be pointed out that the age of the mylonite identified within the detachment fault is also unknown. Based on other regional mylonites, they are likely in the range of middle Mesozoic to mid-Tertiary (Miocene) in age.

Leucocratic igneous rocks identified within some borings in Fenner Gap may correlate to unit Kgr, however units Jgr and Ar both contain some leucocratic members. Unit may correlate to Cretacous age leucocratic (2-mica) granites in the Old Woman Mountains described by Howard, (2002), Horringa, et al., (1989; units Kl and Kmg), and Karlstrom et al., (1993), which is the primary reason this unit was designated as Cretaceous within this report.

JURASSIC IGNEOUS AND METAMORPHIC SUITE (U-Pb ~167 Ma)

This unit has been subdivided into three members: Jgr, Jdg, and Jgr-Ar. The Jurassic Igneous and Metamorphic Suite is considered part of the Eastern Plutonic Belt by Powell (1993).

Jgr - Jurassic Granitics

Medium to fine grained biotite quartz syenite, syenogranite, quartz monzonite, and fine grained hypabyssal equivalents. The unit commonly exhibits dark salmon colored orthoclase feldspar and a paucity of quartz. The unit is typically not ductilly foliated, but does exhibit considerable jointing and fracturing throughout, suggesting some stress at upper crustal levels. Penetrative epidote secondary mineralization is very common. Relatively small to very large roof pendants of older bedrock units and sills are common. This intrusive suite likely correlates well in terms of general age, time transgressive composition variations from mafic to more felsic, occurrence of aplite dikes and emplacement at relatively shallow crustal depths as described by Fox and Miller (1990) evaluating similar rocks in the southern Bristol, southern Providence Mountains and Colton Hills. This unit intruded and deformed all relatively older units, which has led to a change in structure across the Fenner Gap between the relatively un-intruded Marble Mountains and strong intrusions within the Ship Mountains. The contact between these two structural terrains occurs within Fenner Gap. Aplite dikes are also common within this unit.

Jdg - Jurassic Dioritic Gneiss

This unit represents dioritic intrusives that includes zones of a banded gneiss with minor zones exhibiting weak mylonitic fabric. The unit is primarily dioritic but also contains felsic zones. Intercalated zones of lower Cambrian units, particularly Wood Canyon and possibly Zabriskie Quartzite, occur within the unit, indicating that Jdg is not pre-Cambrian in age. Foliation of the unit likely occurred during emplacement into the Archean Igneous and Metamorphic Suite and lower Cambrian stratigraphic units described below. Foliation is nearly vertical and strikes generally east-west. Fine grained aplite dikes and aphanitic rhyolitic injections parallel to the gneiss foliation occur. This newly discovered unit, which was mapped as Pre-Cambrian by earlier studies is considered here to represent part of the Jurassic igneous suite of rocks associated with early stages of emplacement of unit Jgr. Secondary epidote is common, but cannot rule out magmatic crystallization. Aphanitic dikes parallel to foliation are consistent with upper crustal emplacement similar to unit Jgr. Based on current mapping data, unit Jdg may have been emplaced as a tabular body trending approximately east west through the Fenner Gap, then later intrusions associated with unit Jgr primarily occurred south of the Jdg tabular body with unit Jdg representing the northern boundary of unit Jgr. Within this model considerable shearing occurred within unit Jdg as magma associated with uint Jgr was emplaced causing vertical uplift and formation of an antiformal structure to pre-existing rocks. This unit may correlate with unit Jqd of Howard et al. (1989) identified in the northern Kilbeck Hills.

Jgr-Ar - Jurassic Granitics - Archean Complex

This unit represents regions where Jurassic plutonism (primarily Jgr) intruded into pre-existing Archean Igneous and Metamorphic Complex (Ar) and Paleozoic meta-sedimentary rocks (Wc, Za, La, Ch, Ca, Bk, and Bs), producing numerous roof pendants. This unit exhibits various degrees of foliation and contacts are gradational with units Jgr and Jdg.

<u>Bs - PENNSYLVANIAN TO PERMIAN BIRD SPRING AND OTHER LIMESTONE FORMATIONS (LATE PALEOZOIC)</u>

The Bird Spring Formation occurs regionally across the southwestern United States; thickness can exceed 4,000 feet thick. Locally, the formation consists of, and in decreasing order of abundance: marbles (metamorphosed limestone-carbonates), quartzites, marls, and minor slates. The interbeds of quartzites, and chert bearing carbonate layers are distinct compared to other carbonate rocks in the study area. Regional published descriptions of the Bird Spring Formation indicate a Permian basal member 20 feet thick, that contains small black chert pebbles within cross bedded sandy limestone interbeds; however, this member was not observed in the study area. Platy to shaly and part sandy, fossiliferous, chert rich zones separate some of the massive beds. The upper 1,380 feet of section is medium to light gray, sparingly fossiliferous limestone in beds up to five feet thick. Minor chert and sandstone (quartzite) occur. Includes rocks of Wolfcamp and Leonard age. Bird Spring Fm. exists in upper Pennsylvanian to lower Permian section. Regionally, an additional ~1,600 feet of limestone units (Monte Cristo & Sultan Fm) exist from Devonian to Mississippian. Miller et al. (1982) indicate that metamorphosed Bird Spring containing early Pennsylvanian conodonts also occurs in the Marble Mountains and an unmetamorphosed section ~ 2,500 feet thick crops out in the Ship Mountains. This exposure is within the herein referred to Bird Spring Hills. The lowest most and upper most members are not locally exposed in the Bird Spring

Hills; however, the contact between Pennsylvanian and Permian age rocks within the formation is. The Monte Cristo Formation occurs in some places at the base of the Bird Spring Formation - vitreous, nearly pure, typically massive marble, which may occur within the northern Ship Mountains. Marbles (metamorphosed) associated with the Sultan Limestone may also occur locally in the Ship Mountains, although this has not been verified. The Bird Spring Formation in the northern Ship Mountains is attenuated due to emplacement of unit Jgr.

The formation exhibits a high density of fractures and small to relatively large vugs.

Figure A3: Image of the Bird Spring Hills indicating the location of the general stratigraphic section shown on Figure A4.

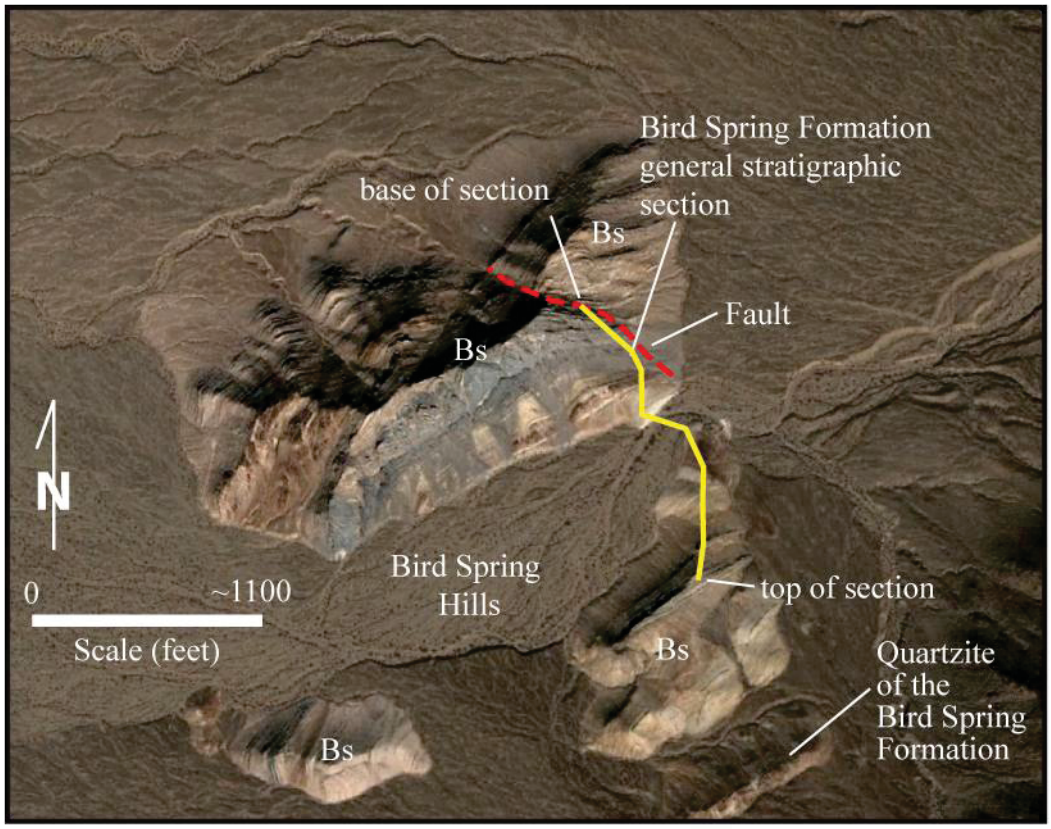
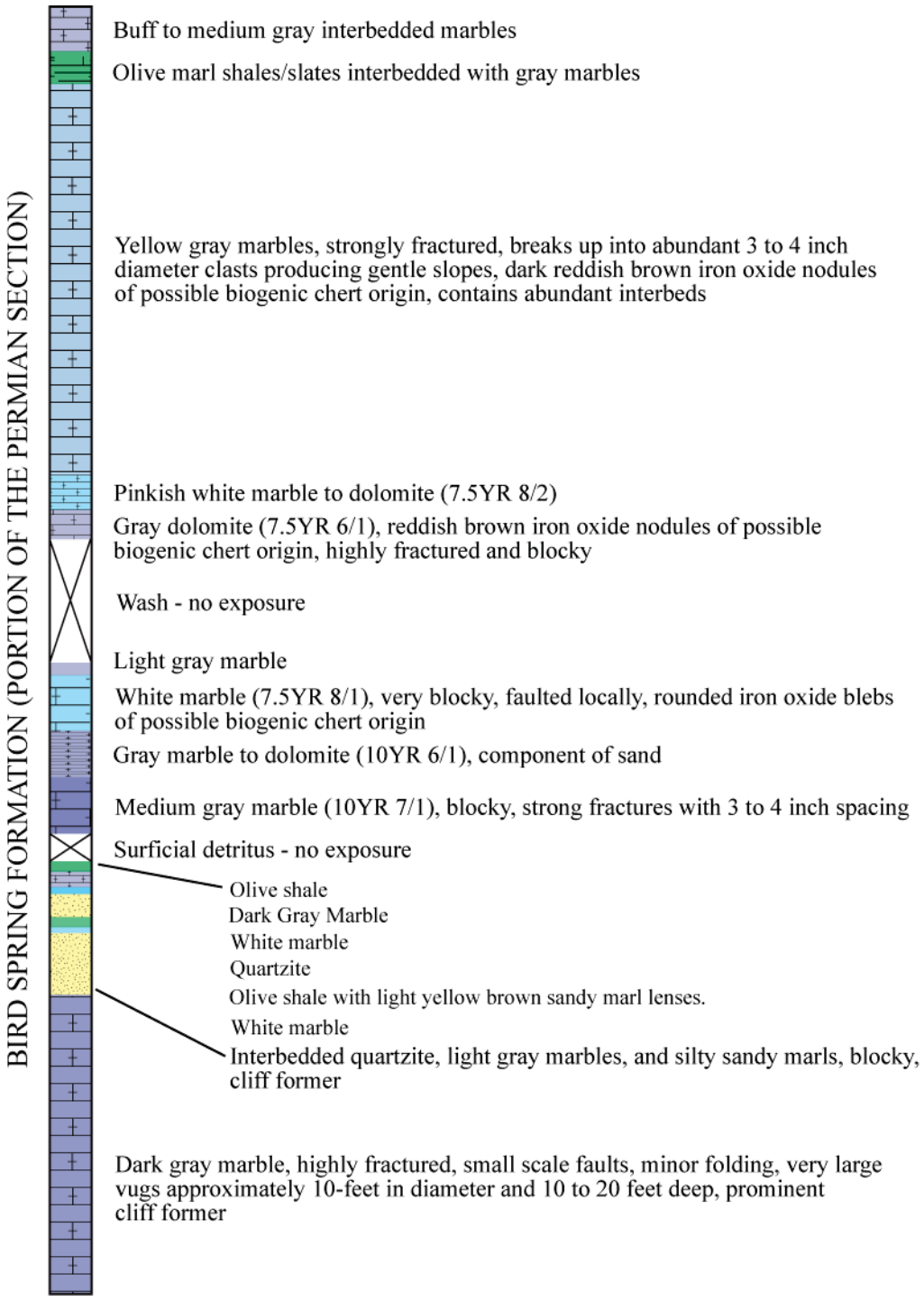


Figure A4: Generalized stratigraphic section within exposures of the Bird Spring Formation in the Bird Spring Hills. Section is not to scale; however, the general relative thicknesses of the units is shown.



Bk - MIDDLE CAMBRIAN BONANZA KING DOLOMITE (EARLY PALEOZOIC)

The middle Cambrian age Bonanza King Dolomite is a regionally occurring formation across the southwestern United States, and is approximately 2,000 feet thick. The formation is dominated by very dark to light gray dolomite and minor marble exhibiting bedding of three to 20 feet thick. Minor interbedded chert layers occur in some members, and mottling of light and dark patterns are common, some of which are likely associated with worm borrows. The unit has locally been mapped as containing upper, middle and lower members, which are briefly described below. Some members, but in particular the lower member of this formation, exhibit a dense network of fractures filled with re-crystallized white carbonate.

Bku: UPPER MEMBER: Light creamy gray dolomite, 200 to 250 feet thick:

Bkm: MIDDLE MEMBER - SILVER KING DOLOMITE: Very dark smoky gray to nearly black dolomite, 200 to 250 feet thick.

Bkl: LOWER MEMBER: Dark smoky gray dolomite and partially dolomitized limestone, locally cherty and sandy. Intraformational pebble and cobble conglomerates occur. This member is approximately 1500 to 1800 feet thick with individual beds 3 to 6 feet thick.

The Bonanza King Dolomite is well exposed in the southern Marble Mountains, and in the Fuz Hills, and the Mt. Bonanza inselberg in the northern Ship Mountains. The formation exhibits a high density of fractures and abundant small to relatively large dissolution vugs (i.e. karst features).

LOWER CAMBRIAN SEDIMENTARY SUITE (EARLY PALEOZOIC)

The lower Cambrian sedimentary suite consists of metasedimentary to sedimentary rocks of the Cadiz Formation (Ca), Chambless Limestone (Ch), Latham Shale (La), Zabriskie Quartzite (Za) and Wood Canyon Formation (W). In total, this package of lower Cambrian rocks is approximately 1,100 feet thick. These formations are described in more detail below from youngest to oldest.

Ca - Cadiz Formation

Buff and gray muddy limestone, purplish, and reddish platy shale, greenish gray to reddish brown platy shale, and platy to massive quartzite. The unit exhibits distinctive one to 10 foot thick beds of alternating green and reddish brown shales and slates in addition to coarse-grained, cross-bedded (herringbone) marls. The formation is generally about 375 feet thick. Some platy shales appear to be similar to the paper-thin platy structures of the Latham Shale.

Figure A5: Image of the southern Marble Mountains indicating the location of the general stratigraphic section of the Cadiz Formation as shown on Figure A6. This portion of the Cadiz Formation represents approximately the lower have of the unit that stratigraphically overlies the Chambless Limestone; however, the upper members of the Cadiz Formation are very similar to those described in the stratigraphic section of Figure A6.

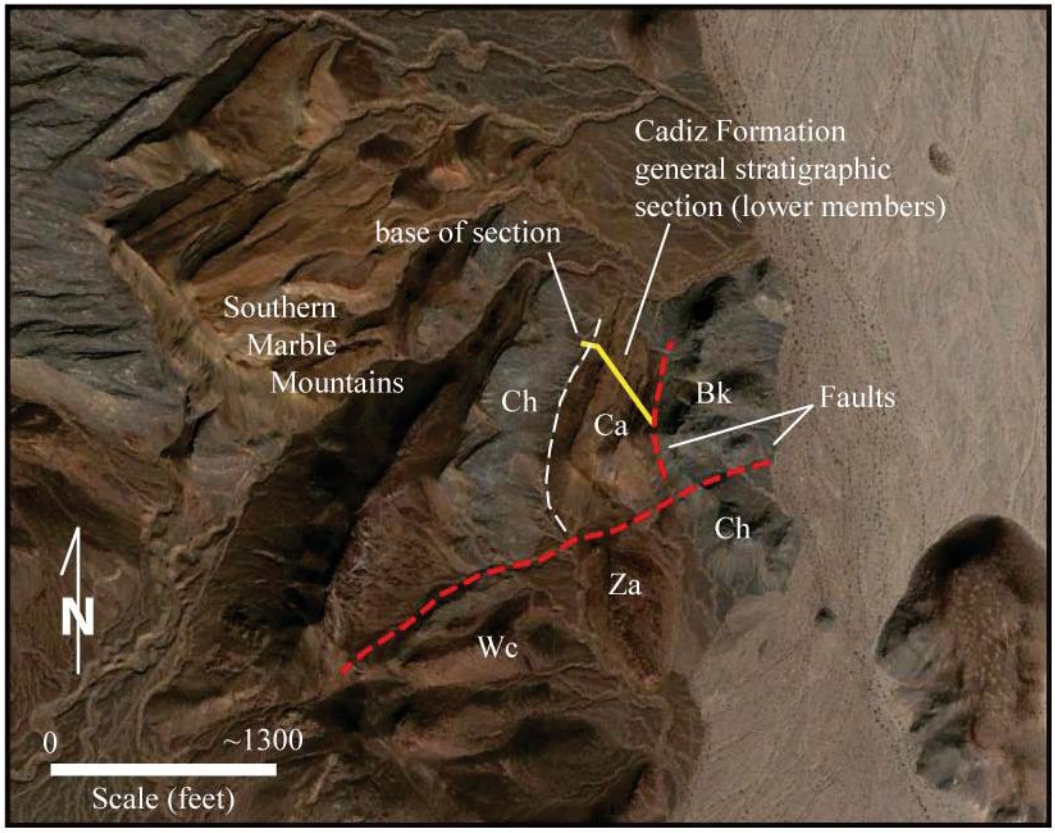
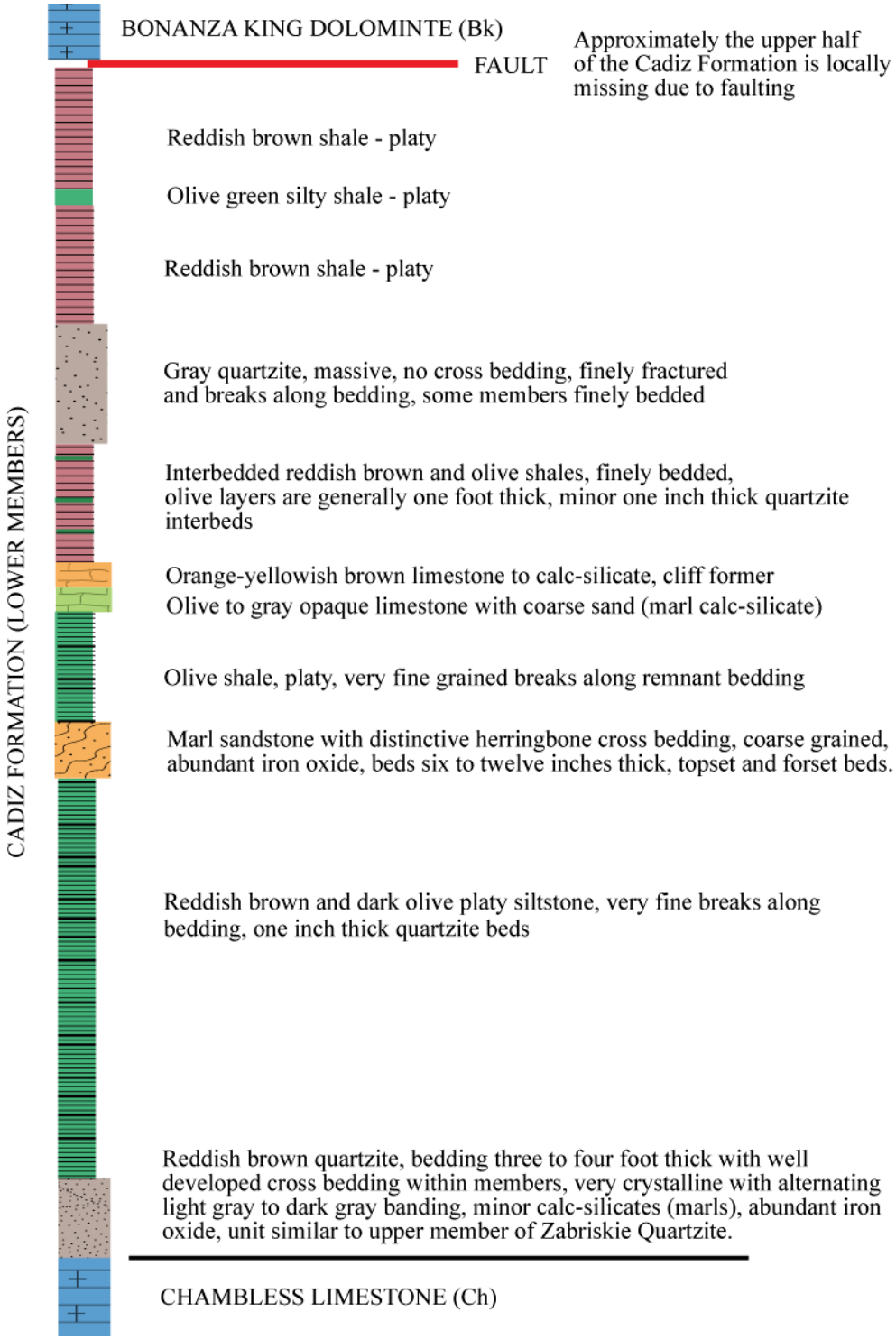


Figure A6: Generalized stratigraphic section within exposures of the lower members of the Cadiz Formation in the southern Marble Mountains. Based on field mapping, the upper section of the Cadiz Formation consists of similar stratigraphy. Section is not to scale; however, the general relative thicknesses of the units is shown.



Ch – Chambless Limestone

The Chambless Limestone is primarily dark gray and occurs in beds one to 10 feet thick. Locally, the unit is 85 to 155 feet thick but may be up to 200 feet thick. Algal nodules and distinctive red blotches of an unknown cause occur throughout the unit. The Chambless Limestone is highly fractured and exhibits vugs.

La - Latham Shale

The Latham Shale consists of fossiliferous, greenish gray, platy shale that weather to platy and paper-thin fragments. The formation is approximately 82 feet thick in the southern Marble Mountains, and contains abundant trilobite fossil beds. The Latham Shale correlates with both the Bright Angel Shale at the base of the Grand Canyon and the Carrara Formation.

Za - Zabriskie Quartzite

The Zabriskie Quartzite ranges between 50 to 75 feet thick and consists of an upper member of fine-grained, gray, cross-bedded quartzite similar to members of the Wood Canyon Formation, and a lower member consisting of very fine grained, massive, white quartzite exhibiting distinctive small red specks. Individual beds within the unit are generally two to six feet thick.

Wc - Wood Canyon Formation

The Wood Canyon Formation is locally between 300 to 425 feet thick, and consists of: fine grained, dark greenish gray, shaly to platy quartzite; fine grained reddish brown weathering to white quartzite in beds six inches to two feet thick that can be friable with cross-bedding and pebble lenses (thick unit); fine grained, dark greenish gray, platy quartzite; minor light gray to reddish brown weathering limestone, locally dolomitized; fine grained, greenish black shaly quartzite with local pebble lenses occur a few feet above the base. The unit in the southern Marble Mountains is dominated by light and dark gray, banded (cross-bedded), fine-grained quartzite that appears to be locally very similar to the upper member of the Zabriskie Quartzite locally. A 20-foot thick, platy siltstone exhibiting alternating gray and reddish brown layers occurs at the top of the unit and just beneath the lower white member of the Zabriskie Quartzite which assists in identifying their point of contact. Approximately 10 feet above the base of the Wood Canyon Formation occurs a very distinctive six to 10-foot thick cobble member. The cobbles are well rounded and abundant. The cobble member was identified in the Jaggar Hills in the northern Ship Mountains where it was only eight inches thick and one foot above the contact with underlying Jurassic dioritic gneiss (Jdg). This observation provides evidence that unit Jdg deformed the Wood Canyon Formation during emplacement and thus, is a distinctly younger unit. In addition, the relative changes in thickness of the Wood Canyon Formation across Fenner Gap indicates that the unit had been attenuated (thinned) approximately 90% in some areas within the northwestern Ship Mountains, and that it resulted from emplacement of the Jurassic Igneous and Metamorphic Suite.

Figure A7: Image of the southern Marble Mountains indicating the location of the general stratigraphic section of the Wood Canyon Formation as shown on Figure A8.

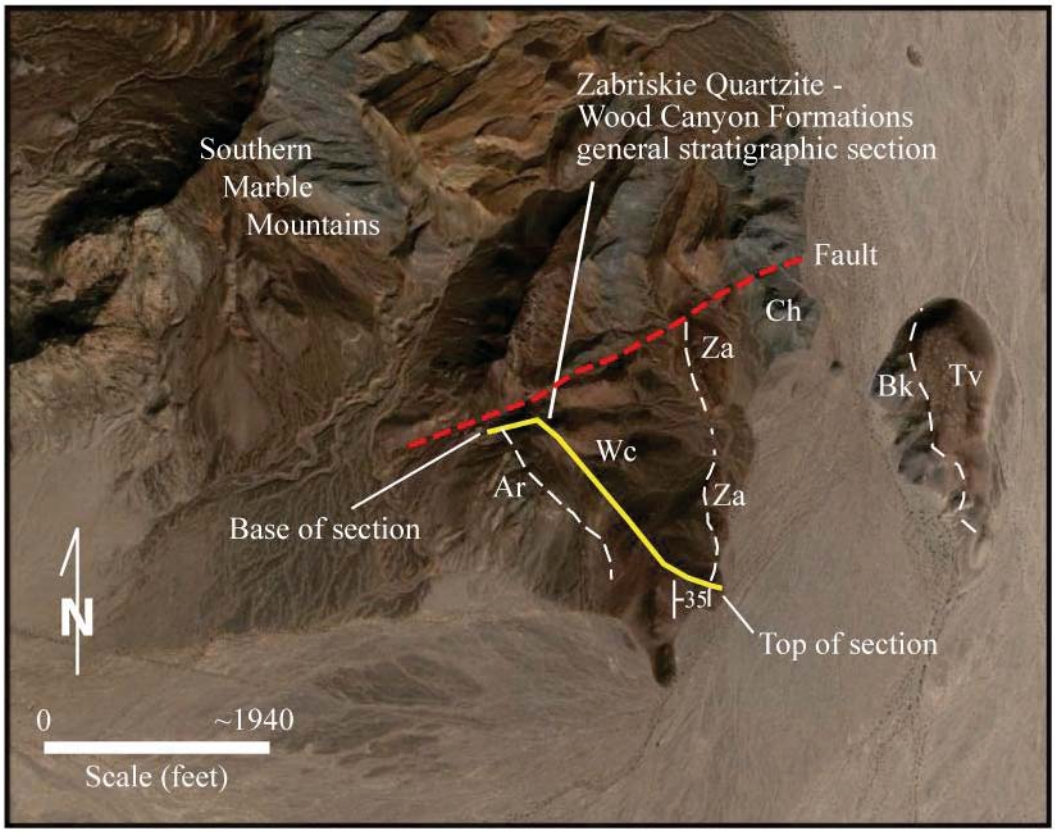
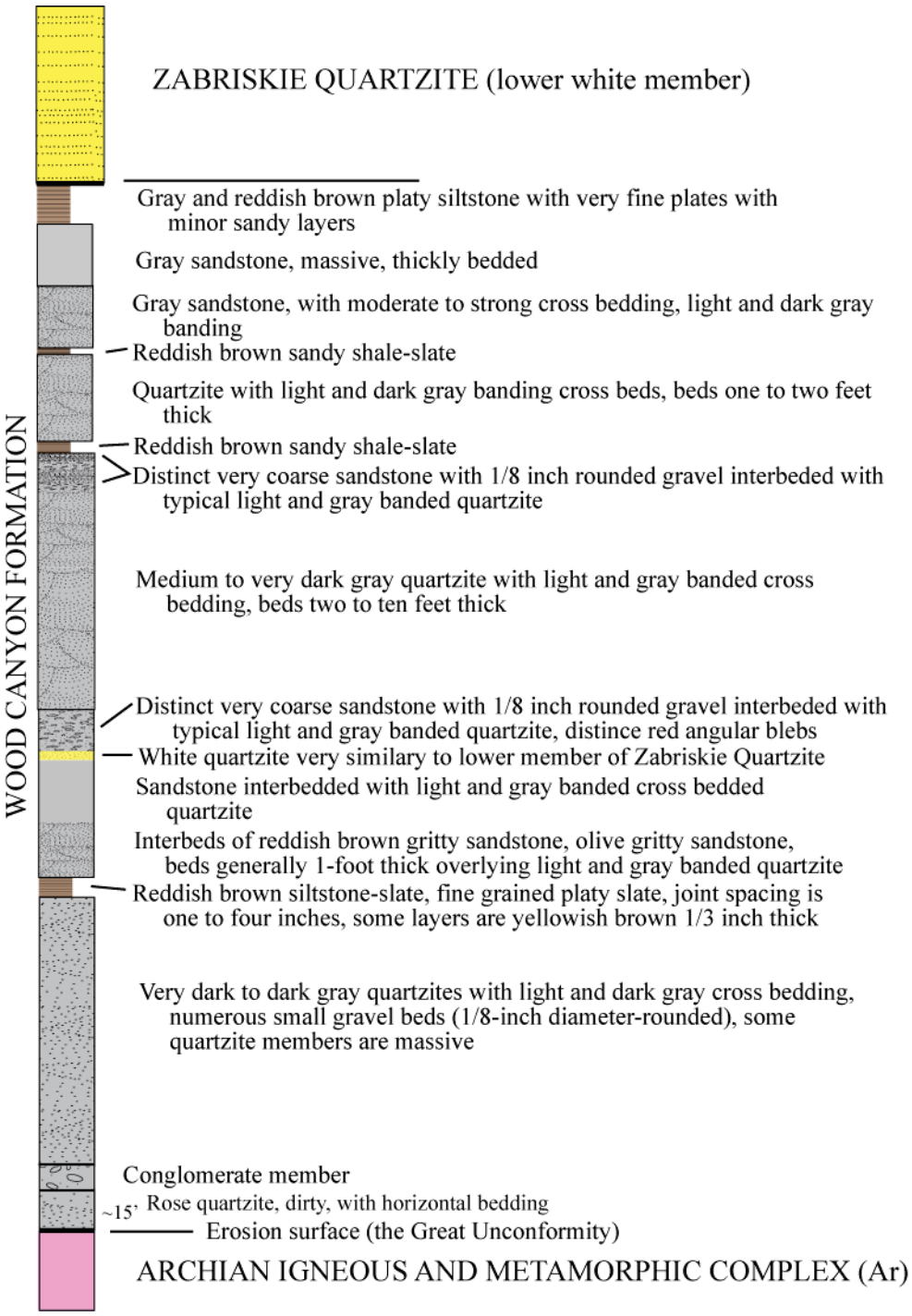


Figure A8: Generalized stratigraphic section of the Wood Canyon Formation in the southern Marble Mountains. Section is not to scale; however, the general relative thicknesses of the units is shown.



Ar - ARCHEAN IGNEOUS AND METAMORPHIC COMPLEX

Regionally, this unit consists of granite, gneiss, and schist; however, locally it is dominated by very coarse grained, leucocratic to pale orange granite. The unit exhibits large pheonocrysts of plagioclase, and lacks penetrative epidote secondary (diagenesis) mineralization. Although the unit has been mapped in this study as Archean (to maintain Hazzard and Mason, 1936 original nomenclature), the unit is actually Proterozoic (1.4 to 1.5 billion years old in the Marble Mountains, Silver and McKinney 1963; Lanphere, 1964). In most places, the Ar unit is moderately grussified, possibly by expansion along biotite cleavages, which causes the unit to weather to "decomposed granite" (DG) on the surface (very coarse sand).

PHOTOGRAPHS OF SITE GEOLOGIC UNITS AND SETTING

This section contains field and sample photographs of geologic units (from youngest to oldest): Tv, Mf, Kgr, Jgr, Jdg, Bs, Bk, Ca, Ch, La, Za, Wc and Ar. An attempt was made to show photographs demonstrating distinguishing characteristics of each unit that assist in their identification in both the field and borings.

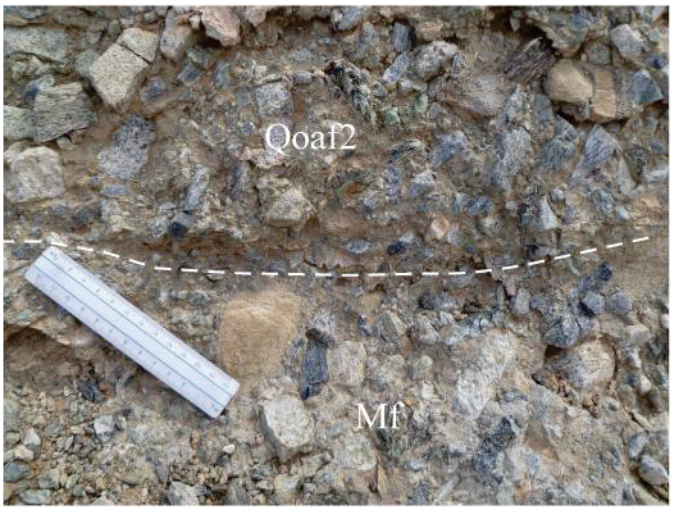
Volcanic Unit Tv

Tv - Member A
(see Plate 2)

Tv - Member B

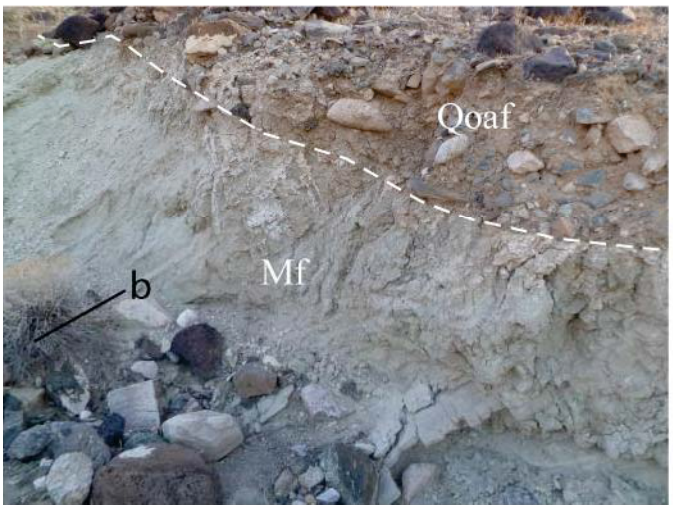
Tv - Member B

Miocene Fanglomerate Unit Mf



Mf: upper members - coarse grained sands and gravel beds composed of local angular (proximal) clasts. This unit is dominated by massive, crudely bedded debris flows. Located in the northeastern volcanic terrrain. The white ruler is approximately six inches long.

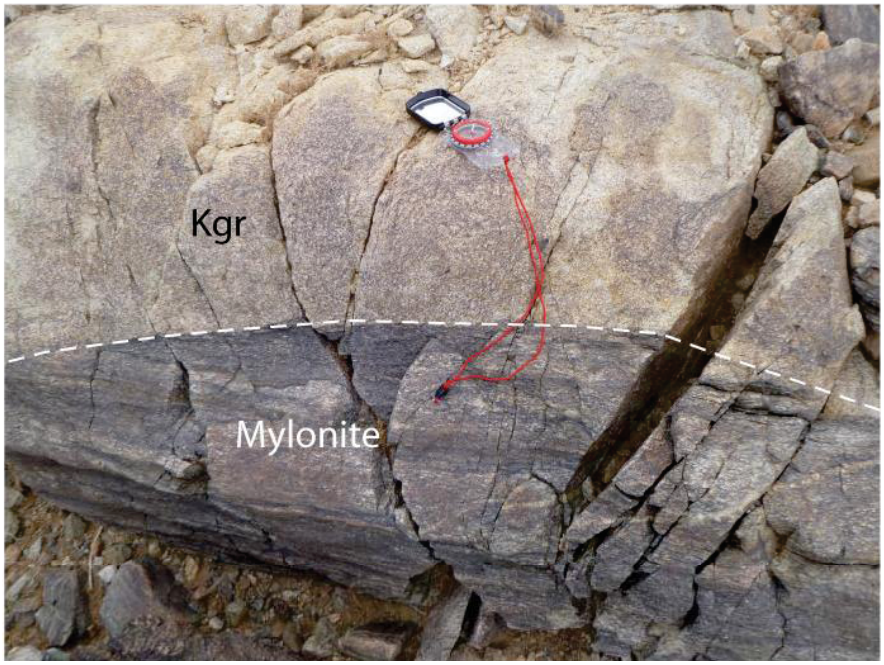
Mf: middle members - coarse grained sands and gravel beds composed of both local and exotic clasts. Notice dip of units. Located in the northeastern volcanic terrrain.



Mf : lower fine grained fluvial deposits with reworked volcanic deposits. The line indicated by a "b" indicates bedding dip. Located in the northeastern volcanic terrain.

Cretaceous Granitics Unit Kgr

Unit Kgr - Leucocratic granite to granodiorite. In places this unit contains biotite and muscovite. Identified in the northeastern volcanic terrrain near the detachment fault.



Unit Kgr - Leucocratic granite to granodiorite intruded subparallel to mylonite fabric within detachment fault zone area. Identified in the northeastern volcanic terrain.

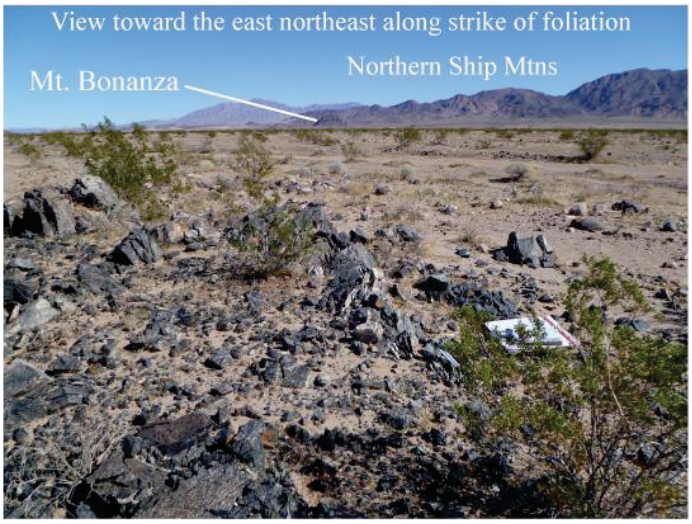
Jurassic Granitics Unit Jgr

Unit Jgr - notice abundant fractures. Photograph taken along ridge of Jgr in the western Ship Mountains south to southeast of Fuz Hills.

Unit Jgr - typical size of clasts produced by weathering of unit Jgr due to dense network of joints and fractures. Photograph taken along ridge of Jgr in the western Ship Mountains south to southeast of Fuz Hills. The white ruler is approximately six inches long.

Jurassic Dioritic Gneiss Unit Jdg

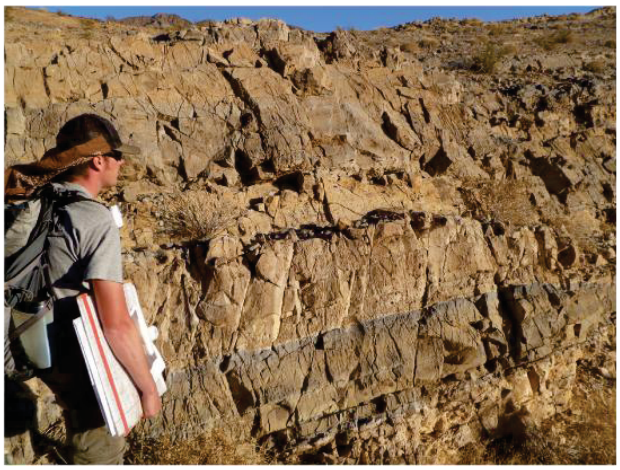
Unit Jdg - banded dioritic gneiss. Near vertical foliation is typical of the unit across Fenner Gap. This photograph is from the Jaggar Hills (type section for unit Jdg), and the photograph below exhibits very similar rocks approximately 400 feet south of the southern tip of the Marble Mountains. White ruler is approximately six inches long.



Unit Jdg - banded dioritic gneiss with nearly vertical foliation. This photograph from a small outcrop located approximately 400 feet south of the southern tip of the Marble Mountains. This outcrop contains intercalated Wood Canyon formation and felsic dikes.

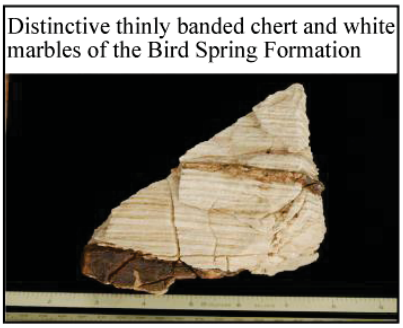
Unit Jdg - banded diortic gneiss at same location as above photograph. White ruler is approximately six inches long.

Pennsylvanian to Permian Bird Spring Formation (carbonate) - Bs



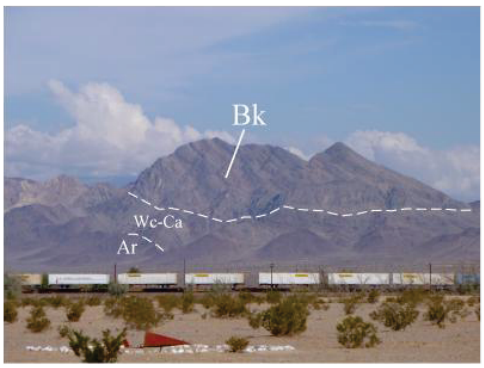
Bird Spring Formation in the Bird Spring Hills. This outcrop demonstrates common bedding member thickness, composition, color and structures of the Bird Spring Formation.

Distinctive white marble of the Bird Spring Formation. Photograph from the Bird Spring Hills.

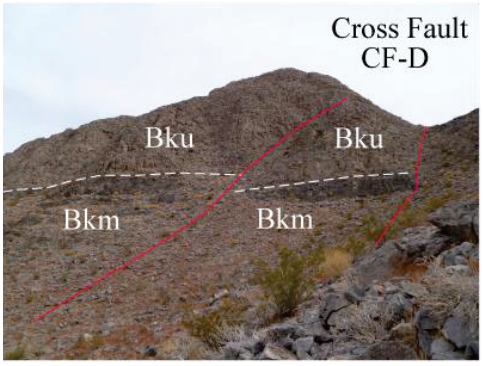


Distinctive chert layers and nodules within white and light gray marbles of the Bird Spring Formation. Photograph from the Bird Springs Hills.

Middle Cambrian Bonanza King Dolomite (carbonate) - Bk



Exposure of the Bonanza King Dolomite in the southern Marble Mountains. Photograph taken from the Cadiz Inc. office. The Bonanza King has a minimum thickness of 2,000 feet thick in this area.



Bonanza King Dolomite on the northern side of Mt. Bonanza. The contact between the upper and middle members of the Bonanza King Dolomite is shown (Bku and Bkm respectively). Cross Fault CF-D is shown (see Plate 2), which locally consists of two faults.

Distinctive worm tracks within some members of the Bonanza King Dolomite.

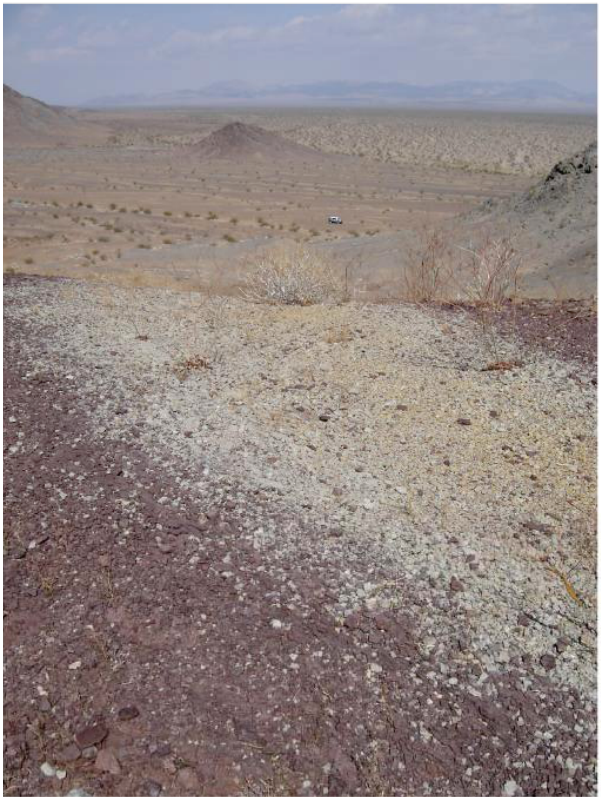
Distinctive breccia zone in the lower portion of the Bonanza King Dolomite lower member. White in-fill material consists of re-deposited carbonate (marble).

Lower Cambrian Cadiz Formation - Ca

Distinctive platy and multicolored shales in the Cadiz Formation - Marble Mountains

Reddish brown, coarse grained marly herringbone cross-bedding member - Marble Mountains

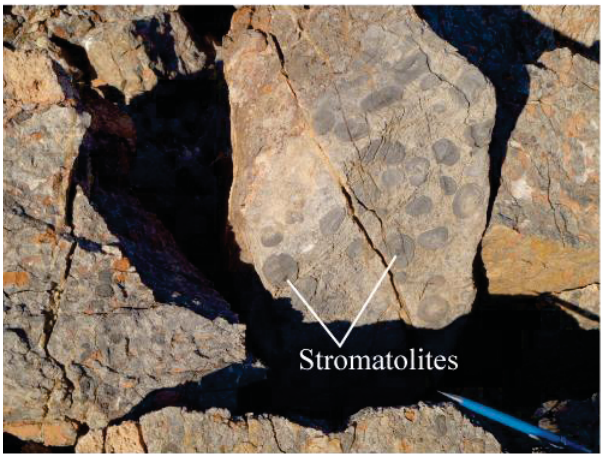
Distinctive alternating reddish brown and olive green shale members of Cadiz Formation- Marble Mountains



Reddish brown, coarse grained marly herringbone cross-bedding member - Marble Mountains

Lower Cambrian Chambless Limestone - Ch

Typical Chambless Limestone exhibiting reddish brown blotches within gray limestone. Photograph taken in the Marble Mountains.



Stromatolites within the Chambless Limestone - Marble Mountains.

Shaly reddish brown member within the Chambless Limestone - Marble Mountains.

Lower Cambrian Latham Shale - La

Trilobite fossil within typical dark brown Latham Shale - Marble Mountains.

Lower Cambrian Zabriskie Quartzite - Za

Typical upper "gray" member of the Zabriskie Quartzite - Marble Mountains.

Typical upper "gray" member of the Zabriskie Quartzite - Marble Mountains.

Typical "white" lower member of the Zabriskie Quartzite - Marble Mountains.

Typical "white" lower member of the Zabriskie Quartzite - sample from the Marble Mountains.

Lower Cambrian Wood Canyon Formation - Wc

Typical light and dark gray cross bedding in quartzite members of the Wood Canyon Formation. Photograph taken in the Marble Mountains.

Common very coarse sand and small pebble conglomerate members in the Wood Canyon Formation. Photograph taken in the Marble Mountains.

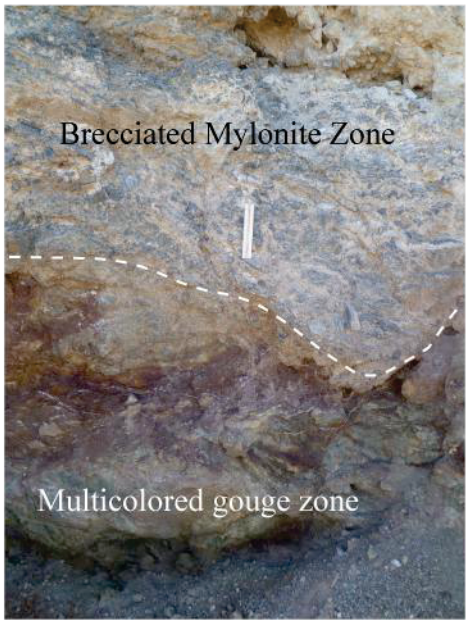
Distinctive conglomerate member near the base of the Wood Canyon Formation. Photograph taken in the Marble Mountains.

Proterozoic Igneous and Metamorphic Complex - Ar

Sample of typical Proterozoic Igneous plutonic complex mapped as Ar during this study. Photograph was taken in the Marble Mountains.

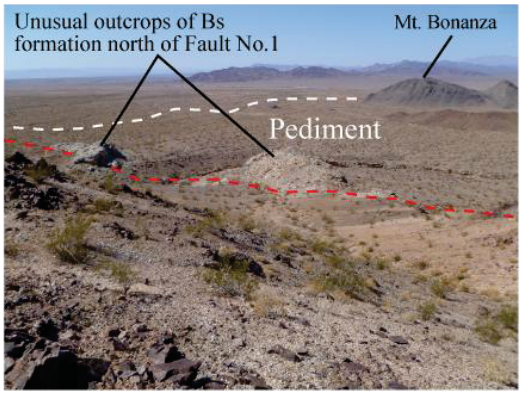
Outcrop of typical Proterozoic Igneous plutonic complex mapped as Ar during this study. Notice large pheonocrysts of plagioclase feldspar and how the unit is grussified and weathers to decomposed granite (very coarse sand size grains). Photograph taken in the Marble Mountains.

The cataclastic-brecciated detachment fault zone in the northeastern volcanic terrain, northern Ship Mountains.



Mylonitic fabric identified at bottom of TW-3 - Likely unit Jdg

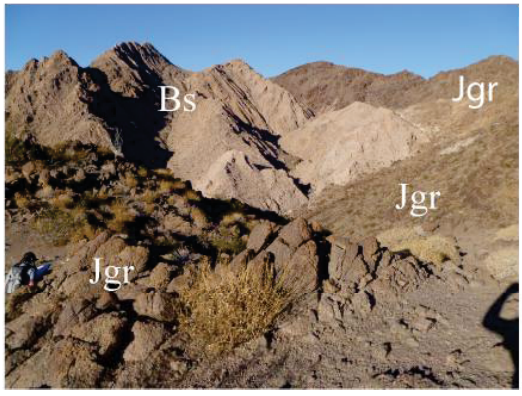
Surface exposures of Faults No.1 and No.2



View toward the west from the Ship Mountians of Fault No.1 exposure in wash (see Plate 2). The photograph also shows the general area of the pediment surface located in the area of the Jaggar Hills, east of Fuz Hills, and south of Mt. Bonanza. This area was likely uplifted, or abandoned during activity of the local cross faults and continued faulting on Fault No. 3.

Fault No. 2 exposure at mine adit within the Jaggar Hills. Fault gouge zone is between 40 and 60 feet thick and contains aboundant secondary minerals (ore deposit) and vibrant colors. This fault zone dips toward the north and is correlated to a similar fault zone identified in TW-3.

No major fault located east of the Vulcan Valley Bird Spring Formation roof pendant

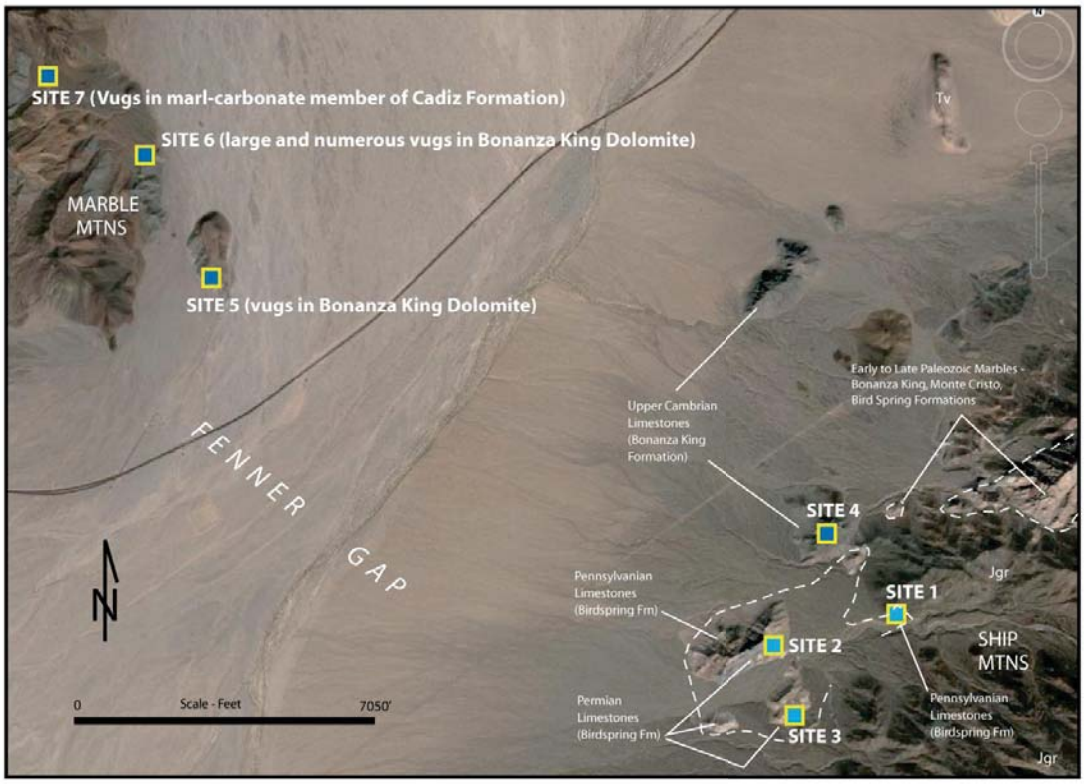


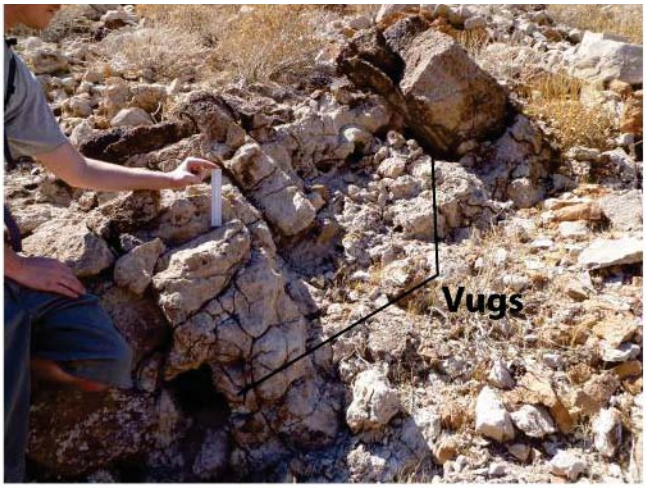
View toward the northeast from a ridge of unit Jgd and looking along the eastern side of Bs exposure in the northern Ship Mountains. No fault was identified along this ridge or bounding the eastern side of the Bs exposure.

LOCATION AND PHOTOGRAPHS OF VUGS WITHIN CARBONATES

This section provides selected photographs of identified vugs (dissolution cavities formed within carbonate rocks formed as karst features) identified during field mapping. The location of the identified vugs and their respective figure in which the photographs are show is provided on Figure A9.

Figure A9: Site location map of carbonate vug photographs.



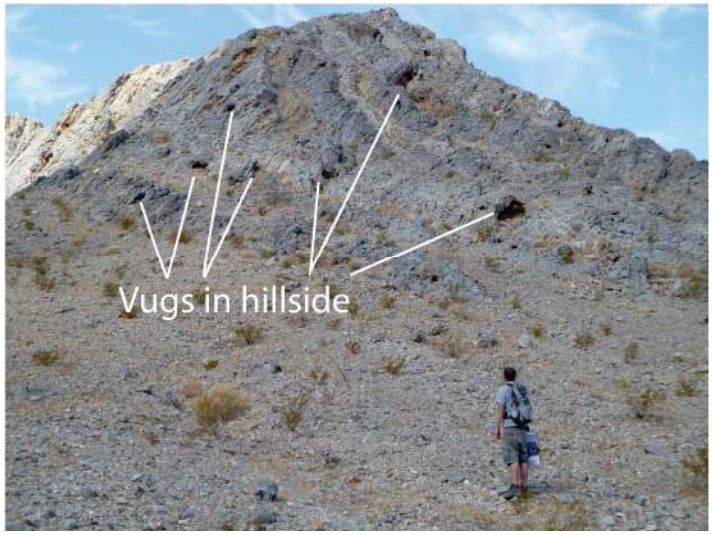


SITE 1

Small vugs in contact metamorphosed Bird Spring Formation of likely Pennsylvanian Age.

SITE 2

Medium size vug in an unmetamorphosed section of Bird Spring Formation of Permian Age.



SITE 2

Very large vugs in an unmetamorphosed section of Bird Spring Formation of Permian Age.

SITE 2

This photograph is a little further up the hill (slope) of Photograph C of Plate 2.

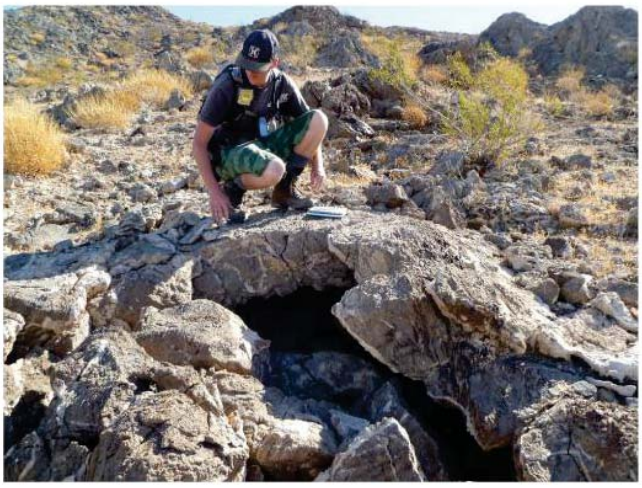
The vugs in this photograph are over 10-feet tall, and extend a minimum of 10 feet deep (depth not explored).

SITE 3

Small vugs in the exposed upper section of the Bird Spring Formation.

SITE 4

Large vugs in Bonanza King Formation of upper Cambrian Age (dolomites and limestones).



SITE 4

Large vugs in Bonanza King Formation of upper Cambrian Age (dolomites and limestones).

SITE 4

Large vugs in Bonanza King Formation of upper Cambrian Age (dolomites and limestones).

SITE 5

Large vug in Bonanza King Formation of the middle Cambrian. Likely Bonanza King lower member. These types of vugs are common in the Bonanza King Formation within the southern Marble Mountains.

SITE 6

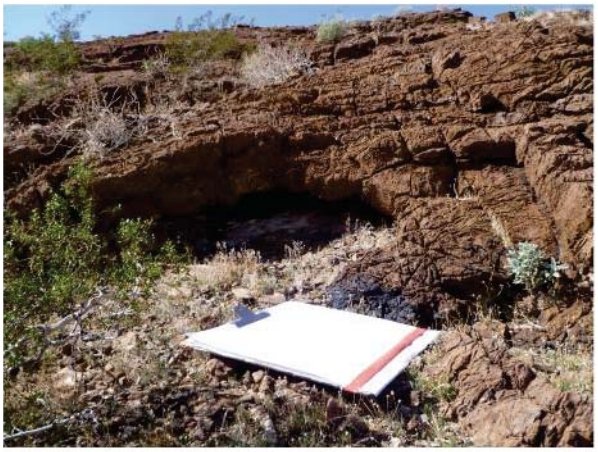
Moderate size vugs in Bonanza King Formation of the middle Cambrian. Likely Bonanza King lower member.

SITE 6

Numerous interconnecting vugs in Bonanza King Formation of the middle Cambrian.

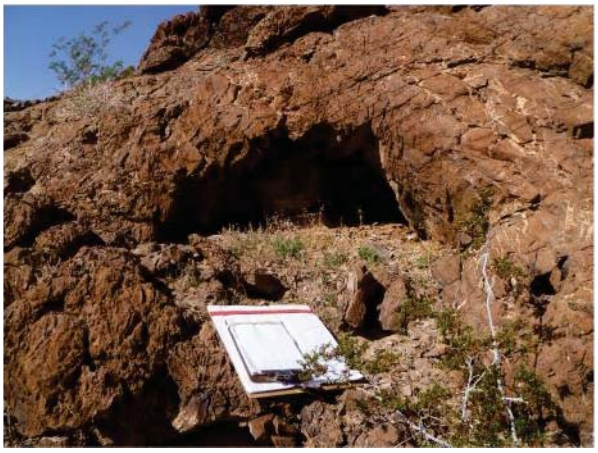
SITE 6

Large vugs (numerous in area) in Bonanza King Dolomite.



SITE 7

Medium size vug in marl-carbonate member of the Cadiz Formation.



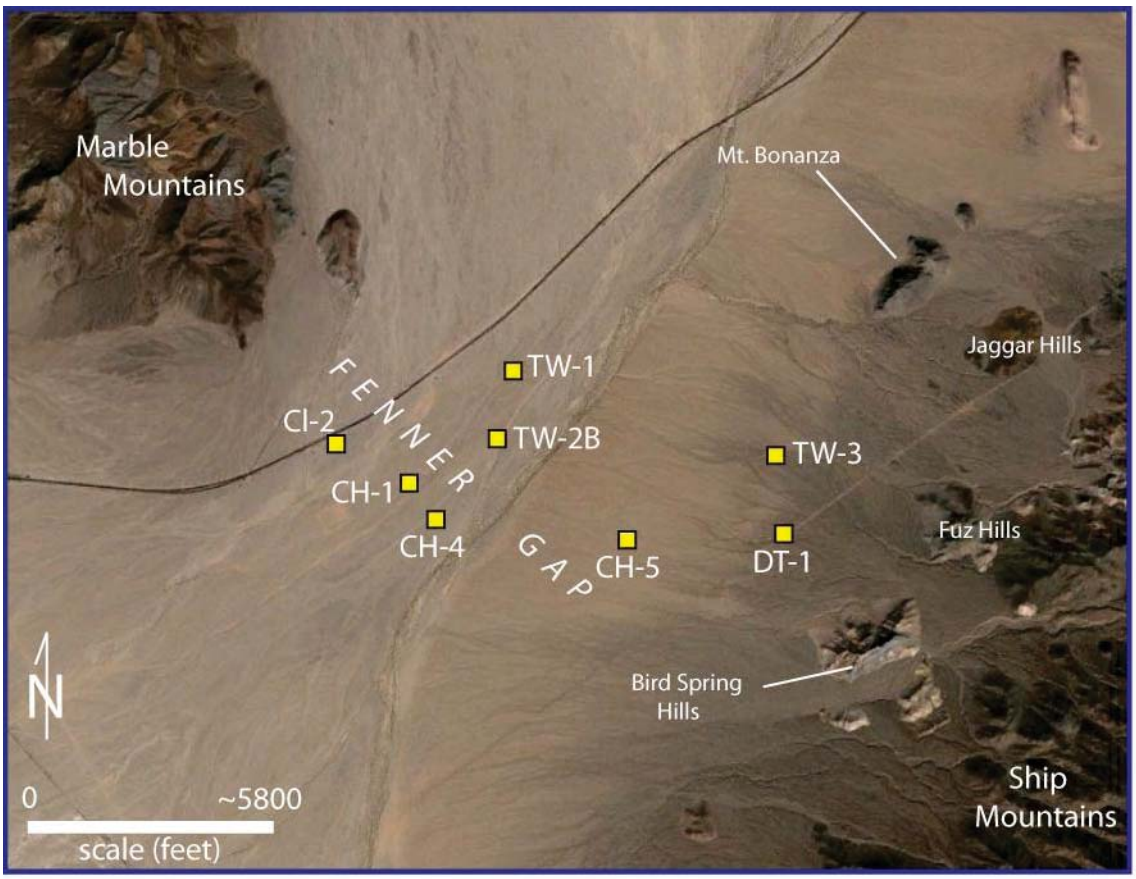
SITE 7

Medium size vug in marl-carbonate member of Cadiz Formation.

BORING LOG DESCRIPTIONS WITHIN FENNER GAP

A number of borings within the Fenner Gap provided extremely useful data during the interpretation of the geologic cross sections provided on Plates 3 and 4 of this report. These borings include: TW-1, TW-2B, TW-3, CH-1, CH-4, CH-5, Cl-2, and DT-1. The locations of these borings are shown on Figure A9 below.

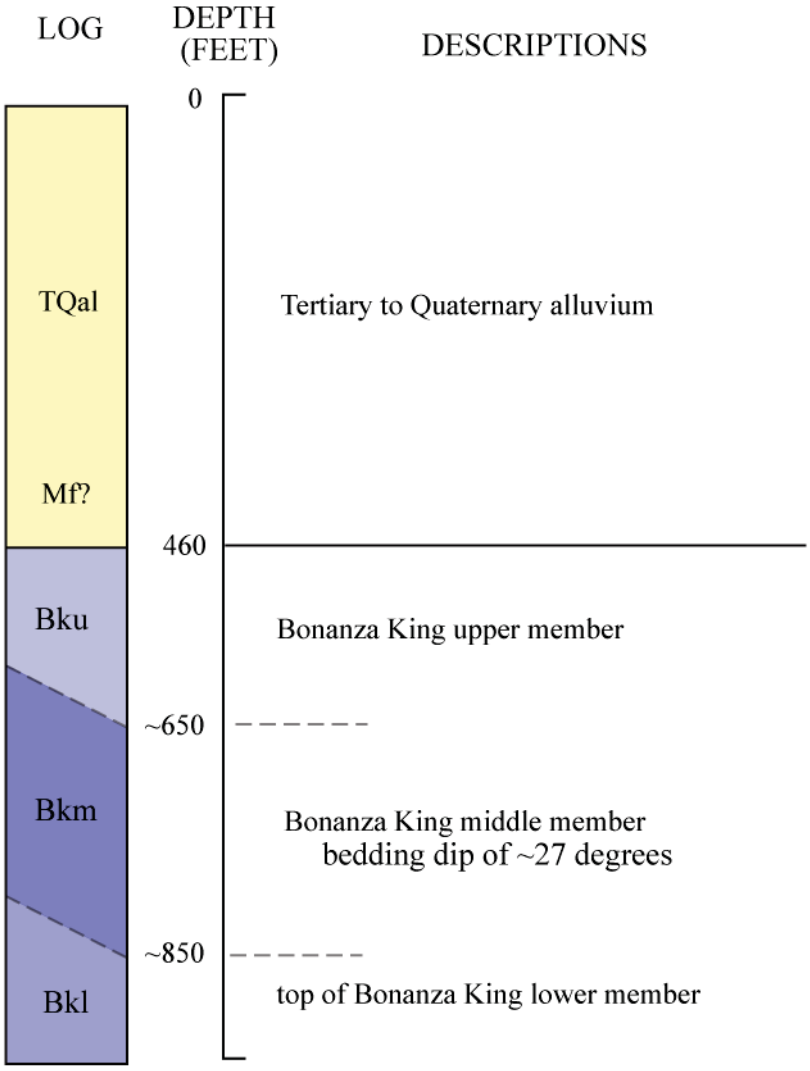
Figure A10: Location map of evaluated Fenner Gap borings.



Interpretations of the stratigraphy and geologic structure from the borings were conducted during this study. Borings providing core samples exhibit logs with considerably more detail than logs interpreted via cutting bag samples or only photographs of samples. An emphasis was placed on attempting to evaluate shears and fractures associated with faulting, dips of structures (faulting and bedding), unit thicknesses, clast composition, and appropriate name for each unit identified. All rocks observed in the borings were also mapped on the surface during this project.

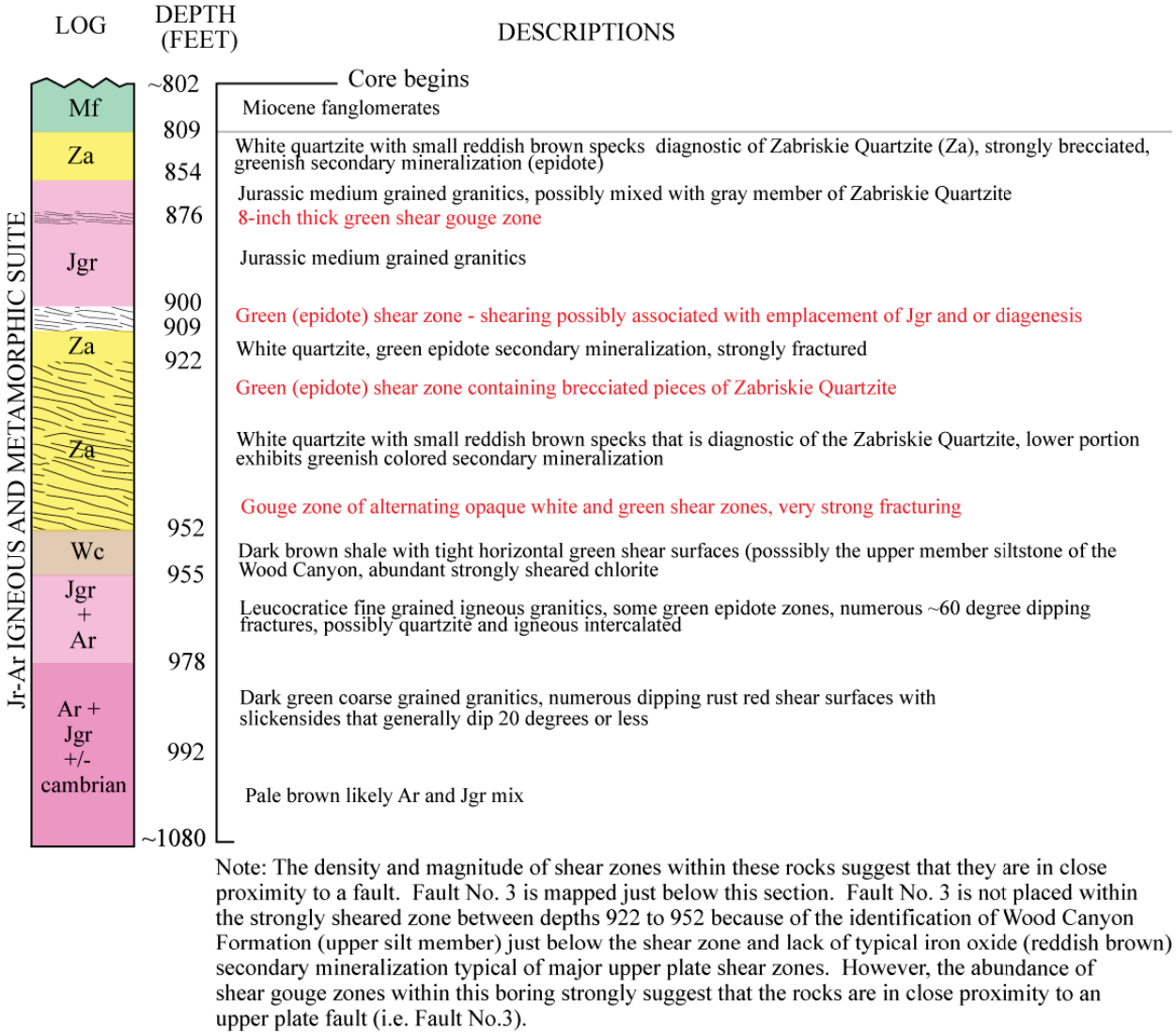
The logs provided below are not to scale, and simply provide information identified from the logs considered to be important in the interpretation of the cross sections shown on Plates 3 and 4.

TW-1



Note: Units TQal and possibly Mf were not evaluated for this boring log other than interpreting the well log conducted by CH2M Hill. The Bonanza King Formation was evaluated from a video log and from the CH2M Hill well log. The contacts between the members of the Bonanza King Formation (Bku - upper, Bkm - middle, and Bkl - lower) were evaluated based on color variations provided in the CH2M Hill well log. A bedding dip of approximately 27 degrees of the Bonanza King Formation was determined by evaluating the dip of bedding in the video log that provided depth measurements in inches.

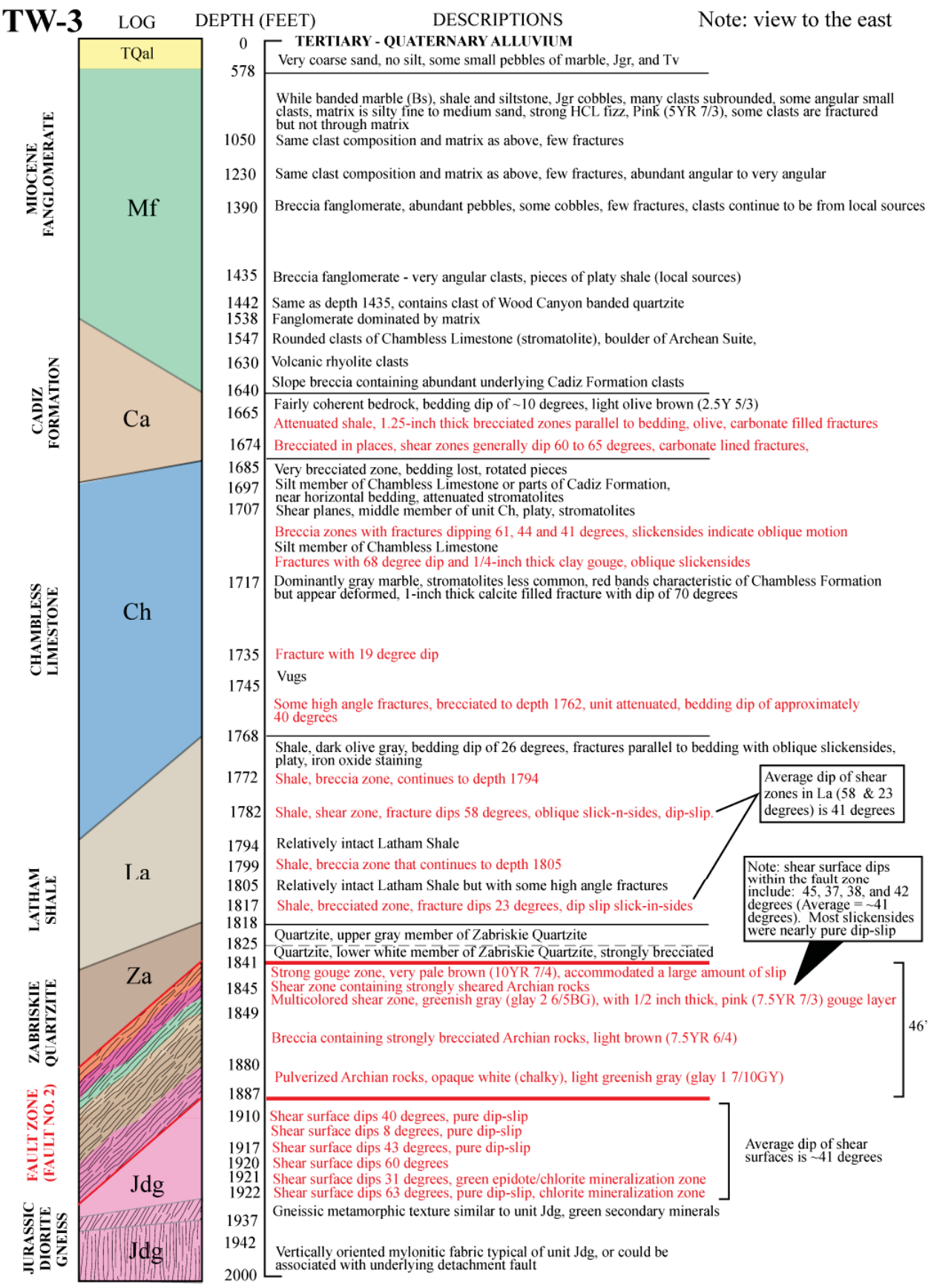
TW-2B



Note: The density and magnitude of shear zones within these rocks suggest that they are in close proximity to a fault. Fault No. 3 is mapped just below this section. Fault No. 3 is not placed within the strongly sheared zone between depths 922 to 952 because of the identification of Wood Canyon Formation (upper silt member) just below the shear zone and lack of typical iron oxide (reddish brown) secondary mineralization typical of major upper plate shear zones. However, the abundance of shear gouge zones within this boring strongly suggest that the rocks are in close proximity to an upper plate fault (i.e. Fault No.3).

TW-3 Notes:

Core samples evaluated for TW-3 provided critical information regarding the potential thickness of the Miocene fanglomerates, and the location of an upper plate fault. A well developed fault zone exhibiting fault gouge, shear surfaces, and secondary mineralization was identified in an approximately 46 foot thick zone. The fault zone is very similar in thickness, composition, color, and structures as exposed upper plate faults in the Jaggar Hills (see Fault No.2 on Plate 2, KGS, 2011). The average dips of the shear surfaces in TW-3, both within the fault zone and structurally above and below it is 41 degrees. Transposing a 41-degree dip to the surface from depth in TW-3 places this fault along the strike with Fault No. 2.


TW-3
LOG
DEPTH (FEET)
DESCRIPTIONS
Note: view to the east
TQal
MIOCENE FANGLOMERATE
Mf
CADIZ FORMATION
Ca
CHAMBLESS LIMESTONE
Ch
LATHAM SHALE
La
ZABRISKIE QUARTZITE
Za
FAULT ZONE (FAULT NO. 2)
Jdg
JURASSIC DIORITE GNEISS
Jdg
0 TERTIARY - QUATERNARY ALLUVIUM
578 Very coarse sand, no silt, some small pebbles of marble, Jgr, and Tv
While banded marble (Bs), shale and siltstone, Jgr cobbles, many clasts subrounded, some angular small clasts, matrix is silty fine to medium sand, strong HCL fizz, Pink (5YR 7/3), some clasts are fractured but not through matrix
1050 Same clast composition and matrix as above, few fractures
1230 Same clast composition and matrix as above, few fractures, abundant angular to very angular
1390 Breccia fanglomerate, abundant pebbles, some cobbles, few fractures, clasts continue to be from local sources
1435 Breccia fanglomerate - very angular clasts, pieces of platy shale (local sources)
1442 Same as depth 1435, contains clast of Wood Canyon banded quartzite
1538 Fanglomerate dominated by matrix
1547 Rounded clasts of Chambless Limestone (stromatolite), boulder of Archean Suite,
1630 Volcanic rhyolite clasts
1640 Slope breccia containing abundant underlying Cadiz Formation clasts
1665 Fairly coherent bedrock, bedding dip of ~10 degrees, light olive brown (2.5Y 5/3)
Attenuated shale, 1.25-inch thick brecciated zones parallel to bedding, olive, carbonate filled fractures
1674 Brecciated in places, shear zones generally dip 60 to 65 degrees, carbonate lined fractures,
1685 Very brecciated zone, bedding lost, rotated pieces
1697 Silt member of Chambless Limestone or parts of Cadiz Formation, near horizontal bedding, attenuated stromatolites
1707 Shear planes, middle member of unit Ch, platy, stromatolites
Breccia zones with fractures dipping 61, 44 and 41 degrees, slickensides indicate oblique motion
Silt member of Chambless Limestone
Fractures with 68 degree dip and 1/4-inch thick clay gouge, oblique slickensides
1717 Dominantly gray marble, stromatolites less common, red bands characteristic of Chambless Formation but appear deformed, 1-inch thick calcite filled fracture with dip of 70 degrees
1735 Fracture with 19 degree dip
1745 Vugs
Some high angle fractures, brecciated to depth 1762, unit attenuated, bedding dip of approximately 40 degrees
1768 Shale, dark olive gray, bedding dip of 26 degrees, fractures parallel to bedding with oblique slickensides, platy, iron oxide staining
1772 Shale, breccia zone, continues to depth 1794
1782 Shale, shear zone, fracture dips 58 degrees, oblique slick-n-sides, dip-slip.
1794 Relatively intact Latham Shale
1799 Shale, breccia zone that continues to depth 1805
1805 Relatively intact Latham Shale but with some high angle fractures
1817 Shale, brecciated zone, fracture dips 23 degrees, dip slip slick-in-sides
1818 Quartzite, upper gray member of Zabriskie Quartzite
1825 Quartzite, lower white member of Zabriskie Quartzite, strongly brecciated
1841 Strong gouge zone, very pale brown (10YR 7/4), accommodated a large amount of slip
1845 Shear zone containing strongly sheared Archian rocks
1849 Multicolored shear zone, greenish gray (glay 2 6/5BG), with 1/2 inch thick, pink (7.5YR 7/3) gouge layer
Breccia containing strongly brecciated Archian rocks, light brown (7.5YR 6/4)
1880 Pulverized Archian rocks, opaque white (chalky), light greenish gray (glay 1 7/10GY)
1887
1910 Shear surface dips 40 degrees, pure dip-slip
Shear surface dips 8 degrees, pure dip-slip
1917 Shear surface dips 43 degrees, pure dip-slip
1920 Shear surface dips 60 degrees
1921 Shear surface dips 31 degrees, green epidote/chlorite mineralization zone
1922 Shear surface dips 63 degrees, pure dip-slip, chlorite mineralization zone
1937 Gneissic metamorphic texture similar to unit Jdg, green secondary minerals
1942 Vertically oriented mylonitic fabric typical of unit Jdg, or could be associated with underlying detachment fault
2000
Average dip of shear zones in La (58 & 23 degrees) is 41 degrees
Note: shear surface dips within the fault zone include: 45, 37, 38, and 42 degrees (Average = ~41 degrees). Most slickensides were nearly pure dip-slip
46'
Average dip of shear surfaces is ~41 degrees

CH-1

	LOG	DEPTH (FEET)	DESCRIPTIONS
Tertiary-Quaternary Alluvial Sediments	TQal	403	Horizontal bedding, Stage IV carbonate one foot thick, medium dense
		450	Horizontal bedding, dark brown silty sand, no carbonate, well sorted
		461	same as 450 depth
		471	same as 450 depth
		504	same as 450 depth
		505-515	Gentle 4 to 5 degree dip, brown silty sand, well sorted, dipping fractures with 3 to 5 foot spacing
		526-533	Gentle 2 to 3 degree dip, brown well sorted sand with silt, occasional dark gray clast
Miocene Fanglomerate	Mf	533-544	same as depth 526-533
		554-565	Likely horizontal bedding, silty dark brown sand, well sorted, scattered gravel, cobble clasts
		565-569	same as depth 554 to 565
		570	Conglomerate, abundant 1 to 4 inch diameter clasts, abundandant dark gray dolomite, matrix has abundant white carbonate, some leucocratic granitic clasts, fractured, very dense
		574-585	same as depth 570
		590	Moderate dip 15 to 20 degrees, abundant white to gray carbonate clasts
Jurassic Granitics	Jgr	593	Jurassic granitics (Jgr), some fracturing at dips of 15 to 30 degrees, some fractures are clean and others are healed with secondary mineralization
		609-611	Green gouge zone
		613-625	Relatively unweathered Jgr, 6-inch thick shear zone at depth 623
		625-637	Strongly fractured, hydrothermally altered Jgr but minor evidence of shearing
		644	Shear surface with slickensides
		650	Relatively unweathered Jgr
		655-664	Relatively unweathered Jgr
		680-682	Greenish shear brecciated zone
		683	Relatively unweathered or deformed Jgr
		708	Pulverized zone, strongly fractured

CH-4

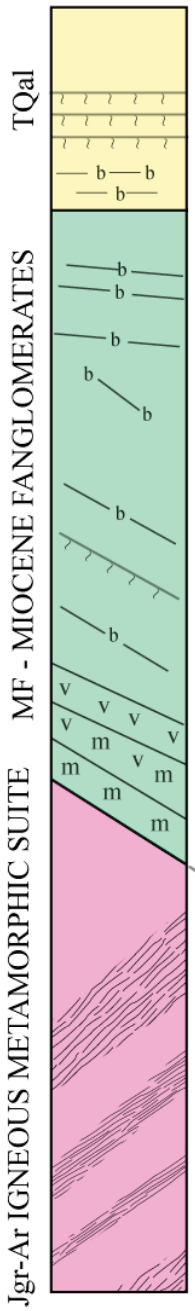
	DEPTH (FEET)	DESCRIPTIONS
Tertiary-Quaternary Alluvial Sediments — TQal	348 -360	Fanglomerate - proximal alluvial fan, angular near source clasts, likely orizontal bedding
	360 - 757	Fanglomerate - proximal fan, angular near source clasts, horizontal bedding, minor secondary carbonate
Jurassic - Archean Granitics — Jgr-Ar	757 - 770	Weathered Jgr possibly from groundwater and not shearing.
	770 - 775	Leucocratic granitics, moderate clean fractures, not typical Jurassic granitics, rock could be Archean (Ar), or the Createous Leucocratic Granite (Kgr)
	775 - 791	Leucocratic granitics, strongly fractured with some secondary mineralization (epidote likely).
	791 - 793	Leucocratic granite stongly fractured, sheared and altered by secondary mineralization.
	793 - 807	Leucocratic granite and some more mafic granitics, strongly fractured and altered by secondary mineralization.
	807 - 819	Typical pinkish Jurassic granitics, strongly fractured with strong secondary mineralization.
	819 - 831	Strongly sheared zone composed primarily of secondary mineralization, light buff olive color
	831 - 842	Strongly sheared and fractured pinkish granitics, with abundant secondary mineralization, one zone may be dominantly clay minerals
	842 - 857	Strongly fractured typical pinkish Jgr
	857 - 860	Strongly altered Jgr, olive hues, abundant secondary mineralization

VERY STRONG FRACTURING AND SECONDARY MINERALIZATION

Note: log interpretated from core photographs. Granitic rocks are strongly fractured and altered suggesting proximity of local faults. Compositional complexities in granitics suggests that the unit may be Jgr-Ar however it is dominated by Jgr. Unit Jgr exposed on the surface does not exhibit abundant secondary mineralization and thick gouge zones.

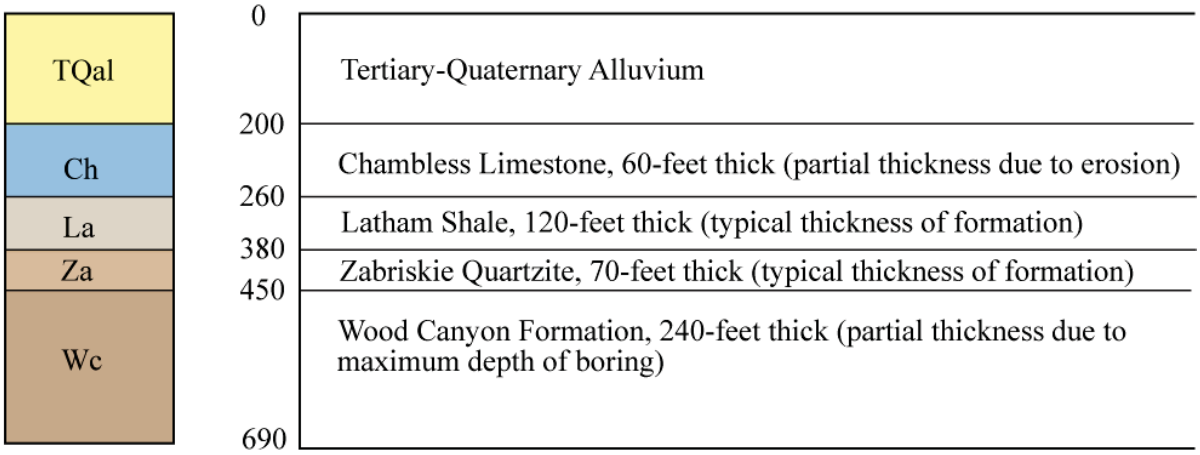
CH-5

View to the east



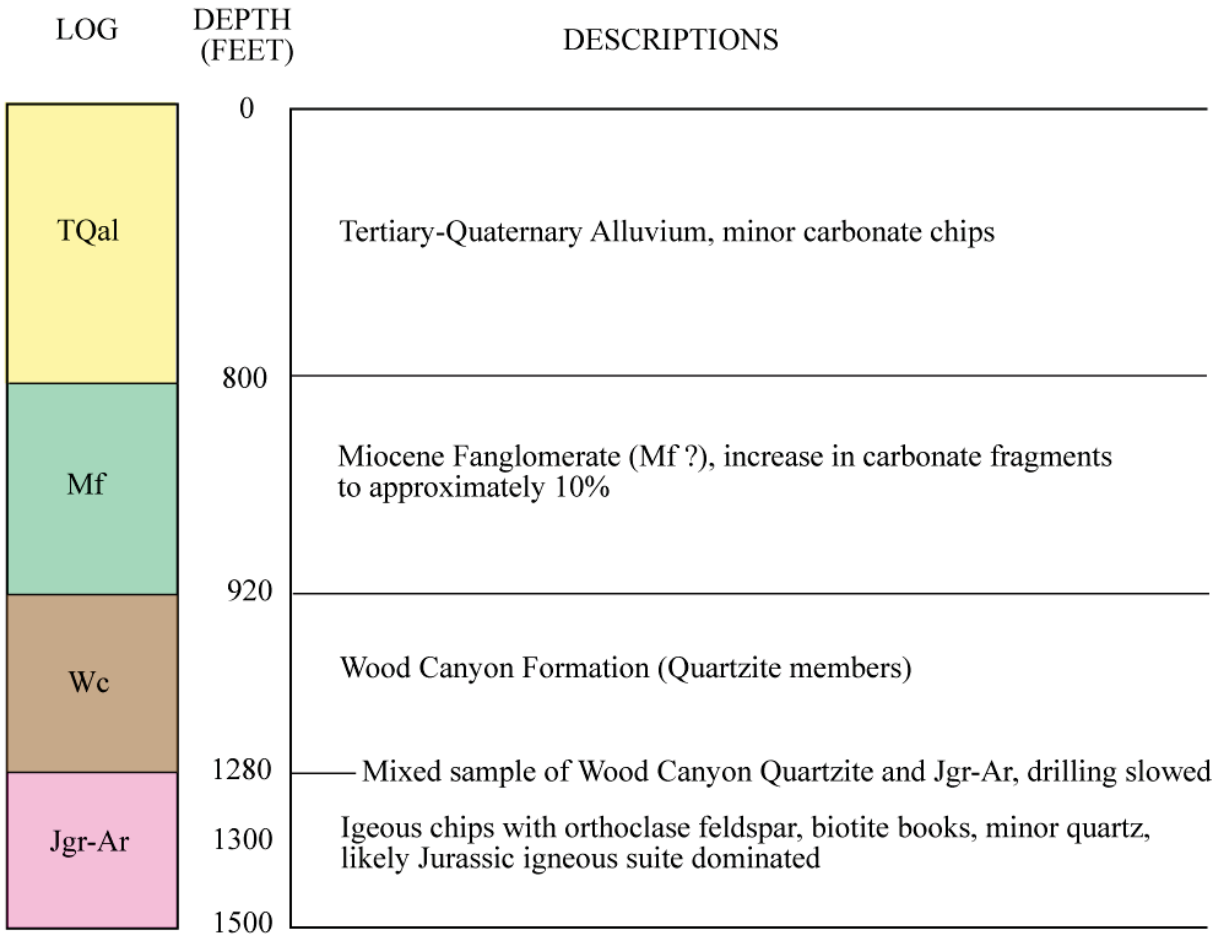
DEPTH (FEET)	DESCRIPTIONS
0	No cores to depth 349
349	Breccia, orange, dense
358	
400	Well sorted sand, horizontal bedding (TQal), carbonate layer - possible paleosol (buried soil) or groundwater infiltration
404	Well sorted sand, horizontal bedding (TQal), carbonate layer - possible paleosol (buried soil) or groundwater infiltration
409	Well sorted sand, horizontal bedding (TQal), carbonate layer - possible paleosol (buried soil) or groundwater infiltration
	Well sorted sand, medium dense, horizontal bedding (TQal)
538	Breccia, pebbles and cobbles, angular to subrounded, dense
550	
560	Breccia, pebbles and small cobbles, angular to subrounded, dense, numerous 37-degree dipping fractures
610	Conglomerate and breccia, some rounded boulders
631	Conglomerate, pebbles and cobbles, angular and subrounded, 5-degree bedding dip
850	Sandstone with angular pebbles, bedding dip of 37 degrees
880	Pebble conglomerate with sand and clay, minor cobbles that are angular
911	Siltstone (clay?) with shear surfaces
940	Siltstone and fine sand, some pebble layers, bedding dip of 29 degrees
951	Well sorted sands and pebble layers, dense, angular pebbles, minor dipping fractures
986	Secondary carbonate layer that may represent a buried soil (paleosol)
1025	Well sorted sand with clay and rounded cobbles, bedding dip of 31 degrees
1055	Pebble breccia with minor small angular cobbles
1070	Rounded cobble conglomerate, cobbles are aphanitic basalt (v), bedding dip of 25 degrees
1080	
1090	Conglomerate and breccia, numerous cobbles of vesicular basalt, and possible marble (m)
1100	Pink reworked ash layer - fine grained, massive
1101	Well sorted sand, dark greenish brown
	Breccia and conglomerate interbedded layers containing marble (m) cobbles from local sources, fat clay member
1106	Either a very large boulder or igneous intrusives (Jgr or Archian), no phenocrysts or plagioclase suggesting unit Jgr
	Breccia zone of same material as depths 1106 to 1110 (Jgr), abundant joints and fractures with average dip of 37 degrees (apparent), orange reddish brown staining, abundant clay gouge, some large phenocrysts of which plagioclase suggesting intercalated Ar; rocks are clearly deformed by faulting
1110	
1114	Breccia zone - greenish tan, broken up pieces of material from depths 1,106 to 1,110
1116	Breccia of Archean igneous rocks, phenocrysts of plagioclase, greenish penetrative hue (epidote likely), abundant secondary minerals, crushed up igneous plutonic rocks, numerous dipping fractures
1123	Relatively less deformed and altered bedrock that is similar to 1,106 to 1,110 depths, no large plagioclase phenocrysts suggesting unit Jgr, penetrative green secondary mineralization (epidote likely)
1124	Strongly weathered and brecciated Archean (Ar)
1131	Relatively less deformed and altered bedrock that is similar to 1106 to 1110 depths, no large plagioclase phenocrysts suggesting unit Jgr, penetrative green secondary mineralization (epidote likely)
1135	
1136	Orange cataclastic gouge zone with very sharp boundaries, dips 37 degrees minimum but likely dips in the range of 40 to 43 degrees, 6-inches thick
1139	

CI-2



Note: Typical section thickness for the Latham Shale and Zabriskie Quartzite indicates that these rocks have not been strongly attenuated by igneous intrusives, faulted, or exhibit very steep dips.

DT-1



Boring excavated via dual tube reverse rotary drilling method. Log determined from CH2M Hill field logs, and obersvation of cutting bag samples, no cores were obtained during drilling.

DESCRIPTIONS OF KEY DEFORMATIONAL STRUCTURES

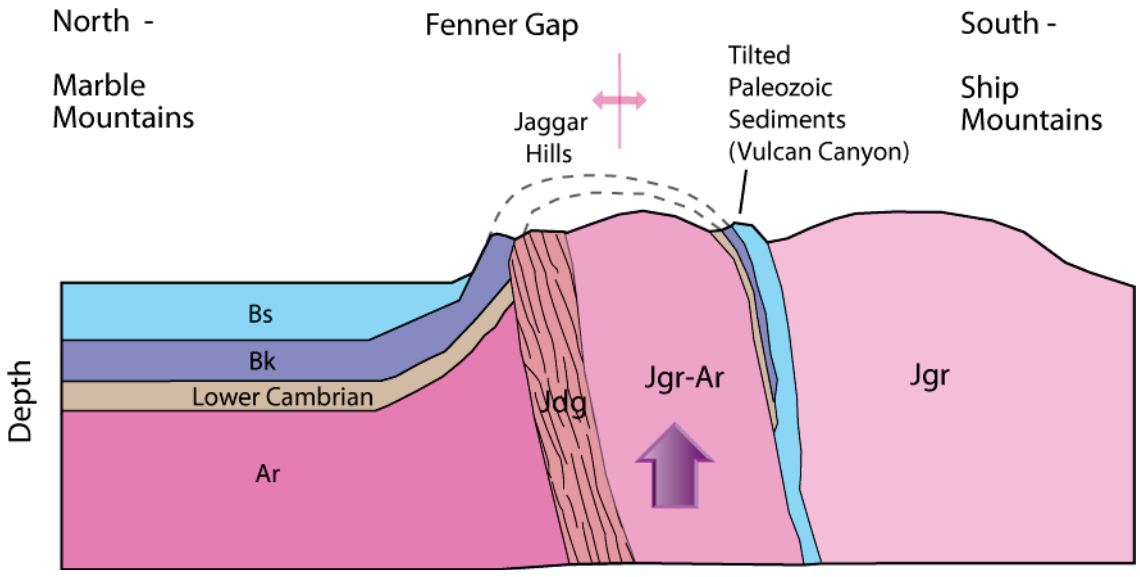
This section provides descriptions, with the use of cartoon drawings to explain some of the key structural relationships of the bedrock units within the Fenner Gap. The deformational events are additive in the sense that younger structures (i.e. faults) will offset all older structures. For example, the normal faults of the Miocene offset all deformed structures caused by the Jurassic intrusive suite. A simplified geologic history of the site includes creation of the "Original System" (see section 8.2) that includes cratonal platform deposits of the Paleozoic sedimentary rocks on top of the Proterozoic Igneous and Metamorphic Complex. These rocks were essentially undeformed until intrusion of the Jurassic Igneous suite, which pushed up, thermally metamorphosed, attenuated, and faulted rocks of the Original System. This primarily occurred in the Ship Mountains and across the now buried regions of the southern and southwestern Fenner Gap. The contact region between the relatively undeformed Original System well exposed in the Marble Mountains, and the deformed Original System occurs along the northern contact of the east-west trending and vertically dipping Jurassic Dioritic Gneiss which extends from 400 feet south of the southern tip of the Marble Mountains across Fenner Gap to the Jaggar Hills. During the Miocene, Epoch extensional normal faults occurred across the Fenner Gap, offset both the relatively undeformed Original System rocks of the southern Marble Mountains and the more deformed rocks buried beneath Fenner Gap primarily due to the Jurassic Intrusives.

The Original System

The "Original System" herein refers to an upper crustal section consisting of the Paleozoic Sedimentary rocks (Bs, Bk, Ca, Ch, La, Za, and Wc) overlying the Proterozoic Igneous and Metamorphic Complex (Ar). This is shown in the cartoon drawing below.

The Original System Deformed by Jurassic Intrusives

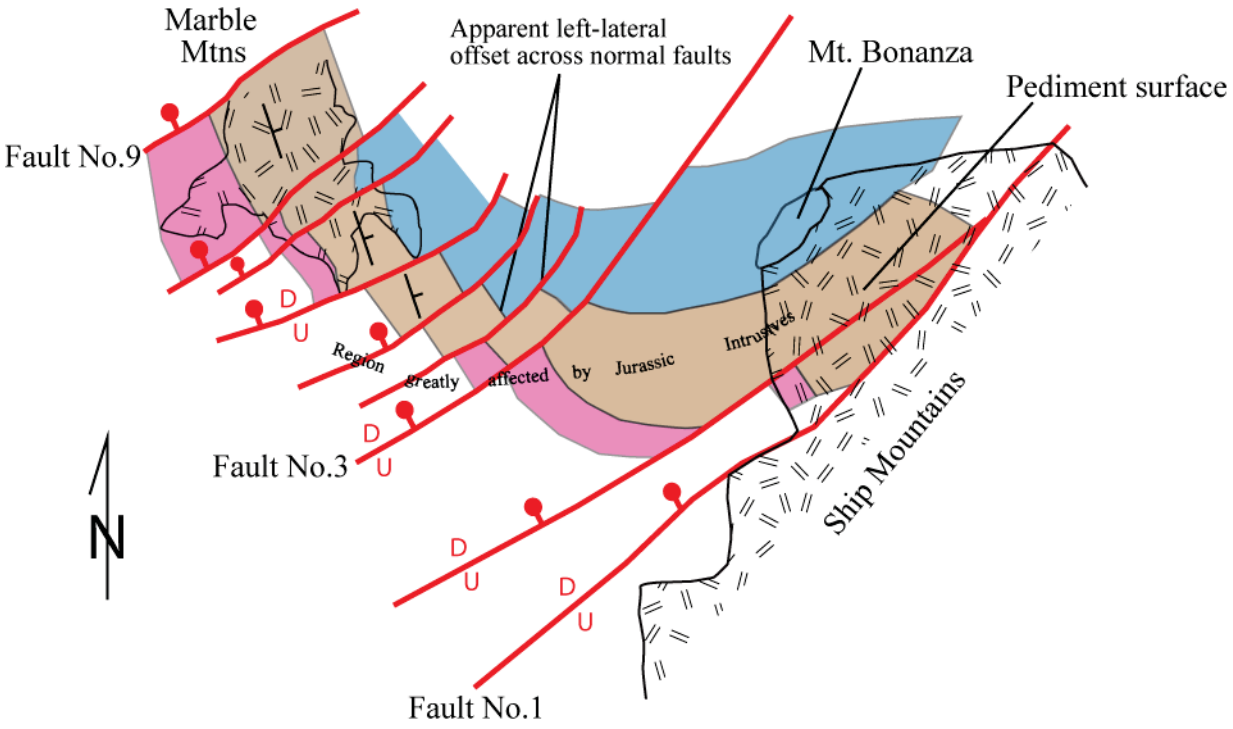
The Original System remained fairly intact and undeformed locally until the intrusion of the Jurassic igneous suite, and metamorphic complexes. This complex consists of the Jurassic Dioritic Gneiss (Jdg), Jurassic intrusives mixed with rocks of the Original System (Jgr-Ar), and nearly pure Jurassic Intrusives (Jgr). The intrusion of the Jurassic igneous rocks primarily caused uplift, erosion, folding, and attenuation (thinning) of the Original System rocks as shown in the cartoon below.



Offset by Miocene Normal Faults

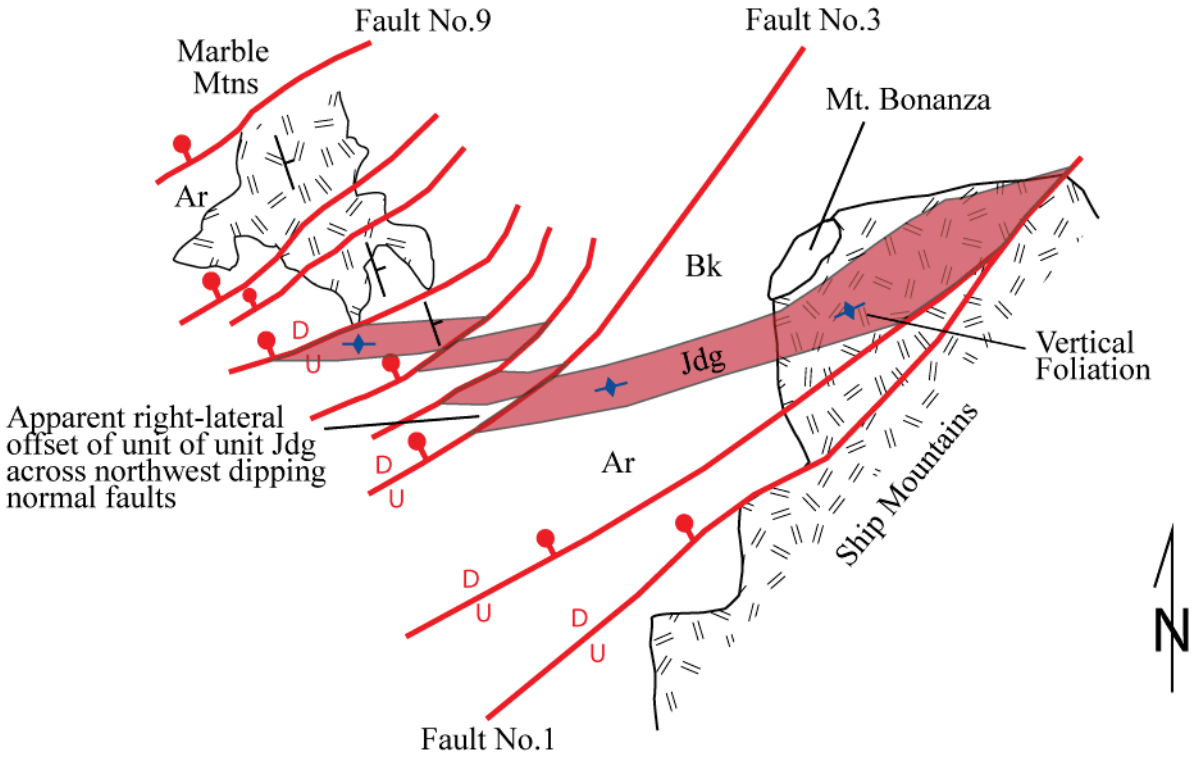
Apparent Left-Lateral Offset of Original System

During the Miocene, a series of normal faults offset the Original System and Jurassic Intrusive rocks. The primary normal faults within Fenner Gap evaluated during this study are Faults No. 1 through 9 that trend northeast to southwest. These faults, shown in the cartoon drawing below, dip toward the northwest with the rocks on the northwestern side going down relative to the rocks on the southeastern side of each fault. The Paleozoic rocks of the Original System tend to strike toward the north-northwest and dip toward the northeast. Offset of beds with this strike and dip across Faults No. 1 through 9 produces an "apparent" left-lateral offset across each fault. This is clearly observed within exposures in the southern Marble Mountains. The net result of an apparent left-lateral offset across all nine normal faults is to shift the Original System rocks toward the west across Fenner Gap.

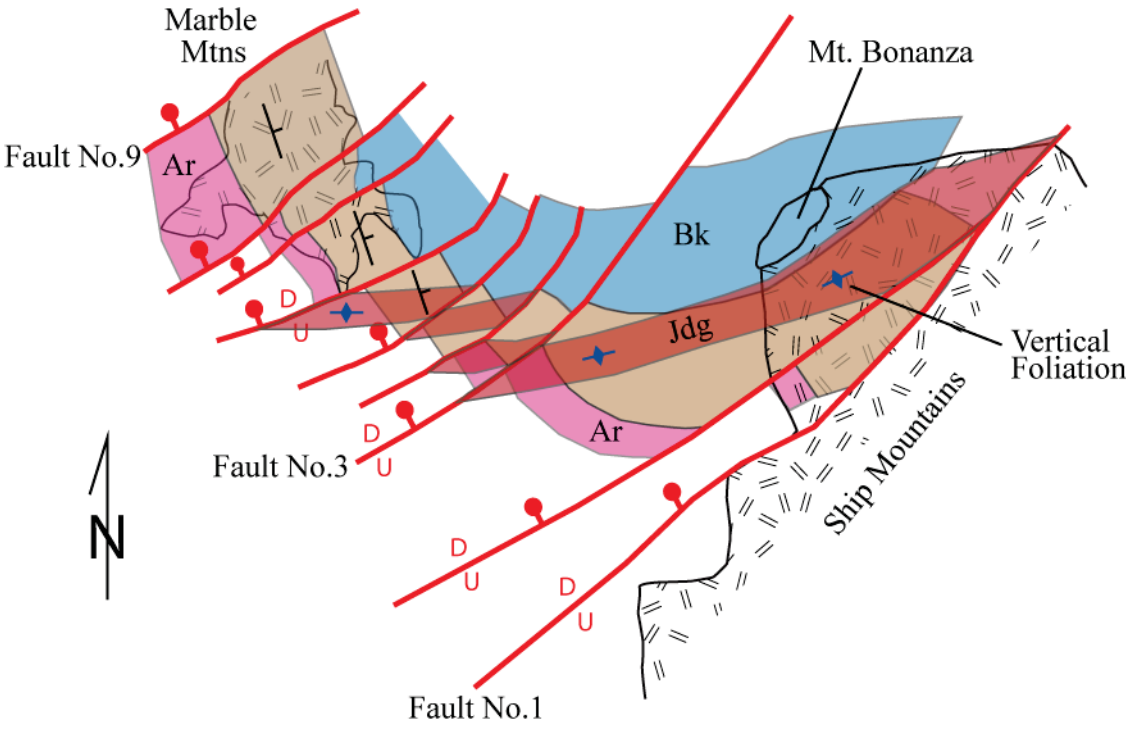


Apparent Right-Lateral Offset of Vertically Dipping Jurassic Diorite Gneiss

An apparent right-lateral offset is produced by offset of the nearly vertically dipping Jurassic Diorite Gneiss across each normal fault. This is shown in the cartoon drawing below. A similar right lateral offset has also likely occurred on Faults No. 1 and 2.



Convolving Apparent Left-Lateral offset of Original System and Right-Lateral offset of Jurassic Diorite Gneiss.



APPENDIX C

Geohydrologic Assessment of the Fenner Gap Area

(Prepared by GEOSCIENCE Support Services, Inc.)

GEOSCIENCE

GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

Prepared for:

Brownstein Hyatt Farber Schreck, LLP

September 1, 2011

Prepared By:

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
T: 909.451.6650
F: 909.451.6638
gssiwater.com

BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL MEMORANDUM

GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

September 1, 2011

CONTENTS

1 EXECUTIVE SUMMARY 1

2 BACKGROUND 4

2.1 Fenner Gap – Location, Drainage and Topography 4
2.2 Prior Field Investigations 5
2.3 Purpose and Scope 5
2.4 Field Reconnaissance 6

3 REGIONAL GEOHYDROLOGIC CONDITIONS 6

3.1 Regional Geology 6
3.1.1 Regional Geologic Units 7
3.1.1.1 Alluvium 7
3.1.1.2 Bedrock Units 8

4 GEOHYDROLOGY OF THE FENNER GAP AREA 8

4.1 Geology 8
4.1.1 Subsurface Geologic Conditions 9

4.1.1.1 Quaternary Alluvium 9
4.1.1.2 Carbonates 10
4.1.1.3 Fanglomerate and Volcanic Rocks 11
4.1.1.4 Granitic Rocks 11
4.1.2 Lithologic Findings in New Test Wells 12
4.1.2.1 Test Well TW-1 12
4.1.2.2 Test Wells TW-2 and TW-2B 12
4.1.2.3 Test Well TW-3 13
4.1.2.4 Test Bore Hole CH-1 13
4.1.2.5 Monitoring Well TW2-MW 13
4.1.2.6 Test Bore Hole CH-4 13
4.1.2.7 Test Well CH-5 14
4.1.2.8 Test Well DT-1 14
4.1.3 Summary of Geology in the Fenner Gap Area 14
4.2 Hydrology 15
4.2.1 Precipitation 15
4.2.2 Ground Water Occurrence and Movement 15
4.2.3 Alluvial Aquifer System 15
4.2.4 Carbonate Aquifer System 16
4.3 New Exploratory Drilling and Well Construction 16
4.3.1 TW-1 17
4.3.2 TW-2 18
4.3.3 TW-3 19
4.3.4 TW2-MW 19
4.3.5 CH-5 20
4.3.6 DT-1 20
4.3.7 TW-2B 20
4.3.8 CH-1 21
4.3.9 CH-4 21
4.4 Analysis of Pumping Test Data 21
4.4.1 Pumping Tests of TW-1 22

4.4.1.1 TW-1 Step Drawdown Test – Alluvial Aquifer 22
4.4.1.2 TW-1 Constant Rate Test – Alluvial Aquifer 22
4.4.1.3 TW-1 Step Drawdown Test – Carbonate Aquifer 22
4.4.1.4 TW-1 Constant Rate Test – Carbonate Aquifer 22
4.4.2 Pumping Test of TW-2 23
4.4.2.1 TW-2 Step Drawdown Test 23
4.4.2.2 TW-2 Constant Rate Test 23
4.4.3 Pumping Test of PW-1 24
4.4.3.1 PW-1 Constant Rate Test 24
4.4.4 Summary of Aquifer Parameters 24

5 UNDERFLOW THROUGH THE FENNER GAP 26

5.1 Historical Estimates 26
5.2 Sensitivity of Recent Aquifer Parameters in Relation to Underflow through the Fenner Gap 26

6 FINDINGS 27

7 REFERENCES 29

FIGURES, TABLES, and APPENDICES

FIGURES

Figure 1 – Project Location
Figure 2 – Regional Geologic Map
Figure 3 – Technical Cross Sections for Testing Wells
Figure 4 – TW-1 Packer Test Configuration
Figure 5 – Technical Cross Sections for Monitoring Wells
Figure 6 – TW-3 Packer Test Configuration
Figure 7 – Technical Cross Sections for
Figure 8 – MW-6 As Built Diagram
Figure 9 – MW-7 and 7A As Built Diagram
Figure 10 – Cadiz TW-1 – Alluvial Aquifer – Step Drawdown Test
Figure 11 – Cadiz TW-1 – Alluvial Aquifer – Specific Drawdown vs. Discharge Rate
Figure 12 – Cadiz TW-1 – Alluvial Aquifer - Specific Capacity and Well Efficiency Diagram
Figure 13 – Cadiz TW-1 – Alluvial Aquifer – Constant Rate Test
Figure 14 – Cadiz MW-7a – Alluvial Aquifer – Constant Rate Test
Figure 15 – Cadiz TW-1 – Carbonate Aquifer - Step Drawdown Test
Figure 16 – Calculation of Thermal Expansion of Water During Pumping of Carbonate Well TW-1
Figure 17 – Pumping Well TW-1 (Carbonates) – Constant Rate Test
Figure 18 – Constant Rate Test on TW-1
Figure 19 – Constant Rate Test on TW-1
Figure 20 – Constant Rate Test on TW-1
Figure 21 – Step Drawdown Test – Cadiz TW-2 – Alluvial Aquifer
Figure 22 – Specific Drawdown Graph – Cadiz – TW-2 Alluvial Aquifer
Figure 23 – Specific Capacity and Well Efficiency Diagram – Cadiz TW-2 Alluvium
Figure 24 – Constant Rate Pumping Test – Cadiz TW-2 Alluvial Aquifer
Figure 25 – Calculated Recovery – Cadiz TW-2 - Alluvial Aquifer
Figure 26 – Calculated Recovery – Cadiz TW-2 - Alluvial Aquifer
Figure 27 – Constant Rate Test on TW-2
Figure 28 – Calculated Recovery – Cadiz Well TW-2 – Alluvial Aquifer
Figure 29 – Constant Rate Test on TW-2
Figure 30 – Constant Rate Pumping Test on TW2-MW (Observation Well)
Figure 31 – Constant Rate Pumping Test with Packer TW-2 Below Packer (Fractured Bedrock Aquifer)
Figure 32 – Constant Rate Pumping Test Well CI-3 (Observation Well)

TABLES

Table 1 – Summary of Pumping Tests and Aquifer Parameters, Fenner Gap Area
Table 2 – Hydraulic Conductivity of Fractured Rock

APPENDICES

Appendix A – Soil Boring Log – TW-1
Appendix B – Soil Boring Log – TW-2
Appendix C – Soil Boring Log – TW-3
Appendix D – Soil Boring Log – TW2-MW
Appendix E – Soil Boring Log – CH-5
Appendix F – Soil Boring Log – DT-1
Appendix G – Soil Boring Log – TW-2B
Appendix H – Soil Boring Log – CH-1
Appendix I – Soil Boring Log – CH-4

BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL MEMORANDUM

GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

1 EXECUTIVE SUMMARY

An analysis of the geohydrologic conditions in the Fenner Gap area was conducted using data from previous GEOSCIENCE investigations along with information developed by CH2M Hill during drilling, well installation, and well testing activities conducted from 2009 through 2011 and from recent detailed geologic mapping conducted by Kenny Geoscience (Kenney, 2011). The following is a brief summary of the analysis:

- Geologic cross-sections (Kenney, 2011) indicate that the alluvium ranges in thickness from 700 ft and 860 ft in the center of Fenner Gap. Alluvium increases in thickness both towards Bristol Valley to the south and Fenner Valley to the north.

- The alluvium consists primarily of gravel and sand with some silt and clay lenses.

- In Fenner Gap, the alluvium is underlain by a sequence of Tertiary fanglomerate and volcanic rock, Paleozoic sediments, and Archaen and Jurassic granitic rock. These geologic units can be observed at the surface on the Flanks of the southern Marble Mountains and western Ship Mountains, and as inselbergs in Fenner Gap.

- A portion of the Paleozoic sequence is missing in the western portion of Fenner Gap at the southerly end of the Valley. The Paleozoic section increases in the cross-sectional area in the subsurface beneath the center of Fenner Gap as you go north towards Fenner Valley.

- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. This carbonate aquifer represents a second significant aquifer in Fenner Gap.

- The extent of Paleozoic limestone units including the Bonanza King Formation and Bird Spring Formations in the subsurface across Fenner Gap is shown on Cross-section 1-1' through 5-5' of the Kenney report (2011). Ground water flow is anticipated to occur, both in secondary porosity as solution cavities and along zones of fractures and joints associated with extensive faulting in the area.

- Other carbonate units such as the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1, and TW-3 may potentially yield a significant volume of water through localized solution cavities and/or joints and fractures.

- Two primary aquifer systems and one secondary aquifer system exist in the Fenner Gap area. The two primary aquifer systems are: 1) an alluvial aquifer system; and 2) a carbonate aquifer system. The secondary aquifer system consists of highly fractured granitic and carbonate rock that is present along fracture zones in the hanging wall of the many faults that cross the project area.

- The alluvial aquifer system consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967). The thickness of this aquifer in Fenner Gap is interpreted to vary from approximately 200 ft towards the flanks of Fenner Gap to as much as 860 ft as depicted in the recent cross-sections. The alluvial material penetrated by recent borings consisted of very permeable gravel and sand with some silt and clay in lenses.

- The carbonate aquifer system consist of ground water present in large solution cavities developed by dissolution of the calcium carbonate rock along bedding, joints and fractures. Large solution cavities were penetrated in borings and can be observed at ground surface in the Bonanza King Formation.

- Ground water flow occurs through the highly fractured and jointed granitic rock which underlies a considerable portion of the Fenner Gap as well as along the numerous fracture zones developed along fault zones that exist in the area.

- Based on previous findings and confirmed by recent drilling and testing in the Fenner Gap area, carbonate bedrock of Paleozoic age, located beneath the lower alluvial aquifer, contains ground water and is considered a second main aquifer unit.

- Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities) that have developed in the rocks over time. Recent tests show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive. It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly transmissive secondary porosity features.

- Aquifer parameters derived from the recent pumping tests in the Fenner Gap area for the alluvial and carbonate units show very transmissive properties in the vicinity of the new test Wells TW-1 and TW-2. Hydraulic Conductivities for the alluvial aquifer system in the vicinity of pumping Well TW-2 located in the

center of the Fenner Gap in Schulyer Wash, average approximately in the range from 37 ft/day (MW-7) to 150 ft/day (TW2). However, an alternative interpretation of the pumping test data for TW2-MW and TW-2, results in alluvial hydraulic conductivities ranging from 598 through 848 ft/day. The pumping test plot suggests that a recharge boundary may be encountered in the later portion of the test. Hydraulic conductivity of the alluvial aquifer system in the vicinity of pumping well PW-1 located in an older alluvial fan northwest of Schulyer Wash was 158 ft/day. Storativities average approximately 0.002 reflecting semi-confined conditions.

Hydraulic Conductivities for the carbonate aquifer in the vicinity of Well TW-1 calculated to be 602 ft/day and 1,023 ft/day. Storativities are representative of semi-confined (i.e., leaky) aquifer systems. The alluvial aquifer in the vicinity of TW-1 exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate aquifer. The alluvial aquifer in the vicinity of TW-2 also shows leakage effects. Hydrologic boundaries were exhibited on the pumping test data reflecting the heterogeneous nature of the alluvial and carbonate aquifer system in the area.

Hydraulic conductivity of fractured granite may range from approximately 5 ft/day to 20 ft/day at depth in TW-2. Published values for hydraulic conductivity in fractured granitic rock range from an average from a low of 0.1 ft/day to a high of 40 ft/day.

- Underflow through the Fenner Gap occurs both in the alluvial and carbonate aquifer systems as well as to a lesser extent through fractured granite and fault zones. Based on previous and current exploratory testing, saturated portions of the Bonanza King Formation may also occur in other sections of the Fenner Gap in addition to the area near Well TW-1. The ranges of hydraulic conductivity based on aquifer test data range between 37 – 150 ft/day for the alluvial aquifer system, and approximately 602 and 1,023 ft/day for the Bonanza King member of the carbonate aquifer, and 5ft/day to greater than 40 ft/day through fractured granite and fault zones.

2 BACKGROUND

2.1 Fenner Gap – Location, Drainage and Topography

The Fenner Gap is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see Figure 1). Specifically, the Fenner Gap is located between the Marble and Ship mountains east of Cadiz within a topographically closed drainage system that includes three main drainage basins: Bristol, Cadiz, and Fenner. These basins are considered one drainage system because all surface and ground water within these basins drains to a central lowland area (i.e., Bristol and Cadiz dry lakes). The Bristol, Cadiz, and Fenner basin system is separated from the surrounding drainage basins by topographic divides (generally mountain ranges). Surface and ground water on the other sides of these divides (i.e., outside of

Fenner Gap Area

the three basin area) flows toward other areas. Because ground water flow directions in the eastern Mojave Desert are generally similar to surface water flow directions, for purposes of this report, the terms drainage basin and ground water basin are used interchangeably.

The total area of the Bristol, Cadiz and Fenner ground water basin system is approximately 2,710 square miles. The Bristol Basin is 1,170 square miles, the Cadiz Basin is 540 square miles, and the Fenner Basin is 1,000 square miles. Ground water flow within the Bristol Basin flows toward, and terminates in, Bristol Dry Lake. Ground water flow within the Cadiz Basin flows toward, and terminates in, Cadiz Dry Lake.

Ground water flow within the Fenner Basin flows through Fenner Gap. Some of the ground water flowing through Fenner Gap migrates toward Bristol Dry Lake and some flows toward Cadiz Dry Lake.

2.2 Prior Field Investigations

In 1998 and 1999 the Metropolitan Water District of Southern California (MWD), evaluated the feasibility of operating a ground water storage and transfer project near Cadiz, California in the eastern Mojave Desert. The project entailed transferring surplus water from the Colorado River Aqueduct (CRA) and artificially recharging it through a series of surface spreading basins located in the vicinity of Fenner Gap. A pipeline would have transported water from the CRA during storage operations (i.e., "put" operations) as well as transport pumped ground water from the Cadiz area back to the CRA during extraction operations (i.e., "take" operations). The project was given the title *Cadiz Ground Water Storage and Dry-Year Supply Program.* As part of the investigation phase of the proposed project, field testing was performed in and around the Fenner Gap to characterize geologic and hydrologic properties.

Leading up to the pilot recharge test, a comprehensive field testing program was conducted from December 1998 through January 1999 to collect geologic, hydrologic, and water quality data from the Fenner Gap vicinity. The field testing program included the installation of a deep 16-inch-diameter production well, and a total of ten ground water monitoring wells drilled and installed in the Fenner Gap area prior to construction of the pilot spreading basin followed by an 8-month large-scale artificial recharge test. The primary objective of the pilot test program was to collect data necessary to determine the feasibility of storing (and retrieving) CRA water. Results from the pilot test program showed good potential for a ground water banking project in the Fenner Gap area.

2.3 Purpose and Scope

The purpose of this Technical Memorandum is to provide an updated evaluation of the geohydrology in the Fenner Gap area considering the recent exploratory drilling and testing performed in late 2009 and early 2011 and recent detailed geologic mapping conducted in 2010 and 2011. In conjunction with this task, independent analyses of pumping test data were made and aquifer parameters evaluated. In addition, the scope involved review of new geologic information gained from the exploratory drilling and testing and revisiting of some existing geophysical data performed in the Fenner Gap area, and an incorporation of detailed geologic structural information prepared by Dr. Miles Kenney (Kenney, 2011) into our analysis.

2.4 Field Reconnaissance

On November 11, 2009, Dr. Dennis Williams (GEOSCIENCE) visited the well site of Wells TW-1 and TW-2.

Well TW-2 was pumping at an approximate rate of 1,100 gallons per minute (gpm). The inset photograph shown to the right shows the discharge from Pumping Well TW-2 on November 11, 2009.

Discharge from Pumping Well TW-2
(See Figure 2a for Location)

An additional reconnaissance was conducted with Dr. Miles Kenney and Staff of CH2M Hill on January 28, 2011 to review the type sections for geologic units and faults in the project area with reference to the geohydrologic conditions.

3 REGIONAL GEOHYDROLOGIC CONDITIONS

3.1 Regional Geology

The geohydrologic conditions in the Project area were initially evaluated based on previous geohydrologic reports and information provided from two exploratory/test wells (TW-1 and TW-2), one shallow test boring (TW-2B) and one deep test boring (TW-3). However, beginning in October, 2010 and extending through May, 2011, four additional borings, deepening and testing of TW-2, and an injection test at borehole DT-1 was completed by CH2M Hill in the Fenner Gap area in an effort to further characterize the subsurface geologic conditions and distribution of geologic units. Subsurface data developed by CH2M Hill is provided in Appendix A through Appendix I.

The geologic mapping of the geology in the area prepared by the California Division of Mines and Geology (CDMG, 1964) has served as the basis for understanding local geologic conditions in the Fenner Gap. Recent surface mapping of the geology in southeastern portion of the Marble Mountains, the Fenner Gap, and the northwestern portion of the Ship Mountains was conducted for this Investigation by Dr. Miles Kenney. His report entitled “Draft Geologic Structural Evaluation of the Fenner Gap region located between the southern Marble Mountains and Ship Mountains, San Bernardino

County, California." is presented as Appendix B of GEOSCIENCE report entitled "Cadiz Groundwater Modeling and Impact Analysis," dated September 1, 2011. This recent work has provided a framework for understanding the distribution of geologic units as well as the location and condition of faulting pertinent to ground water movement through the Fenner Gap.

3.1.1 Regional Geologic Units

The project area is located within portions of the Bristol, Cadiz, and Fenner Valley watersheds in the Eastern Mojave Desert of California. Together the Bristol and Cadiz watersheds form a broad valley-like depression that has been referred to in literature as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). Because all surface and ground water flow terminate in the Bristol and Cadiz dry lakes, which are the low points of the regional watershed, (Bassett et al., 1959; Handford, 1982; Rosen, 1989), it is considered to be a closed system. The depression that forms Bristol Dry Lake is thought to be 6-10 million years old (Rosen, 1989)--having formed as a result of movement on a system of regional faults. This movement resulted in the relative raising of the mountain ranges and lowering of the basin floor.

3.1.1.1 Alluvium

Sediments eroding from the bedrock are deposited on the flanks of the hills and mountains as alluvium. Over time, this alluvium has largely filled the valleys between the mountain ranges. Geophysical evidence indicates that its depth locally exceeds 3,500 ft below ground surface in the area between Bristol Dry Lake and Fenner Gap in the vicinity of the irrigation wellfield (Maas, 1994). Based on recent drilling, alluvial sediment depths in Fenner Gap are known to reach 860 ft in the center of the Gap. It is believed that most of the ground water in the Bristol, Cadiz, and Fenner watershed area is stored in these alluvial sediments. However, permeable bedrock lying beneath the alluvium may contain an appreciable amount of ground water within secondary porosity features.

Alluvial sediments are primarily composed of layers of gravel, sand, silt, and clay in varying proportions (Koehler, 1983; Freiwald, 1984). The grain size of the alluvium is generally coarse on the upper parts of the alluvial slopes with more fine-grained deposits down slope (Dibblee, 1980b; Koehler, 1983; Freiwald 1984). However, significant layers of coarse-grained material (including cobbles and boulders) have been noted in Fenner Gap and as far down slope as Bristol Dry Lake (Rosen, 1989). Most of the exposed alluvial sediments were deposited from 10,000 years ago to the present. However, deposits older than 10,000 years have been noted in some areas (Dibblee, 1980, Kenney, 2011).

3.1.1.2 Bedrock Units

Bedrock formations found in the Bristol, Cadiz, and Fenner watersheds can be grouped into two categories:

1) Archean to Jurrassic granitic and metamorphic rock of the mountain ranges and watershed margins; and
2) Tertiary volcanic and fanglomerate units.

Volcanic terrane in the foreground with the Ship Mountains in the background

The bedrock exposed in the mountain ranges surrounding these regional watersheds consists of Archaen (up to 1.4 billion years old; Silver et al., 1963) and in some areas Mesozoic (167 to 151 million years old) granitic and metamorphic rocks; Paleozoic (570 to 240 million years old) sedimentary rocks (sandstone, shale, limestone, and dolomite); and Tertiary (66 to 1.6 million years old) volcanic rocks. The most common rocks in the area are granitic and metamorphic rocks of Jurassic and Archaen age, which are found in almost all of the hills and mountains. Paleozoic sedimentary rocks are limited primarily to the southern Marble Mountains and northwest Ship Mountains.

Volcanic rocks are found primarily on the northeast side of the Marble Mountains, the north side of the Ship Mountains, and in the Clipper Mountains. Fanglomerate is exposed along the north portion of the Ship Mountains. Figure 2 shows the general distribution of geologic units in the project vicinity.

4 GEOHYDROLOGY OF THE FENNER GAP AREA

4.1 Geology

Overall, the geologic formations found in the Fenner Gap can be grouped into four broad categories:

1) The bedrock of the Marble and Ship mountains, which consist of Archaen (up to

1.4 billion years old; Silver et al., 1963) granitic rock, Paleozoic (570 to 240 million years old) formations consisting of Cambrian sediments (carbonate, shale, and quartzite), Permian and Pennsylvanian marine sedimentary and metasedimentary rocks, and Jurassic (205 to 138 million years old) granitic and metamorphic rocks;

2) Tertiary (66 to 1.6 million years)fanglomerates and volcanic;

3) Quaternary (1.6 million years to current time) alluvial deposits consisting of alluvial fan and wash deposits which were eroded from the surrounding mountains filling a basin between the Ship and Marble Mountains; and

4) More recent alluvial wash deposits located in Schulyler Wash and the ephemeral drainages in the gap and the flanks of the mountains.

For a complete description of the geologic units in the study area please refer to Kenney, 2011. The surface and subsurface distribution of geologic units in the project area is provided as Plates 2, 3, and 4, of the Kenney report.

4.1.1 Subsurface Geologic Conditions

The analysis of subsurface geologic condition was conducted from the recent geologic cross-sections prepared by Kenney (2011). The geologic cross-sections were constructed using information collected from:

1) Recent borings conducted by CH2M Hill (TW-1, TW-2, TW-2B, and TW-3, 2009/2010), and CH-1, CH-4, CH-5, and DT-1 conducted in 2010/2011;

2) GEOSCIENCE data collected during previous investigations (CI-1, CI-2, CI-3, and Monitoring Wells MW-1, MW-2, MW-3, MW-5, MW-6, and MW-7; GEOSCIENCE, 1995 and 1999);

3) Geologic cross-sections presented on Plate 3 and Plate 4 of the Kenney report (2011);

4) Field reconnaissance geologic mapping in the Marble and Ship Mountains conducted by GEOSCIENCE staff (2010); and

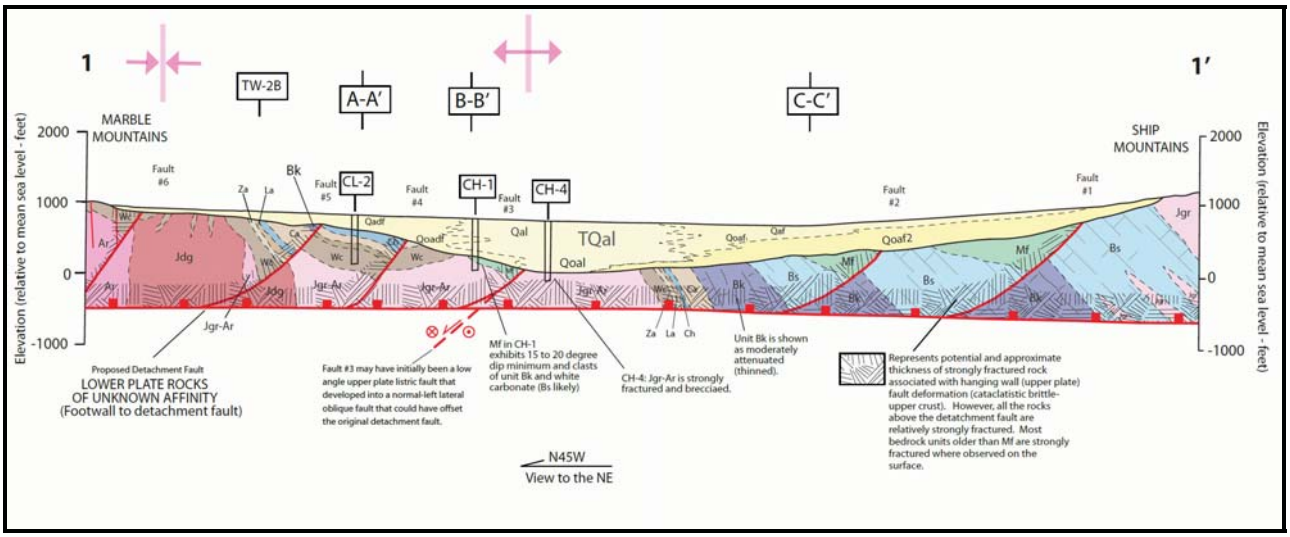
5) Inspection of recent aerial photographs available online from Google Earth (2010).

4.1.1.1 Quaternary Alluvium

Monitoring wells MW-1, MW-3, MW-5, and MW-6 were drilled in 1999 and are shown on Figure 1. The wells did not encounter bedrock to depths of 500, 550, 400, and 410 ft

below ground surface respectively, however, bedrock was penetrated in MW-7, also drilled in 1999 at a depth of 400 ft bgs. The cross-section below shows an example of the thickness of alluvium through the southern portion of Fenner Gap. Quaternary alluvium (yellow area of cross-section below) was penetrated in borings TW-1, TW-2, TW-2B, and TW-3 to depths of 457, 860, 810, and 960 ft below ground surface respectively. However, the depth of alluvium was interpreted by Kenney (2011) at a depth of 600 ft bgs in TW-3 underlain by fanglomerate. The alluvium consists of sand and gravel with silt and clay. Alluvium was interpreted to extend to depths of depth of 550, 700, 480, and 400 ft in CH-1, CH-4, CH-5, and DT-1 respectively (see cross-sections 1-1', 2-2', 3-3', and 4-4' of Kenney report, 2011).

The alluvium penetrated in borings consisted of permeable to highly permeable silty sand, poorly graded sand, well graded sand, gravel, and cobbles. Several 10-foot thick clay layers were logged below a depth of 710 ft in the boring for TW-2 and TW-2B.



Cross-section 1-1' from Kenney report
(See Plate 2 of that report for cross-section location)

The deepest portion of the alluvium in Fenner Gap ranges from 700 to 860 ft in thickness in the subsurface along the axis of the valley. The alluvial thickness decreases towards the mountain fronts and increases southwest towards Bristol Valley and northeast towards Fenner Valley.

4.1.1.2 Carbonates

Boring CI-2 drilled in 1999, penetrated a section of carbonates beneath alluvium and a sequence of Cambrian (Lower Paleozoic) Dolomite, Shale and Quartzite which may represent from youngest to oldest, the Cambrian Bonanza King Formation and underlying Cambrian Cadiz Formation, and Wood Canyon Formation.

The Cambrian Bonanza King Formation (lower Paleozoic) overlying the Cambrian Cadiz Formation was interpreted to be present in boring TW-1. The boring drilled to a depth of 1,002 ft was in carbonate rock from the base of alluvium encountered at 457 ft bgs to the total depth. Undifferentiated Paleozoic carbonate, shale, and quartzite underlying sandstone and conglomerate were penetrated by boring TW-3 at a depth of 1,630 ft bgs. The units were approximately 250 ft in thickness at this location and were highly fractured. Correlation of these Paleozoic units to Paleozoic units on the west side of Fenner Gap are shown on the geologic cross sections prepared by Kenney (2011).

Based on geologic mapping and cross-sections (Kenney, 2011), carbonate rocks are present in the subsurface on the eastern portion of Fenner Gap at the south end of the valley and primarily present in the subsurface on the west side of the valley near the middle of Fenner Gap (see cross-sections 1-1', 2-2', 3-3', and 4-4' of Kenney report, 2011).

4.1.1.3 Fanglomerate and Volcanic Rocks

The aerial and vertical distribution of Tertiary fanglomerate and volcanic rocks is shown on Plate 2 and the cross-sections presented in the Kenney report (2011). Based on current data, both units are insignificant with respect to ground water production within the study area.

4.1.1.4 Granitic Rocks

The aerial and vertical distribution of the Archaen and Jurassic granitic rocks is shown on Plate 2 and the cross-sections presented in the Kenney report (2011). The granitic rock is present in the subsurface on the western portion of Fenner Gap at the southern end of the Gap. Granitic rock both directly underlies alluvial units and Paleozoic shales, quartzite, limestone, and dolomites. Where penetrated in borings, the granitic rock was observed to range competent to highly fractured and jointed. Surface exposures of granitic rocks alone faults zones, showed the rock to be intensely fractured and sheared (see inset below).

Photograph showing fanglomerate (two left side core holders) and Jurassic granitic rock (two right side core holders)

4.1.2 Lithologic Findings in New Test Wells

4.1.2.1 Test Well TW-1

TW-1 penetrated carbonate rocks consisting of dolomite and limestone from a depth of 457 ft to the bottom of the boring at approximately 1,000 ft. The upper portion of the carbonate rocks contained numerous solutions cavities developed along what appear to be joint systems which yield large quantities of water. This section of the carbonate rocks extended to a depth of approximately 735 ft below ground surface. Below this depth, sandy limestone with a much less proportion of solution cavities was penetrated to the bottom of the boring. The dolomite and sandy limestone penetrated in TW-1 were identified by CH2M Hill (2009) as units of the Cambrian Bonanza King formation. The boring penetrated a sequence of dolomite, shale, and sandy limestone which is likely representative of the Cadiz Formation which lies stratigraphically below the Cambrian Bonanza King Formation. The log of the soil boring is provided in Appendix A.

4.1.2.2 Test Wells TW-2 and TW-2B

Test Wells TW-2 and TW-2B are located south of TW-1, but to the east in relation to the trend of the drainages in Fenner Gap. These borings penetrated granitic bedrock at depths of 860 ft and 810 ft respectively. Core collected from TW-2B was highly fractured and contained at least one rock face bearing slickensides. It is assumed that the granitic rocks represent intrusive Mesozoic granitic rock which has been subjected to faulting. The log of the soil boring is provided in Appendix B and C, respectively.

4.1.2.3 Test Well TW-3

Test Well TW-3 penetrated alluvium to 960 ft underlain by approximately 670 ft of conglomerate and sandstone (960 ft to 1,630 ft bgs) followed by a sequence of carbonate rock with shale interbeds (1,630 to 1,768) consisting of a 38-ft of limestone with shale interbeds followed by 50-foot thick shale unit, underlain by 32 ft of quartzite, and in turn underlain by 20-ft of carbonates resting upon granitic rock. This sequence of rock may be correlative with the portions of the Chambless Formation, Cadiz Formation, and Zabriesky/Wood Canyon Quartzite faulted into contact with Mesozoic granitic basement rock, however this designation is uncertain. The log of the soil boring is provided in Appendix D.

4.1.2.4 Test Bore Hole CH-1

CH-1 was drilled immediately west of Schulyler Wash. The upper approximately 200 ft of the boring penetrated well graded sand with gravel beds locally. The depth between approximately 200 ft and 260 ft contained an increase in silt content with well graded sand. Below a depth of approximately 300 ft, the sediments consisted of well graded sand and poorly graded sand. Decomposed fractured granite was encountered at 600 ft. The boring extended through fractured granite to a depth of 710 ft. The log of the boring is presented as Appendix E.

4.1.2.5 Monitoring Well TW2-MW

TW2-MW was drilled in Schulyler Wash, approximately 90 ft northwest of Well TW-2 and southeast of TW-2B. The boring for Monitoring Well TW2-MW encountered poorly graded and well graded sand to a depth of approximately 210 ft. A 30-foot thick silt layer was observed between depths of 210 to 240 ft. Silty sand and well graded sand beds were present from 240 ft to 270 ft. Gravelly well graded sand was present between 270 and 370 ft. Well graded sand with silt is present between 370 and 410 ft underlain by well graded sand and gravel from a depth of 410 ft to the total depth of the boring at 740 ft. The log of the boring is presented as Appendix F.

4.1.2.6 Test Bore Hole CH-4

CH-4 was drilled in axis of Schulyler Wash. The boring penetrated primarily poorly graded sand with gravel to a depth of approximately 720 ft. The log of the boring provided as Appendix G indicates that an increase and silt and clay content was observed in the sediments between depths of approximately 650 and 720 ft, underlain by poorly graded sand with silt to a depth of 750 ft. Decomposed, highly altered granitic rock with some reported slickensides was penetrated from 750 ft to the depth of the boring at 860 ft. The log of the boring is presented as Appendix G.

4.1.2.7 Test Well CH-5

CH-5 was drilled approximately 2,600 ft southeast of Schulyler Wash on an older alluvial fan surface. The boring encountered poorly graded and well graded sand with gravel in beds locally t a depth of 350 ft. Fanglomerate was reported to be present between a depth of 350 ft and 1,100 ft which in turn was underlain by decomposed granite to a depth of 1,150 ft. The log of the boring is presented as Appendix H.

4.1.2.8 Test Well DT-1

DT-1 was drilled approximately one-mile southeast of Schulyler Wash at the contact between two older alluvial fan units. The upper approximately 340 ft of the boring penetrated poorly graded and well graded sand with gravel in beds locally. The sediments penetrated were observed to show an increase in silt content at a depth of 340 ft to 410 ft. Mixed silty sand and sand layers were present between a depth of 520 and 570 ft. The boring log provided in Appendix I reports well graded sand to a depth of 925 ft underlain by Paleozoic quartzite to a depth of 925 ft and in turn underlain by decomposed granite to the total depth of the boring at 1,285 ft. Note that a cross-section (3-3') prepared by Kenny (2011) during this investigation interprets the depth of alluvium to be approximately 410 ft at this location, underlain by the fanglomerate unit, quartzite, and granitics. The log of the boring is presented as Appendix I.

4.1.3 Summary of Geology in the Fenner Gap Area

The geologic cross-sections depict an alluvial-filled basin formed by extensive faulting. The boring logs and the geologic cross-Sections prepared by Kenney indicate that the alluvium may reach a thickness of as much 860 ft in the center of Fenner Gap and is underlain locally by Tertiary fanglomerate and volcanics (western Ship Mountains), Paleozoic sediments, and Archaen and Jurassic granitic rock. The alluvium ranges in thickness from 700 to 860 ft in the subsurface along the axis of Fenner Gap (see logs of borings CH-4 and TW-2 located in the axis of the Valley). The alluvium increases in thickness to the northeast in the Fenner Valley and to the southwest into the Bristol Valley. The alluvium is underlain by a sequence of Paleozoic rock in the subsurface, on the Flanks of the southern Marble Mountains and western Ship Mountains. The Paleozoic sequence is missing in the center of Fenner Gap beneath the southern area of the Gap (due to faulting and erosion). The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. The extent of this unit (Bonanza King Formation) in the subsurface below Fenner Gap is shown on the cross-sections prepared by Kenney (2011). Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may also yield water through localized solution cavities or joints and through fracture zones developed along the faults.

4.2 Hydrology

The Eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot with a relatively large range in daily temperature. Temperature and precipitation vary greatly with altitude. Lower temperatures and higher precipitation amounts occur in the higher elevations.

4.2.1 Precipitation

Most of the precipitation in the Eastern Mojave Desert accumulates during the winter months from November through March. Early summer and late fall are typically periods of little rainfall. The amount of precipitation in the Bristol, Cadiz, and Fenner basins vary with differences in altitude. Average annual precipitation ranges from approximately 3 inches on the Cadiz and Bristol dry lakes (elevations of 545 to 595 ft amsl) to over 12 inches in the Providence and New York mountains (elevations over 7,000 ft amsl). However, most of the study area receives, on the average, 4 to 6 inches of rain annually.

4.2.2 Ground Water Occurrence and Movement

In the Fenner Gap area, the principal geologic deposits that store and transmit ground water (i.e., aquifers) can be divided into two main aquifer units (alluvial and carbonate). Within these two main units four subunits exist:

1) An upper alluvial aquifer,
2) A lower alluvial aquifer,
3) Tertiary fanglomerates, and
4) A bedrock aquifer consisting primarily of Paleozoic Limestone and to a much lesser extent, fractured and faulted granite.

In general, the alluvial units and the Paleozoic Limestone are in hydraulic continuity with each other and the separation is primarily due to stratigraphic differences or the extent of interconnecting secondary porosity with the limestone. Movement of ground water in the Fenner Gap is from northeast to the southwest at a gradient of approximately 10 ft/mi.

4.2.3 Alluvial Aquifer System

The alluvial aquifer system consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967). The thickness of this aquifer in Fenner Gap is interpreted to vary from approximately 200 ft towards the flanks of Fenner Gap to as much as to 800 ft as depicted in the cross-sections prepared by Kenney (2011). The alluvial material penetrated by recent

borings (2009 through 2011) consisted of very permeable gravel and sand with some silt and clay in lenses. Three clay layers between 10 and 20 ft thick were penetrated below a depth of 710 ft to the depth of bedrock at 860 ft in boring TW-2. While only one 10-foot clay lens was encountered in TW-2B. No clay material was reported in the logs of the other borings described above.

4.2.4 Carbonate Aquifer System

Based on findings during previous and recent drilling work in the Fenner Gap area, carbonate bedrock of Paleozoic age, located beneath the lower alluvial aquifer, contains ground water and is considered a second main aquifer unit. Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities that have developed in the rocks over time) (GEOSCIENCE, 1999). Recent tests performed by CH2M Hill (to be discussed in a subsequent section in this report), show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive. It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly-transmissive secondary porosity features.

4.2.5 Granitic and Fracture Zone Aquifer System

Granitic and metamorphic basement rock forms the subsurface margins of the aquifer system within the project area (Freiwald, 1984). This basement rock is generally impermeable but can have significantly increased permeability along well developed fracture zones which are associated with the numerous faults that cross Fenner Gap. Surface exposures and boring data suggest that highly fractured granitic rock is present under large areas of the Fenner Gap, and especially along the numerous fault zones that exist in the project area. Fracture zones in the hanging wall of the fault zones and along the detachment fault range in thickness from 150 to 400 ft and occupy a significant portion of the cross-sectional area in the Fenner Gap as depicted on the recent cross-sections presented in Kenney (2011) report.

4.3 New Exploratory Drilling and Well Construction

Four exploratory borings were drilled at the project site between October 2009 and February 2010. Five additional exploratory borings were drilled between October 2010 and February 2011.

The following borings were completed as test wells:

1) TW-1, drilled to a total depth of 1,002 ft (completed October 2009).

2) TW-2, drilled to a total depth of 1,380 ft (completed December 2009).

The following borings were completed as monitoring wells:

3) TW-3 drilled to a total depth of 1,942 ft (completed February 2010).
4) TW-2-MW, drilled to a total depth of 740 ft (completed October 2010).
5) CH-5 drilled to a total depth of 1,191 ft (completed November 2010).
6) DT-1 drilled to a total depth of 1,500 ft (completed February 2011).

The following borings were abandoned by backfilling with bentonite grout to ground surface:

7) TW-2B, drilled to a total depth of 1,007 ft (completed January 2010).
8) CH-1, drilled to a total depth of 711 ft (completed October 2010).
9) CH-4, drilled to a total depth of 860 ft (completed October 2010).

Additionally, Well TW-2 was redrilled in May 2011 to a total depth of 1,160 ft.

The borings provided information on depth to the base of the alluvial sequence and information on the subsurface distribution of Paleozoic meta-sedimentary rock, Jurassic granitic rock and faulting.

4.3.1 TW-1

TW-1 was initially drilled using the mud rotary method to a depth of 467 ft below ground surface (bgs). Geophysical logging was conducted which consisted of dual-induction, natural gamma, and caliper logs. A well was constructed by installing 10-inch well casing in the boring to a depth of 455 ft within the alluvium. The well was constructed with 10-inch-ID, mild steel and screen supplied by Roscoe Moss. FullFlo louvered well screen with a 0.060-inch slot size was used; the as-built screen interval is 355 to 440 ft bgs. Tacna 8x20 gradation filter pack was emplaced to a depth of 335 ft bgs, and a cement-grout seal was installed to ground surface. Blank casing was installed below the well screen to a depth of 455 ft bgs without a base plate.

After installation of the well casing, the borehole was advanced past the base of the well casing to a total depth of 1,002 ft bgs. The dual-tube reverse air rotary drilling method, using a 9.5-inch-diameter bit was used to advance the boring to total depth. Geophysical logs were prepared for the completed borehole; the logging suite included long and short normal resistivity, spontaneous potential, lateral resistivity, natural gamma, sonic, and caliper logs. The boring penetrated carbonate rock, underlying alluvium from a depth of approximately 457 ft to the total depth of the boring. A video log was made to confirm well construction details and to observe the condition of the carbonate rock at depth. The as-built diagram for the TW-1 is provided as Figure 3.

Figure 4 provides information on the packer testing assembly used to isolate the deeper carbonate aquifer from the shallow alluvial system. [See Appendix A for details of the soil boring log.]

4.3.2 TW-2

Well TW-2 was drilled and completed as a cased well within the alluvium in December 2009. Afterward, the borehole was advanced below the cased well further into alluvium and crystalline bedrock. The pilot borehole in alluvium at TW-2 was initially advanced to a total depth of 352 ft bgs using reverse rotary drilling techniques. Geophysical borehole logs consisting of dual induction, natural gamma, and caliper logs were run. Installation of a 24-inch-ID mild steel surface casing was installed to a depth of 340 ft bgs to control water loss while drilling through the vadose zone. After installing the 24-inch casing, the pilot borehole was continued to a total depth of 799 ft bgs, where loss of fluid circulation occurred. The pilot borehole was reamed and conditioned for geophysical logging. The suite of geophysical logs included long and short normal resistivity, spontaneous potential, lateral resistivity, natural gamma, sonic, and caliper logs.

The well was constructed with 10-inch-ID mild steel and screen supplied by Roscoe Moss. FullFlo louvered well screen with a 0.060-inch slot size was used; the as-built screen interval was 340 to 779 ft bgs. Blank casing was installed below the well screen to a depth of 799 ft bgs without a base plate. The borehole annulus and bottom of the well were backfilled with cement grout to a depth of 785 ft bgs to form a seal between the alluvium and underlying rocks. Afterward, Tacna 8x20 gradation filter pack was emplaced to ground surface (inside the intermediate surface casing).

Subsequent to testing of the alluvial well, the cement plug at the base of TW-2 was drilled out and an exploratory borehole was advanced into the underlying rocks. The borehole was advanced to a total depth of 1,380 ft bgs by dual-tube reverse air rotary drilling. However, before geophysical logging, the completed borehole collapsed to a depth of approximately 870 ft bgs. TW-2 was video logged to confirm the as-built well condition and to assess the condition of the upper portion of the borehole below the well screen. The as-built diagram for TW-2 is provided as Figure 3. Reportedly the borehole penetrated alluvium to a depth of 860 ft underlain by Mesozoic granitic rock. [See Appendix B for details of the soil boring log.]

Well TW-2 was redrilled from 870 to 1,160 ft bgs in May of 2011. The well was cased using 8-inch-ID mild steel cased to a total depth of 1,004 ft bgs directly against bedrock with an annular filter pack. The blank casing was perforated in four vertical rows using a mills knife from 869 to 992 ft bgs.

4.3.3 TW-3

Well TW-3 is located approximately 6,200 ft east of TW-2, and was drilled to explore the deep lithologic conditions in the eastern side of Fenner Gap. Drilling for TW-3 was similar to TW-2B with a conductor casing set to 85 ft using 6-inch-diameter STRATEX® casing to stabilize the upper portion of the borehole. The borehole was advanced to a depth of 960 ft bgs by dual-tube reverse air rotary drilling. A 4.5-inch-diameter casing was then installed in the exploratory boring to the total depth of 960 ft. HQ core was advanced through the casing to a depth of 1,230 ft bgs, at which point the borehole was telescoped and NQ core was advanced to a total depth of 1,942 ft bgs.

Reportedly, conglomerate was encountered from a depth of 960 ft to a depth of 1,630 ft bgs. Shale, limestone, and quartzite which were highly fractured were encountered between 1,630 and 1,880 ft bgs and presumably represent Cambrian sequences. Granitic basement was encountered from 1,880 ft bgs to total depth. Geophysical and video logs were run separately in the core hole after retracting the 4.25-inch casing to a depth of 538 ft bgs.

When drilling was completed, packer testing was conducted at two depths in the HQ hole to estimate the hydraulic conductivity of the conglomerates encountered at this location. TW-3 was subsequently completed as a 2-inch-diameter Schedule 80 polyvinyl chloride (PVC) monitoring well with a well screen positioned from 502 to 522 ft bgs. The borehole annulus and open borehole below 472 ft bgs was backfilled with Tacna 8x20 gradation filter pack. A bentonite grout seal was installed from the top of the filter pack to ground surface. Figure 5 provides the as-built diagram of Well TW-3. Figure 6 shows the packer assembly used for the slug testing. [See Appendix C for details of the soil boring log].

4.3.4 TW2-MW

Well TW2-MW is located approximately 90 ft northwest of TW-2, and was drilled to monitor the drawdown effects from pumping TW-2. Drilling consisted of 5.25-inch-diameter dual-tube reverse air rotary drilling to a total depth of 740 ft bgs. TW2-MW was completed as a 1.5-inch-diameter Schedule 80 polyvinyl chloride (PVC) monitoring well with a well screen positioned from 600 to 700 ft bgs. A bentonite grout seal was installed from the top of the filter pack to ground surface. Figure 6 provides the as-built diagram. Details for the monitoring well are shown on Figure 5. [See Appendix D for details of the soil boring log].

4.3.5 CH-5

Test corehole CH-5 is an exploratory boring which was ultimately completed as a monitoring well, located approximately 3,575 ft southeast of TW-2. Drilling for CH-5 was similar to TW-3 with a conductor casing set to 55 ft using 6-inch-diameter STRATEX® casing to stabilize the upper portion of the borehole. The borehole was advanced to a depth of 349 ft bgs by dual-tube reverse air rotary drilling. A 5.25-inch-diameter casing was then installed in the exploratory boring to the total depth of 349 ft. HQ core was advanced through the casing to a depth of 1,191 ft bgs.

CH-5 was subsequently completed as a 1.5-inch-diameter Schedule 80 polyvinyl chloride (PVC) monitoring well with a well screen positioned from 338 to 438 ft bgs. A bentonite grout seal was installed from the top of the filter pack to ground surface. Figure 5 provides the as-built diagram. [See Appendix D for details of the soil boring log].

4.3.6 DT-1

DT-1 is an exploratory boring which was ultimately completed as a monitoring well, located approximately 1,840ft southeast of TW-3. A 24-inch mild steel conductor casing was installed within a 30-in borehole to 38 ft bgs. A 20-inch diameter borehole was advanced to a depth of 935 ft bgs by dual-tube reverse air rotary drilling. The borehole was further advanced within a 12 inch diameter borehole to 1,285 ft bgs, and 6.5 inch-diameter borehole to a total depth of 1,500 ft bgs.

DT-1 was completed as a 2-inch-diameter Schedule 80 polyvinyl chloride (PVC) monitoring well with a well screen positioned from 935 to 980 ft bgs. From the top of the filter pack to a depth of 55 ft bgs, the area between the 12-incg steel casing and PVC well casing was filled with crushed rock. A bentonite grout seal was installed from the top of the crushed rock to ground surface. Figure 5 provides the as-built diagram. [See Appendix F for details of the soil boring log].

4.3.7 TW-2B

Well TW-2B is an exploratory boring located approximately 380 ft northwest of TW-2. It was drilled to confirm the deep lithologic conditions in this area after caving conditions in TW-2 precluded evaluation of the underlying bedrock. Exploration was conducted using a 6-inch-diameter STRATEX® casing advanced to a depth of 85 ft bgs to stabilize the upper portion of the borehole. Drilling continued through the casing using a small diameter drill bit (5.25-inch) a total depth of 798 ft bgs using dual-tube reverse air rotary drilling. Small diameter casing (4.25-inch) was subsequently set in the small diameter drill hole to the total depth. Drilling continued through the casing with HQ core equipment. Coring continued to a total depth of 1,007 ft bgs. After drilling was complete, the borehole was abandoned by backfilling with bentonite grout to ground

surface. Details for the exploratory boring are shown on Figure 7. [Also see Appendix G for details of the soil boring log].

4.3.8 CH-1

Test corehole CH-1 is an exploratory boring located approximately 380 ft southwest of MW-5. Exploration was conducted using a 6-inch-diameter STRATEX® casing advanced to a depth of 175 ft bgs to stabilize the upper portion of the borehole. Drilling continued through the casing using a small diameter drill bit (5.25-inch) a depth of 398 ft bgs using dual-tube reverse air rotary drilling. Drilling continued through the casing with HQ core equipment. Coring continued to a total depth of 711 ft bgs. After drilling was complete, the corehole was abandoned by backfilling with bentonite grout to ground surface. Details for the exploratory boring are shown on Figure 7. [Also see Appendix H for details of the soil boring log].

4.3.9 CH-4

Test corehole CH-4 is an exploratory boring located approximately 950 ft northeast of MW-3. Exploration was conducted using a 6-inch-diameter STRATEX® casing advanced to a depth of 50 ft bgs to stabilize the upper portion of the borehole. Drilling continued through the casing using a small diameter drill bit (5.25-inch) a depth of 348 ft bgs using dual-tube reverse air rotary drilling. Drilling continued through the casing with HQ core equipment. Coring continued to a total depth of 860 ft bgs. After drilling was complete, the corehole was abandoned by backfilling with bentonite grout to ground surface. Details for the exploratory boring are shown on Figure 7. [Also see Appendix I for details of the soil boring log].

4.4 Analysis of Pumping Test Data

Well and aquifer tests were performed on the exploratory/test wells constructed between October, 2009 and May, 2011. Well construction details for monitoring wells MW-6 and MW7/7a used as observation wells for pump testing are shown on Figures 8 and 9. Pumping tests performed on these wells included step-drawdown tests, step-rate injection tests, constant rate interference tests, isolated packer tests and slug tests. Time drawdown and recovery analyses were performed; and aquifer parameters obtained from the two principal aquifer systems (i.e., alluvium and carbonates) based on the TW-1 and TW-2 pumping test results. Additionally, an isolated packer test was conducted in TW-2 to isolate the fractured bedrock. A summary of these tests are reported in the following sections and are tabulated in Table 1. Graphical analysis of the pumping tests can be seen in Figures 10 through 32. Transmissivities, storativities, and leakance (where applicable) were calculated from the pumping test data. Estimates of hydraulic conductivity were calculated from transmissivities assuming a

saturated thickness based on the completed interval of the well in the particular aquifer being tested (see Table 1).

4.4.1 Pumping Tests of TW-1

4.4.1.1 TW-1 Step Drawdown Test – Alluvial Aquifer

The alluvial aquifer portion of Well TW-1 was isolated from the deeper carbonate system through an inflatable packer (see Figure 5). A step drawdown test performed on the alluvial portion of this well is shown in Figures 10, 11 and 12. Discharge rates for the four step tests ranged from 181 gpm to 383 gpm. Formation and Well Loss Coefficients were 0.0062 ft/gpm and 0.00074 ft/gpm^2 respectively. The specific capacity diagram (Figure 12) shows that the alluvial portion of Well TW-1 is very inefficient. This may be in part to the fact that during construction of the deeper carbonate borehole, drilling debris may have impacted the shallow alluvial screened section resulting in lower permeability and inefficiency measured.

4.4.1.2 TW-1 Constant Rate Test – Alluvial Aquifer

Figures 13 and 14 show results from a 24-hr constant rate test performed on Well TW-1 alluvium. Transmissivity was low in the pumping well possibly reflecting a clogged screen section (see above section). Figure 14 also shows effects of leakage between the underlying carbonate aquifer as measured in alluvial monitoring Well MW-7a (see Figure 9 for the technical cross section of the monitoring well). Transmissivity for the upper alluvial aquifer at this location was calculated as 23,500 gpd/ft with a storativity of 0.008-- reflecting semi-confined conditions.

4.4.1.3 TW-1 Step Drawdown Test – Carbonate Aquifer

Figure 15 shows the step-drawdown test for the carbonate aquifer. The discharge rates ranged from 291 gpm to 1,168 gpm. The rise in ground water levels during pumping were due to the very low drawdown in the well (negligible) and the result of thermal expansion of water in the sounding tubes (see explanation on Figures 16 and 17). As such, the step drawdown data from the carbonate aquifer testing on TW-1 could not be analyzed for well and formation loss coefficients.

4.4.1.4 TW-1 Constant Rate Test – Carbonate Aquifer

Figures 16 and 17 show analyses during the three-day constant rate pumping test on the Well TW-1 carbonate aquifer system. Figure 16 is a calculation of the thermal expansion

observed during pumping of the carbonate section in Well TW-1. Ground water temperatures near the pump were measured as approximately 100 degrees F while ambient temperatures were measured at Needles during the November 9-12, 2009 pumping test period as averaging 69 degrees F. During pumping, the hot water flowing in the pump column "warms" the annular space, including the sounding tubes, resulting in the thermal expansion rise in water levels during pumping. Ground water elevations rose over 5 inches during pumping (due to thermal expansion of the water) and dropped during recovery due to thermal contraction of the water. As can be seen in Figure 17, this approximate 5 inch rise calculated from the thermal expansion equation (Figure 16) was actually observed during pumping. Kawecki, (1995) also reports this phenomenon.

Figures 18, 19 and 20 show results from the three day constant rate interference test on the carbonate aquifer system. TW-1 was pumping at a discharge rate of 1,168 gpm and interference was measured at monitoring well MW-7 which is 83 ft from the pumping well. MW-7 was completed in the carbonate aquifer as part of the 1999 MWD recharge evaluation program (see Figure 9). Results show a very high tranmissivity of 3,083,500 gpd/ft with a storativity of 0.012 which is reflective of the carbonate aquifer system (Sharp, 2010). Figure 19 is the calculated recovery analysis and Figure 20 shows the evaluation of boundaries. Based on the method of Strausberg (1967), boundaries occur at approximately 1,000 ft and 4,000 ft from the pumping well TW-1.

4.4.2 Pumping Test of TW-2

4.4.2.1 TW-2 Step Drawdown Test

Figures 21, 22 and 23 show the step drawdown test performed on the alluvial aquifer system in the vicinity of new Well TW-2. Discharge rates ranged from 420 gpm to 1,130 gpm. Formation and Well Loss Coefficients were measured as 0.0057 gpm/ft and 3.48×10^{-7} ft/gpm^2 respectively (Figure 22). The specific capacity diagram (Figure 23) shows that if the well were designed at a discharge rate of 1,100 gpm the drawdown in the pumping well would be 6.7 ft with a well efficiency of 94% and a specific capacity of 165 gpm/ft--reflecting very permeable materials.

4.4.2.2 TW-2 Constant Rate Test

Figures 24 through 29 show results of the three day constant rate pumping test performed on Well TW-2. The discharge rate was 1,116 gpm. Transmissivity from the interference analysis with monitoring Well TW-6 can be seen in Figures 27, 28 and 29. Well MW-6 was constructed during the original MWD testing and is 815 ft from Well TW-2.

The effects of leakage are shown in the interference analysis of data from monitoring well MW-6 located 815 ft from pumping well TW-2 (see Figure 27). Transmissivities

were very high being approximately 2 million gpd/ft from the time drawdown and recovery analysis. Storativities of 0.002 reflect a leaky aquifer system as does the leakance coefficient (K'/b') of 0.022 / days. Boundary effects were noticed on the time drawdown and recovery measurements and were estimated to range between approximately 3,000 ft and 9,000 ft from the Pumping well. Two methods were used to analyze the boundaries. Strausberg (1997) was used for the analysis on Figure 29; and Roscoe Moss (1990) was used to analyze the distance to the boundary observed on Figure 27.

More recently in October of 2010, a monitoring well was installed approximately 90 ft to the south east of TW-2 to determine interference effects of pumping at TW-2. Figure 30 shows the interference analysis if data from monitoring well TW2-MW. An early and late analysis were performed using the Jacobs straight line method to show transmissivity to be 311,000 gpd/ft for the early portion of the curve and approximately 2.5 million gpd/ft for the later part of the curve.

Additionally, in June of 2011 an inflatable packer was installed within TW-2 to isolate the fractured bedrock below a depth of approximately 870 ft, and a 24-hour constant rate test was performed. The discharge rate was 207 gpm. Transmissivity was approximately 5,900 gpd/ft as shown on Figure 31 and Table 1. However, based on construction of the well it is likely that much of the recharge to the well during the pumping test was coming from the fractured area os caving in the open hole below the casing.

4.4.3 Pumping Test of PW-1

4.4.3.1 PW-1 Constant Rate Test

In January of 1999 a 24-hour constant rate test was performed on PW-1. The discharge rate was 1,998 gpm. Transmissivity from the interference analysis with observation well CI-3 can be seen in Figure 32. Well CI-3 and PW-1 were constructed during the original MWD testing and is 85 ft from Well PW-1.

Transmissivities were high being approximately 620,000 gpd/ft from the time drawdown and recovery analysis. Storativities of 0.00054 reflect a semi confined to confined aquifer system.

4.4.4 Summary of Aquifer Parameters

Table 1 is a summary of aquifer parameters derived from the historical and recent pumping tests in the Fenner Gap area. Various methods were used in the analysis and are stated in the Table. Hydraulic Conductivity for the alluvial aquifer system range

from 37 – 158 ft/day but may be high as 848 ft/day. Storativities average approximately 0.002 reflecting semi-confined conditions.

- Aquifer parameters derived from the recent pumping tests in the Fenner Gap area for the alluvial and carbonate units show very transmissive properties in the vicinity of the new test Wells TW-1 and TW-2. Hydraulic Conductivities for the alluvial aquifer system in the vicinity of pumping Well TW-2, range from 37 ft/day (MW-7) to 106 ft/day (see Table 1). As described in section 4.4.1.1, the low transmissivity and thus the hydraulic conductivity calculated from MW-7 testing is likely not reflective of the alluvial aquifer in this area. In addition, an alternative interpretation of pumping and recovery plots for TW-2 (see Figures 27, 28, and 29) and TW2-MW (see Figure 30) suggest much higher alluvial hydraulic conductivities ranging from 598 through 848 ft/day (see Table 1). The pumping test plot suggests that a recharge boundary may be encountered in the later portion of the test (See Figure 30) for the TW2-MW plot. Storativities average approximately 0.002 reflecting semi-confined conditions. Hydraulic conductivity of the alluvial aquifer system in the vicinity of pumping well PW-1 was 158 ft/day.

- Hydraulic Conductivities for the carbonate aquifer in the vicinity of Well TW-1 were calculated to be 602 ft/day and 1,023 ft/day. Storativities are representative of semi-confined (i.e., leaky) aquifer systems. The alluvial aquifer in the vicinity of TW-1 exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate aquifer. The alluvial aquifer in the vicinity of TW-2 also shows leakage effects. Hydrologic boundaries were exhibited on the pumping test data reflecting the heterogeneous nature of the alluvial and carbonate aquifer system in the area.

- A pumping test was conducted in the granitic bedrock portion of TW-2. The pumping test plot is provided on Figure 31. Hydraulic conductivity was calculated (see Table 1) using a saturated thickness to include the full length of well screen and 40-ft of open borehole below the pump. The hydraulic conductivity was calculated to be approximately 5 ft/day. However, based on the construction of the well it is likely that the major source of inflow to the well was from the lower 40-foot open borehole at the bottom of the well, Using the lower open borehole section only for well recharge, yields a hydraulic conductivity value of approximately 20 ft/day. Table 2 provides a range of published values for fractured granitic and metamorphic rock. Based on this research, hydraulic conductivity values in fractured rock may range from an average low of 0.1 ft/day to an average high of 40 ft/day.

5 UNDERFLOW THROUGH THE FENNER GAP

5.1 Historical Estimates

Ground water recharge to the aquifers in the Cadiz irrigation wellfield is primarily from infiltration of precipitation and runoff in the higher elevations of the Fenner Watershed. A smaller contribution of recharge comes from Orange Blossom Wash. Historical estimates of average annual recharge in the Fenner Watershed have included ranges from 2,070 to 10,343 acre-ft/yr (United States Geological Survey, 2000; unpublished report) and 15,000 to 37,000 acre-ft/yr (GEOSCIENCE, 1999). Lawrence Livermore National Laboratory has estimated average annual recharge to the Fenner Watershed (based on site-specific measurements of elevation versus precipitation and conservative parameters) within a range of 7,864 to 29,185 acre-ft/yr (Davisson & Rose, 2000).

5.2 Sensitivity of Recent Aquifer Parameters in Relation to Underflow through the Fenner Gap

In the Bristol and Cadiz watersheds, ground water flows toward the Bristol and Cadiz dry lakes from Fenner Gap and the surrounding hills and mountains (see Figures 2a and 2b). In Orange Blossom Wash, located between the Marble and Bristol mountains, ground water flows southeasterly from the Granite Mountains through the wash, before it veers southwestward into Bristol Dry Lake. In the Fenner watershed, ground water generally flows southward from the New York and Providence mountains into the main part of Fenner Valley, and then southwesterly through Fenner Gap. Some of the ground water flowing through Fenner Gap migrates toward Bristol Dry Lake and some of the ground water flows toward Cadiz Dry Lake. Based on recent ground water elevation measurements, the hydraulic gradient in the vicinity of the Fenner Gap is approximately 10 ft/mi.

The underflow through the Fenner Gap may be estimated using a Darcian calculation, namely:

$$Q = 365 \times A \times V / (43{,}560 \times 5{,}280)$$

Where:

Q = Underflow through the Fenner Gap (acre-ft/yr)
A = Cross Sectional Area of Ground Water Flow through Aquifers in the Gap (ft^2)
V = Darcian Velocity = K x dh/dx, (ft/day)
K = Hydraulic Conductivity, (ft/day)
dh/dx = Hydraulic Gradient, (ft/mi)

Underflow through the Fenner Gap occurs both in the alluvial and carbonate aquifer systems as well as to a lesser extent through fractured granite and fault zones. Based on previous and current exploratory testing, saturated portions of the Bonanza King

Formation may also occur in other sections of the Fenner Gap in addition to the area near Well TW-1. The ranges of hydraulic conductivity based on aquifer test data range between 37 – 158 ft/day for the alluvial aquifer system and possibly as great as 848 ft/day, approximately 602 and 1,023 ft/day for the Bonanza King member of the carbonate aquifer, and 5ft/day to greater than 40 ft/day through fractured granite and fault zones.

6 FINDINGS

- Based on drilling data, geologic mapping, and recent geologic cross-sections the alluvium beneath the center of Fenner Gap ranges in thickness between 700 and 800 ft.

- The alluvium consists primarily of gravel and sand with some silt and clay lenses.

- Alluvial thickness increases from Fenner Gap southwest towards Bristol Lake and northwest towards the Fenner Valley.

- In Fenner Gap, the alluvium is underlain by a sequence of Paleozoic rock which is represented on the Flanks of the southern Marble Mountains and western Ship Mountains.

- The Paleozoic sequence is faulted, tilted and folded beneath Fenner Gap.

- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. However the full extent of this unit (Bonanza King Formation) in the subsurface below Fenner Gap is uncertain. This carbonate aquifer represents a second significant aquifer in Fenner Gap.

- Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may potentially yield a significant volume of water through localized solution cavities and/or joints and fractures.

- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. This carbonate aquifer represents a second significant aquifer in Fenner Gap.

- The distribution of Bonanza King Formation in the subsurface across Fenner Gap is shown on recently constructed cross-sections. A significant amount of subsurface underflow is anticipated based on the currently know extent of the formation in the subsurface and the results of aquifer testing.

- Two primary aquifer systems exist in the Fenner Gap area. They are:

1) an alluvial aquifer system; and
2) a carbonate aquifer system.

- A third aquifer system, but to a much lesser extent than the alluvial or carbonate aquifers is fractured and faulted granitic rock. Due to the extensive faulitn in Fenner Gap and the large cross-section area of granitic rock beneath Fenner Gap, even with lower hydraulic conductivity values, the fractured rock aquifer can likely may a significant contribution to ground water flow beneath fenner Gap.

- Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities that have developed in the rocks over time.

- Recent tests show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive.

- It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly transmissive secondary porosity features.

- Aquifer parameters derived from the recent pumping tests in the Fenner Gap area for the alluvial and carbonate units show very transmissive properties in the vicinity of the new test Wells TW-1 and TW-2.

- Hydraulic Conductivities for the alluvial aquifer system in the vicinity of pumping Well TW-2 range from 37 to 150 ft/day but may be as high as 848 ft/day.

- Storativities for the alluvial aquifer in the vicinity of TW-2 average approximately 0.002 reflecting semi-confined conditions.

- Hydraulic Conductivities for the carbonate aquifer in the vicinity of Well TW-1 were calculated to be 602 and 1,023 ft/day.

- Carbonate aquifer Storativities are representative of semi-confined (i.e., leaky) aquifer systems.

- The alluvial aquifer in the vicinity of TW-1 exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate aquifer.

- Hydraulic conductivity values from TW-2 well test for the fractured rock portion range from 5 to 20 ft/day. Published values for fractured rock range from a average low of 0.1 ft/day to an average high of 40/ft/day.

- The alluvial aquifer in the vicinity of TW-2 shows leakage effects.

- Hydrologic boundaries in the alluvial and carbonate aquifer pumping tests reflect the heterogeneous nature of the alluvial and carbonate aquifer system in the area.

- Underflow through the Fenner Gap occurs both in the alluvial, carbonate, and fractured granitic rock aquifer systems.

- Both transmissivities and hydraulic gradients vary in aquifers across the Fenner Gap depending upon the various aquifer systems (alluvium and carbonate) through which flow occurs. As such, the underflow is dependent upon the saturated thickness, the hydraulic conductivity and the hydraulic gradient.

- The ranges of hydraulic conductivity based on aquifer test data range between 37 – 158 ft/day (possibly as high as 848 ft/day) for the alluvial aquifer system, and between 602 and 1,023 ft/day for the Bonanza King member of the carbonate aquifer.

7 REFERENCES

CH2M Hill, 2010. Draft Exploratory Drilling and Well Completion Report for TW-1, TW-2, TW-2B, and TW-3 in the Fenner Gap Area, March 2010.

CH2M Hill, 2010. Draft Cadiz Water Conservation Project Report, April 2010.

CH2M Hill, 2010. Cadiz Groundwater Conservation and Storage Project, June 2010.

Davidson, C.C., et al. 1993. Hydrogeological Characteristics of Major Fracture Zones in a Granite Batholith of the Canadian Shield. National Ground Water Association Online Publication.

Davisson, M.L.; Rose, T.P. 2000c. Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California: Lawrence Livermore National Laboratory UCRL-ID-139027.

Dibblee, T.W., Jr. 1980a. Pre-Cenozoic Rock Units of the Mojave Desert: in D.L. Fife and A.R. Brown (eds.) Geology and Mineral Wealth of the California Desert. South Coast Geological Society, Santa Ana, CA.

Dibblee, T.W. 1980b. Cenozoic Rock Units of the Mojave Desert: in D.L. Fife and A.R. Brown (eds.) Geology and Mineral Wealth of the California Desert. South Coast Geological Society, Santa Ana, CA.

Driscoll, F. G. 1986. Groundwater and Wells. Johnson Division, St Paul, MN.

Freiwald, D.A. 1984. Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California: US Geological Survey Water Resources Investigation

Report 83-4082.

GEOSCIENCE Support Services, Inc. 1991. Review and Comments on the Cadiz Valley Hydrology Report: Pacific Agricultural Holding, Inc. (Cadiz Inc.) June 23.

GEOSCIENCE Support Services, Inc. 1995. Cadiz Well 33 Results of Well Rehabilitation and Pumping Test: Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) February 20.

GEOSCIENCE Support Services, Inc. 1995. Cadiz Well 21N Results of Drilling, Testing and Recommended Pump Design: Cadiz Land Company, Inc. (Cadiz Inc.) February 20.

GEOSCIENCE Support Services, Inc. 1995. Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins: Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) and Mojave Water District. September 6.

GEOSCIENCE, 1995. Lithologic Report for Well 6N/15E-33. Prepared for Cadiz Land Company , Inc., November 22, 1995.

GEOSCIENCE, 1995. Lithologic Report for Well 6N/15E-01 HO1. Prepared for Cadiz Land Company, Inc., November 22, 1995.

GEOSCIENCE, 1995. Lithologic Report for Well 6N/15E-29Q01. Prepared for Cadiz Land Company, Inc., November 22, 1995.

GEOSCIENCE. 1997. Baseline Monitoring Report (First Annual Monitoring Report) November 1993 – December 1996, Cadiz Valley Agricultural Development: Prepared for Cadiz Land Company Inc. (Cadiz Inc.) May 1.

GEOSCIENCE Support Services, Inc. 1997. Ground Water Monitoring Plan, Cadiz Valley Agricultural Development: Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) July 24.

GEOSCIENCE, 1998. Technical Specifications for Fenner Gap Production Well- Pilot Spreading Basin Study - Phase I. Prepared for Cadiz, September 3, 1998.

GEOSCIENCE Support Services, Inc. 1999. Second Annual Monitoring Report, January 1997-December 1998, Cadiz Valley Agricultural Development: Prepared for Cadiz Inc. January 31.

GEOSCIENCE, 2000. Cadiz Ground water Storage and Dry-Year Supply Program Ground water Monitoring and Management Plan. Prepared for Metropolitan Water District of Southern California/Cadiz, Inc., March 2, 2000.

GEOSCIENCE, 2000. DRAFT Ground water Monitoring and Management Plan Cadiz Ground water Storage and Dry-Year Supply Program. Prepared for Metropolitan Water District of Southern California / Cadiz, Inc., May 15, 2000.

GEOSCIENCE, 2003. Five-Year Monitoring Report January 1998-December 2002 Cadiz Valley Agricultural Development. Prepared for Cadiz, Inc., January 27, 2003.

GEOSCIENCE Support Services, Inc. 2009. Draft Detailed Technical Specifications for Drilling, Construction, Development, and Testing of Carbonate Test Well, Cadiz, California, Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) September 21.

Hamm, S., et al.2007. Relationship Between Hydraulic Conductivity and Fracture Properties Estimated from Packer Tests and Borehole Data in a Fractured Granite. Engineering Geology, Vol. 92 Issue 1-2, pg 73-87.

Hantush, M. S. 1964. Hydraulics of wells. Advances in Hydroscience, v. 1. V. T. Chow, Editor, pp. 281-432. (Textbook)

Karlstrom, K.E et al. 1993. Pluton Emplacement along an active ductile thrust zone, Piute Mountains, southeastern California: Interaction between deformational and solidification processes: Geological Society of America Bulletin v.105, pages 213-230.

Kawecki, M.W., 1995, Meaningful interpretation of step-drawdown tests: Ground Water, v. 33(1)

Kenney Geoscience, 2011. Geologic Structure Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. August 31, 2011.

Kruseman, G.P. 2000. Analysis and Evaluation of Pumping Test Data, International Institute for Land Reclamation and Improvement, Publication 47, Second Edition.

Kupfer, D.H. and A.M. Bassett. 1962. Geologic Reconnaissance Map of the Southeastern Mojave Dessert, California: US Geological Survey, Field Investigations Map MF-205, Scale 1:125,000.

Mace, R.E. 1997. Determination of Transmissivity from Specific Capacity Tests in a Karst Aquifer, Groundwater Vol 35, No. 5 September-October 1997.

Morris, D. A., and A. I. Johnson, 1967. Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U. S. Geological Survey 1948-60.

Moyle, W.R. 1967. Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California: California Department of Water Resources Bulletin 91-14.

Moyle, W.R.,Langer, W.H., Woolfenden, L.R., and Mulvihill, D.A. 1984. Maps Showing Ground-Water Levels, Springs, and Depth to Ground-Water, Basin and Range Province, Southern California: U. S. Geological Survey Water Resources Investigation Report 83-4116-B.

NORCAL Geophysical Consultants, Inc. 1997. Seismic Reflection Survey Cadiz Valley, Cadiz, California. Proprietary report to Cadiz Inc.

Rukavikova, L., et al. 2008. Distribution of Hydraulic Conductivity in Fractured Compact Granite. http://www.cprm.gov.br/33IGC/1259273.html

Sharp, J, 2010, Personal Communication

Simpson, R.W., R.C. Bracken and D.J. Stierman. 1984. Aeromagnetic, Bouguer Gravity, and Interpretation Maps, Sheep Hole-Cadiz Wildness Study Area, California: US Geological Survey MF 1615-B, 4 sheets, scale 1:62,500.

South Coast Geological Society. 1994. Mojave Desert, Annual Field Trip Guidebook #22, Martin Stout Volume.

Strausberg, S.I. 1967 Estimating Distances to Hydrologic Boundaries from Discharging Well Data, Groundwater, Vol 5, No.1, January 1967.

Thompson, D.G. 1929. The Mohave Desert Region, California, A geographic, geologic, and hydrologic reconnaissance: US Geological Survey Water Supply Paper, 578. 795 pp.

Todd, D. K. and Mays L. W. 2005. Groundwater Hydrology. John Wiley and Sons, Hoboken, NJ

USGS, 2000, “Comments made during meeting" (14-Feb-2000).

United States Geological Survey. 1962. Theory of Aquifer Tests: Water Supply Paper 1536-E

United States Geological Survey. 1981. Tectonic Framework of the Mojave and Sonoran Deserts, California and Nevada: Open-File Report 81-503.

United States Geological Survey. 2009. Gravity and Magnetic Investigations of the Mojave National Preserve and Adjacent Areas, California and Nevada: Open-File Report 2009-1117.

Wolff, Roger, G., 1982. Physical Properties of Rocks: Porosity, permeability, distribution coefficients, and dispersivity.

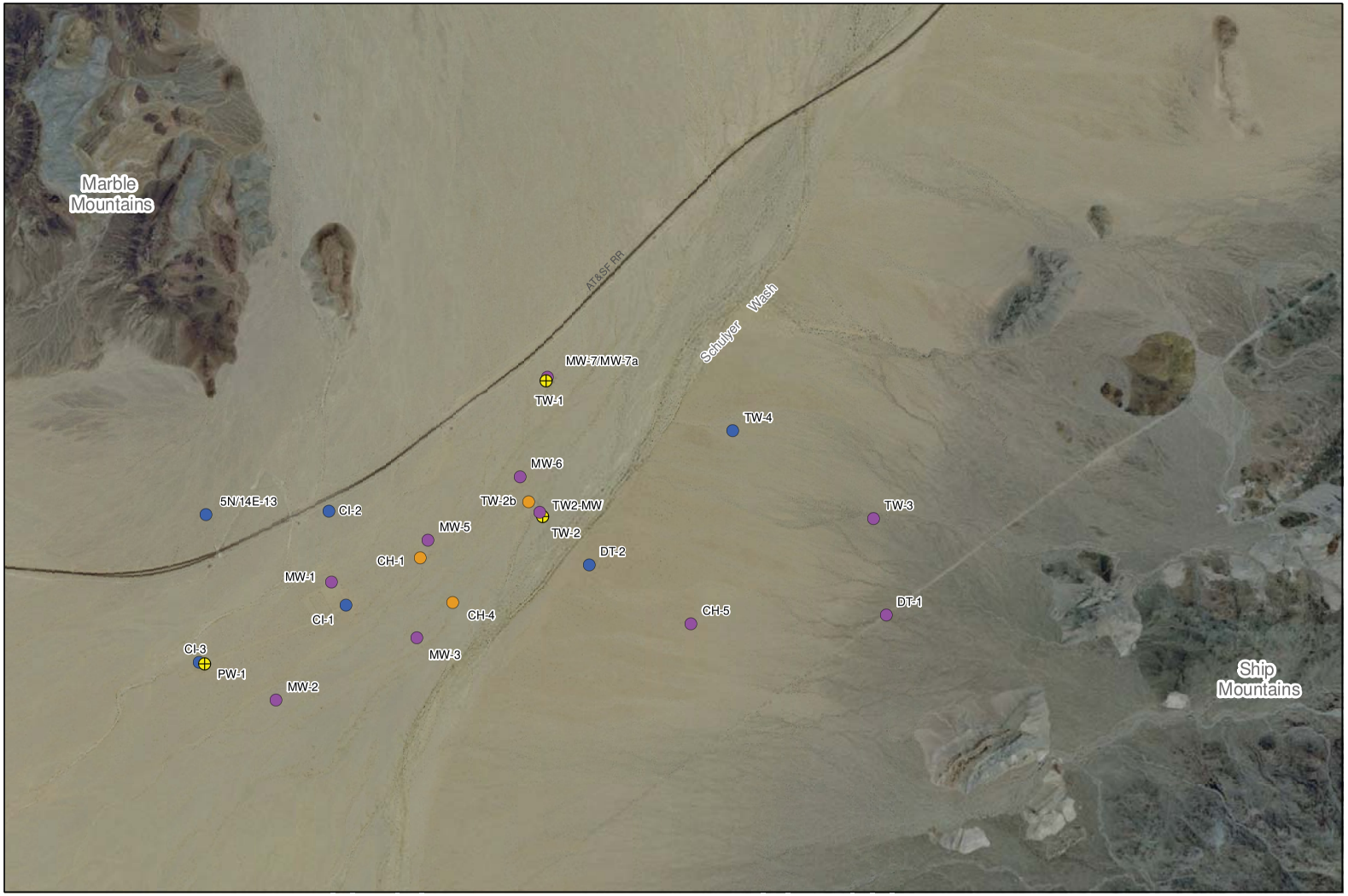
Zhang, F. 2004. Determining the Permeability of Fractured Rocks Based on Joint Mapping. Groundwater, Jul-Aug 2004, 44(4) 509-15.

FIGURES

BROWNSTEIN HYATT FARBER SCHRECK, LLP

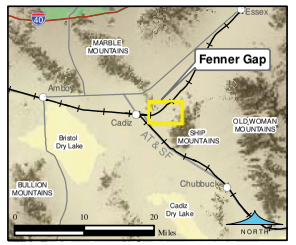
GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

PROJECT LOCATION



EXPLANATION

- Test Well
- Monitoring Well
- Exploratory Borehole
- Other Wells not discussed in this report



1-Sep-11

Prepared by: LB

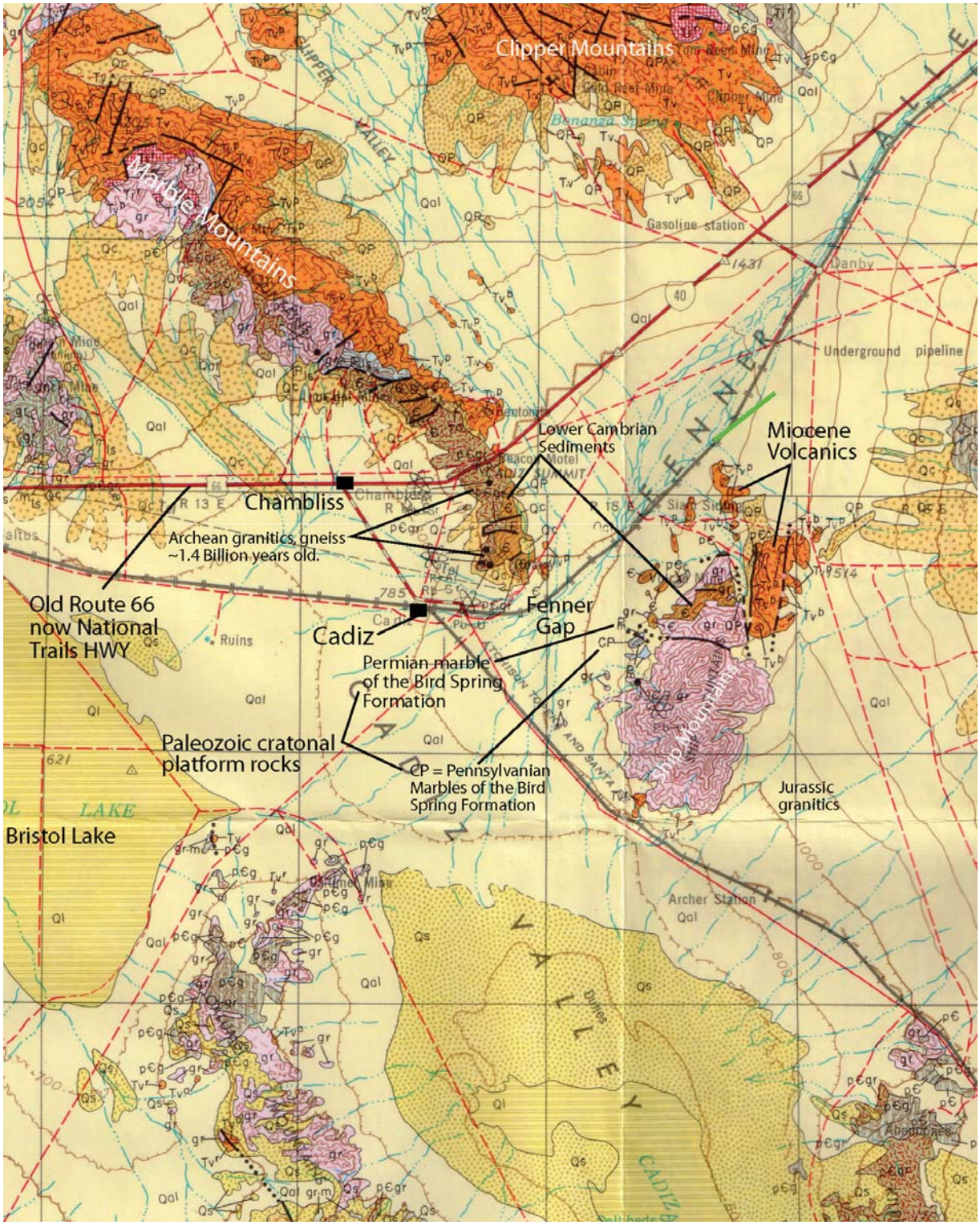
Map Projection:
State Plane, Zone 5 (1983)

NORTH
0 2,000 4,000
Feet

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 1

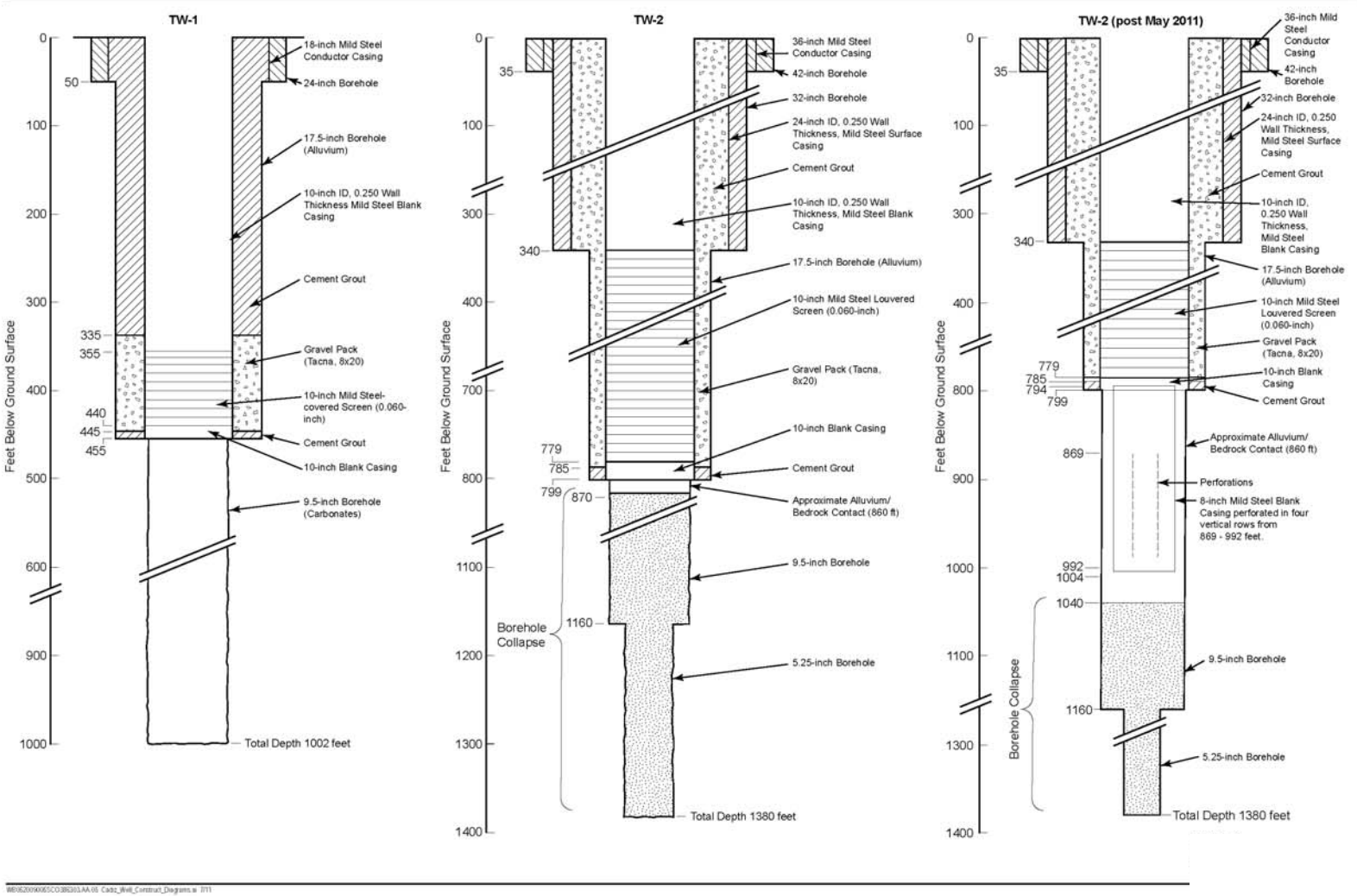
GIS_proj/brownstein_cadiz_Fenner_asses_UPDATE_9-11/0_Fig_1_regional_location_9-11.mxd



Source: Kenney GeoScience, Draft Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. June 20, 2011.

GEOSCIENCE GEOSCIENCE Support Services, Incorporated P.O. Box 220, Claremont, CA 91711 Tel: (909)451-6650 Fax: (909)451-6638 www.gssiwater.com	Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP	Figure 2
	Checked:	REGIONAL GEOLOGIC MAP	
	Approved:		
	Date: 1-SEP-11		

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\82) TM 4_16_2010_Revision\02) Figures\Fig_2_reg_geol_map_9-11.ai



Source: CH2MHill. Exploratory Drilling, Testing, and Well Completion Report Fenner Gap Area. August 2011.

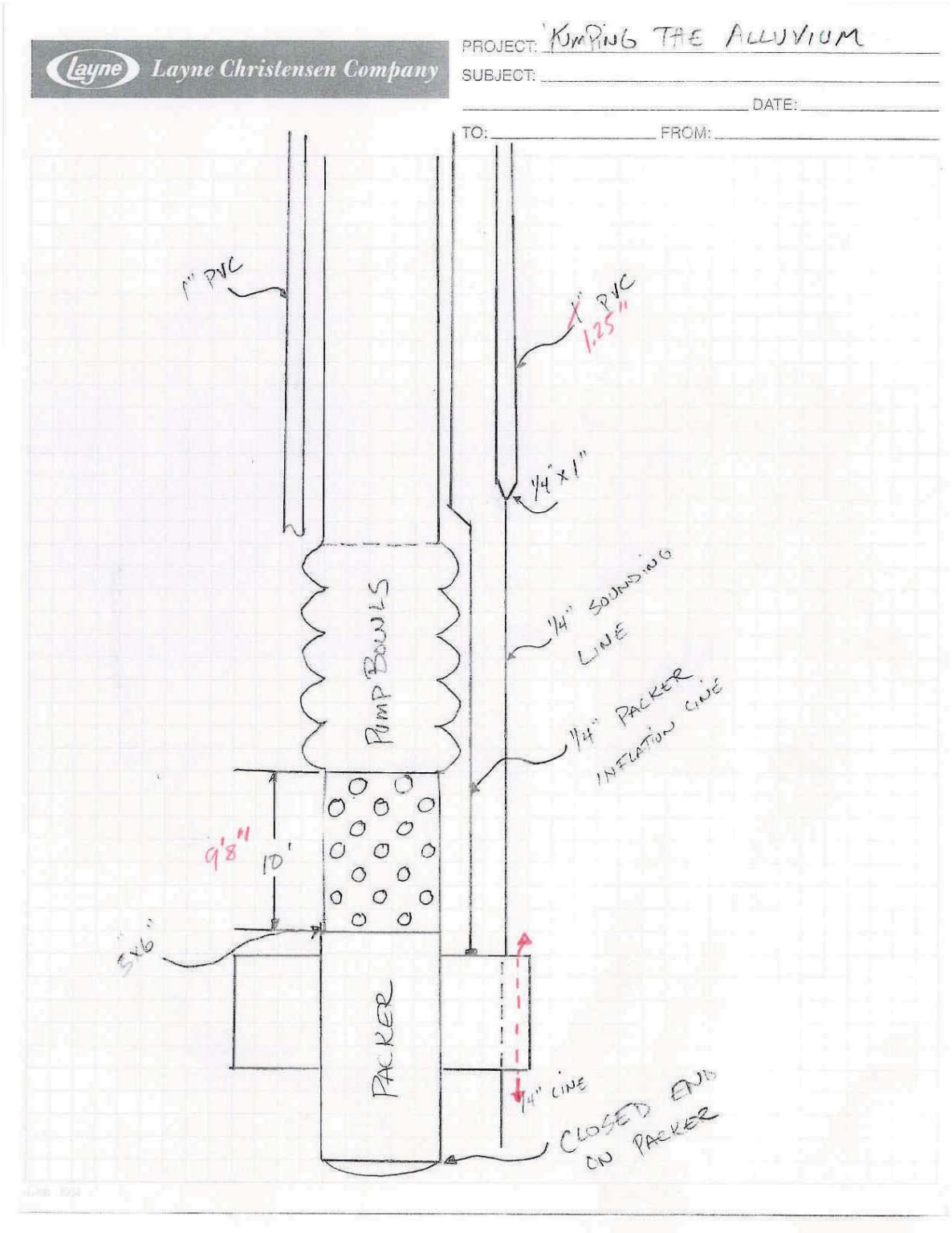
GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gsiwater.com

BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL CROSS SECTIONS FOR TESTING WELLS

Drawn:
Checked:
Approved:
Date: 1-SEP-2011

Figure 3

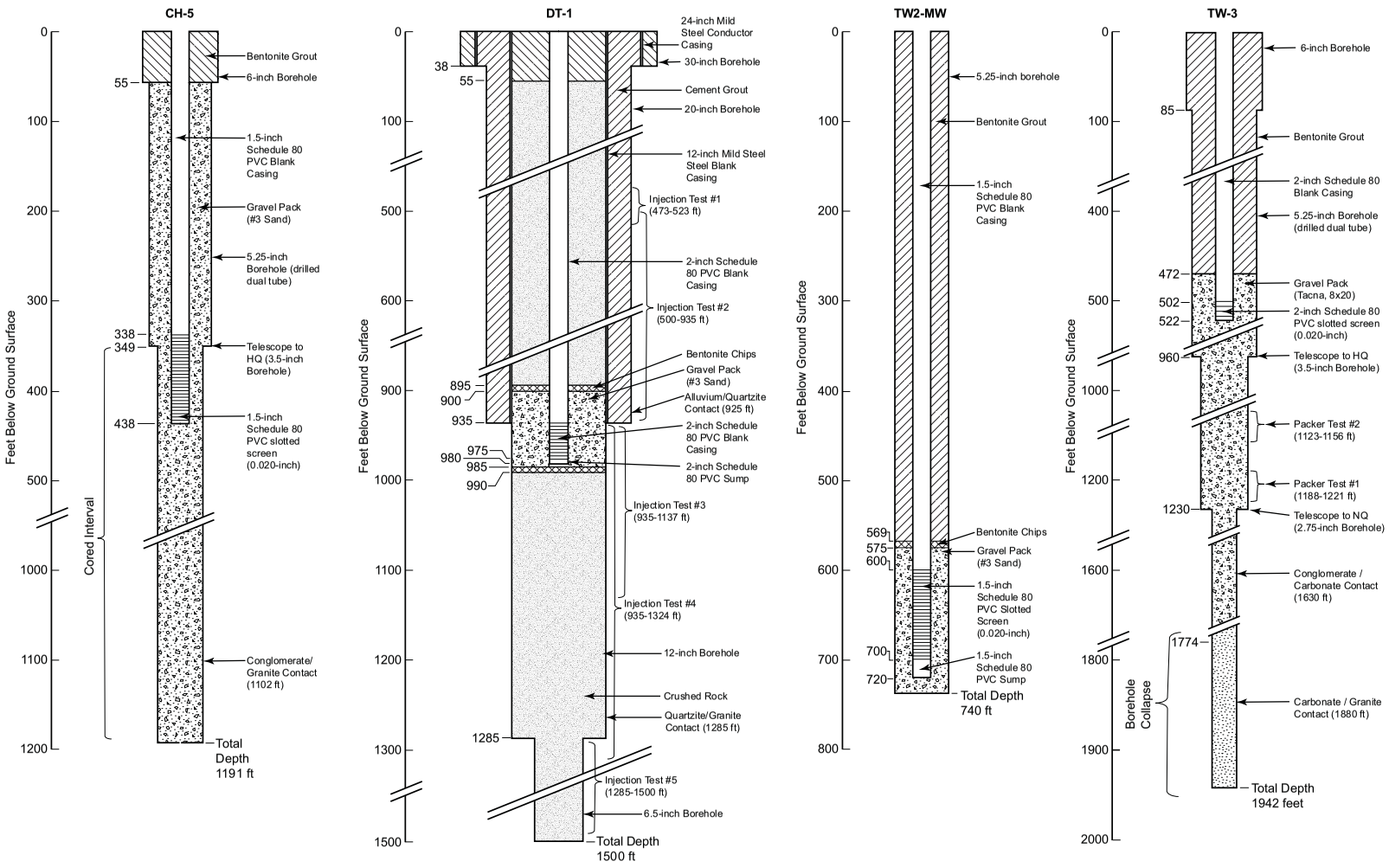


Source: CH2MHill.

NOT TO SCALE

GEOSCIENCE GEOSCIENCE Support Services, Incorporated P.O. Box 220, Claremont, CA 91711 Tel: (909) 451-6650 Fax: (909) 451-6638 www.gssiwater.com	Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP	Figure 4
	Checked:	TW-1 PACKER TEST CONFIGURATION	
	Approved:		
	Date: 1-SEP-11		

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\82) TM 4_16_2010_Revision\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\02) Technical X-Sections of Wells\Fig_4_TW-1_packer_9-11.ai



WB05200900SSCO386903.AA.05 Cadiz_Well_Construct_Diagrams2.ai 7/11

Source: CH2MHill. Exploratory Drilling, Testing, and Well Completion Report Fenner Gap Area. August 2011.

GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gsiwater.com

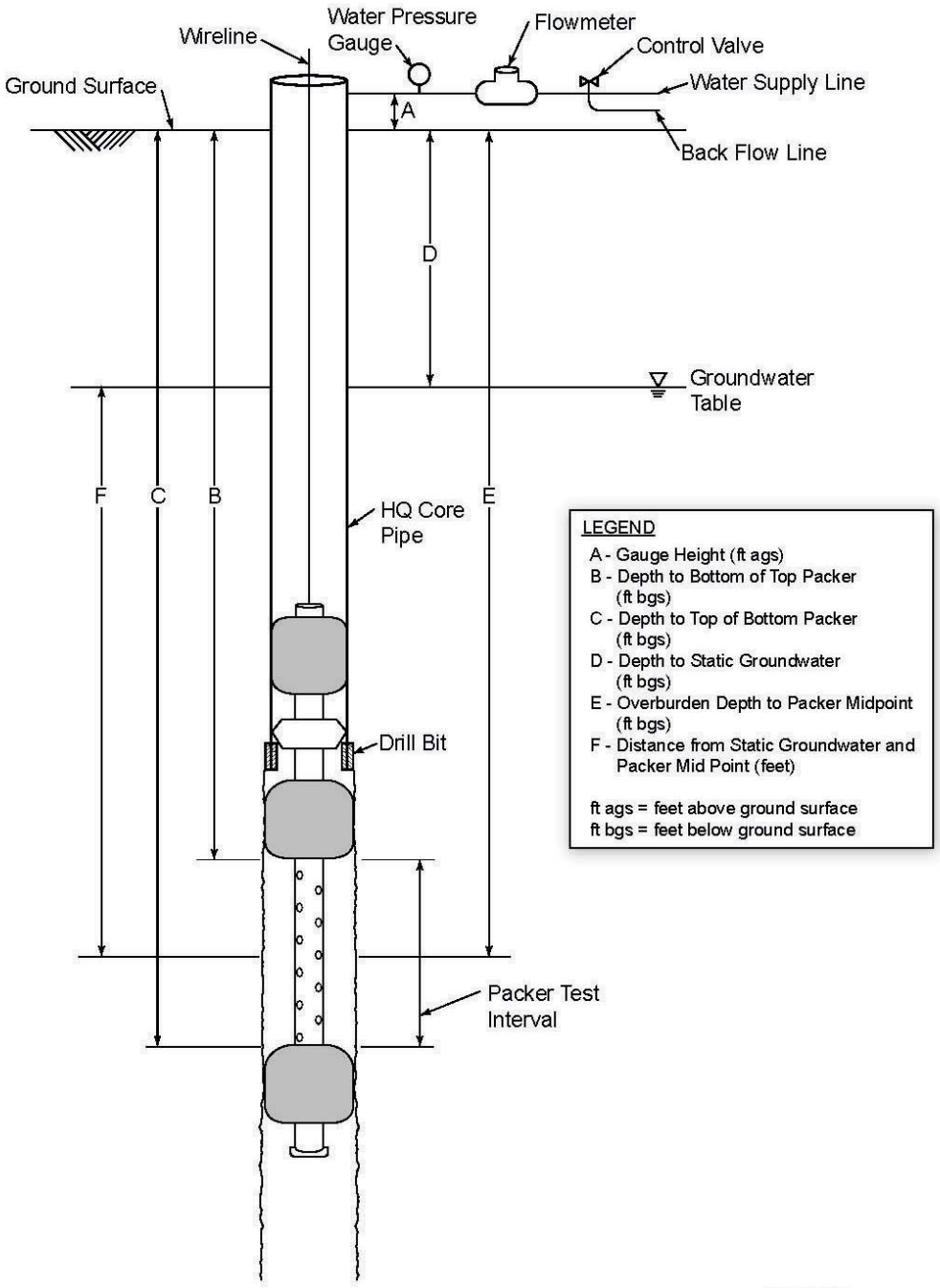
BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL CROSS SECTIONS FOR MONITORING WELLS

Drawn:
Checked:
Approved:
Date: 1-SEP-2011

Figure 5

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-1082\ TM 4_16_2010_Revision\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\02) Technical X-Sections of Wells\Fig_5_MW_as_built_9-11.ai



Source: CH2MHill. Exploratory Drilling, Testing, and Well Completion Report Fenner Gap Area. August, 2011

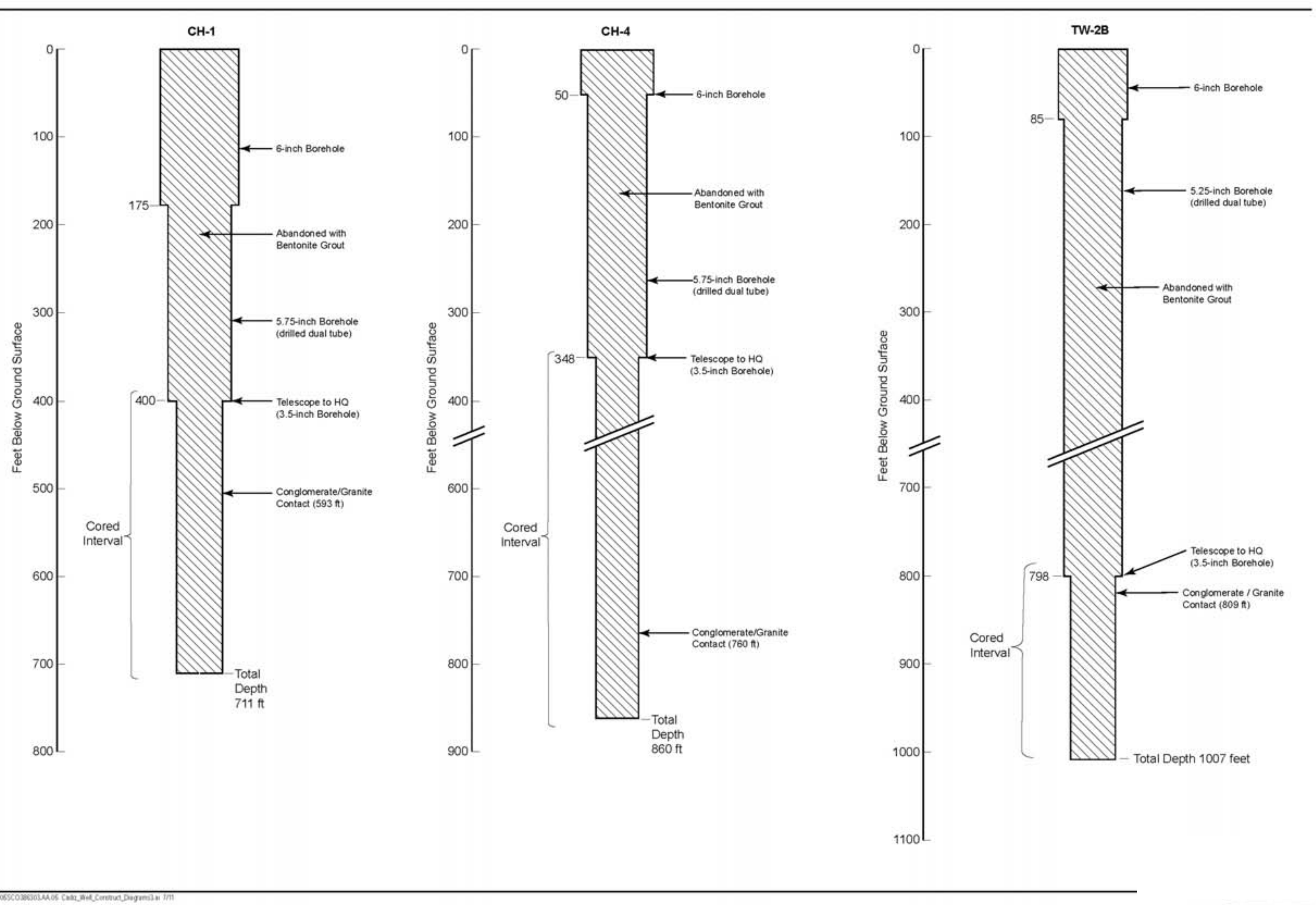
NOT TO SCALE

GEOSCIENCE
GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP
Checked:	TW-3 PACKER TEST CONFIGURATION
Approved:	
Date: 1-SEP-11	

Figure 6

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\82) TM 4_16_2010_Revision\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\02) Technical X-Sections of Wells\Fig_6_TW-3_packer_9-11.ai



Source: CH2MHill. Exploratory Drilling, Testing, and Well Completion Report Fenner Gap Area. August 2011.

GEOSCIENCE

GEOSCIENCE Support Services, Incorporated
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

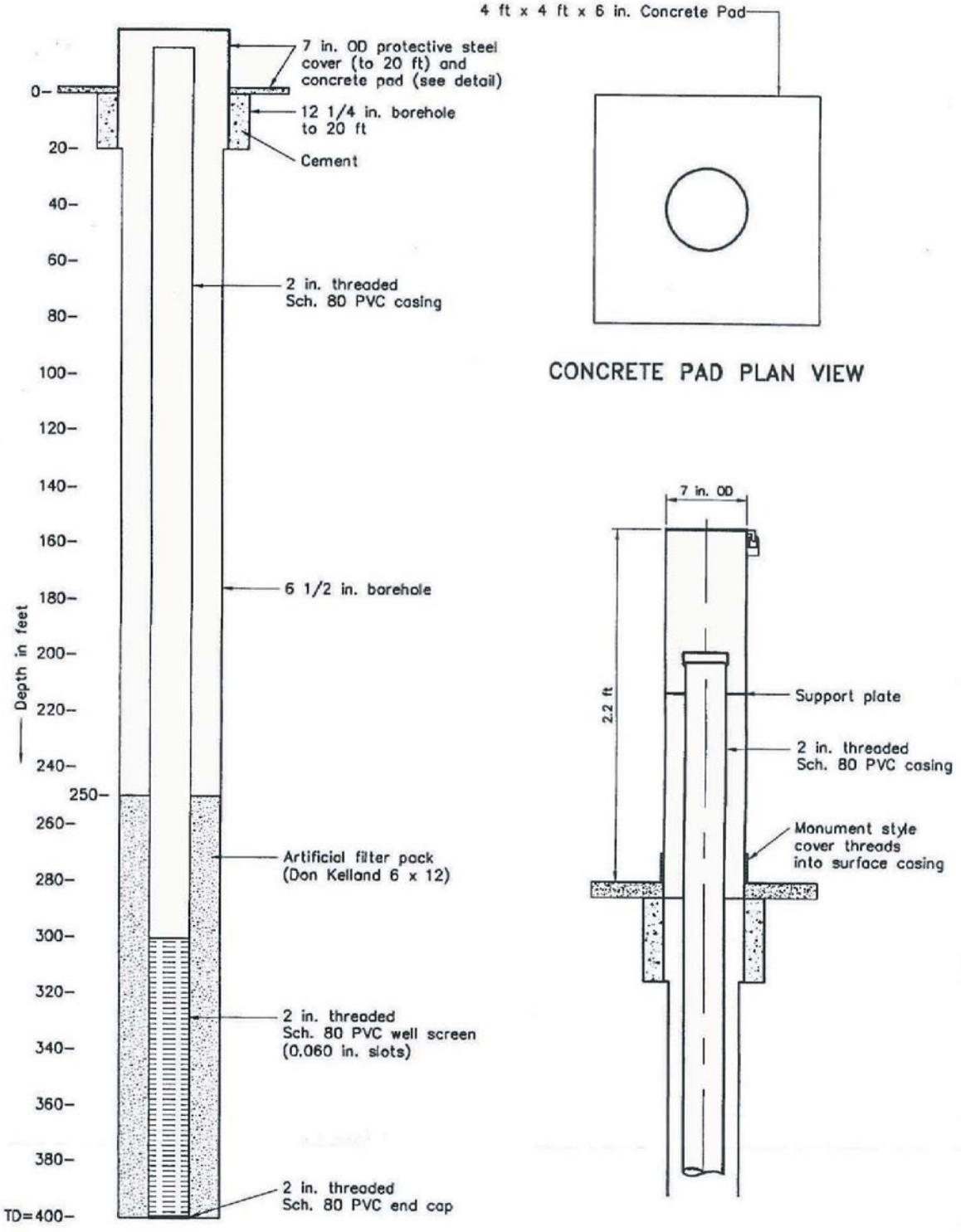
BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL CROSS SECTIONS FOR EXPLORATORY BOREHOLES

Drawn:
Checked:
Approved:
Date: 1-SEP-2011

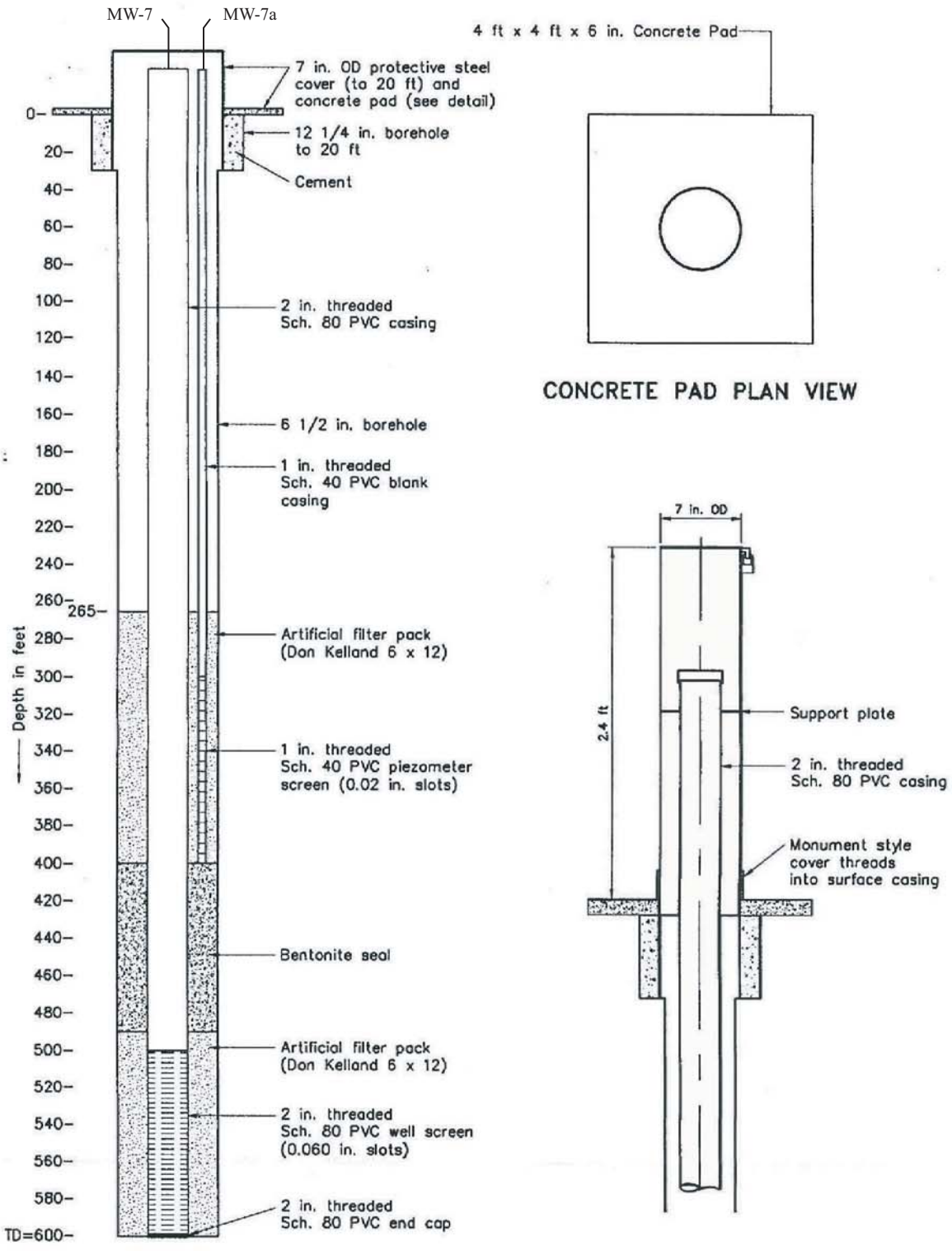
Figure 7

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\82) TM 4_16_2010_Revision\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\02) Technical X-Sections of Wells\Fig_7_BH_as_built_9-11.ai



GEOSCIENCE GEOSCIENCE Support Services, Incorporated P.O. Box 220, Claremont, CA 91711 Tel: (909) 451-6650 Fax: (909) 451-6638 www.gssiwater.com	Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP	Figure 8
	Checked:	MW-6 AS BUILT DIAGRAM	
	Approved:		
	Date: 1-SEP-11		

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\82) TM 4_16_2010_Revision\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\02) Technical X-Sections of Wells\Fig_08_MW-6_as_built_9-11.ai



GEOSCIENCE GEOSCIENCE Support Services, Incorporated P.O. Box 220, Claremont, CA 91711 Tel: (909) 451-6650 Fax: (909) 451-6638 www.gssiwater.com	Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP	Figure 9
	Checked:	MW-7 AND 7A AS BUILT DIAGRAM	
	Approved:		
	Date: 1-SEP-11		

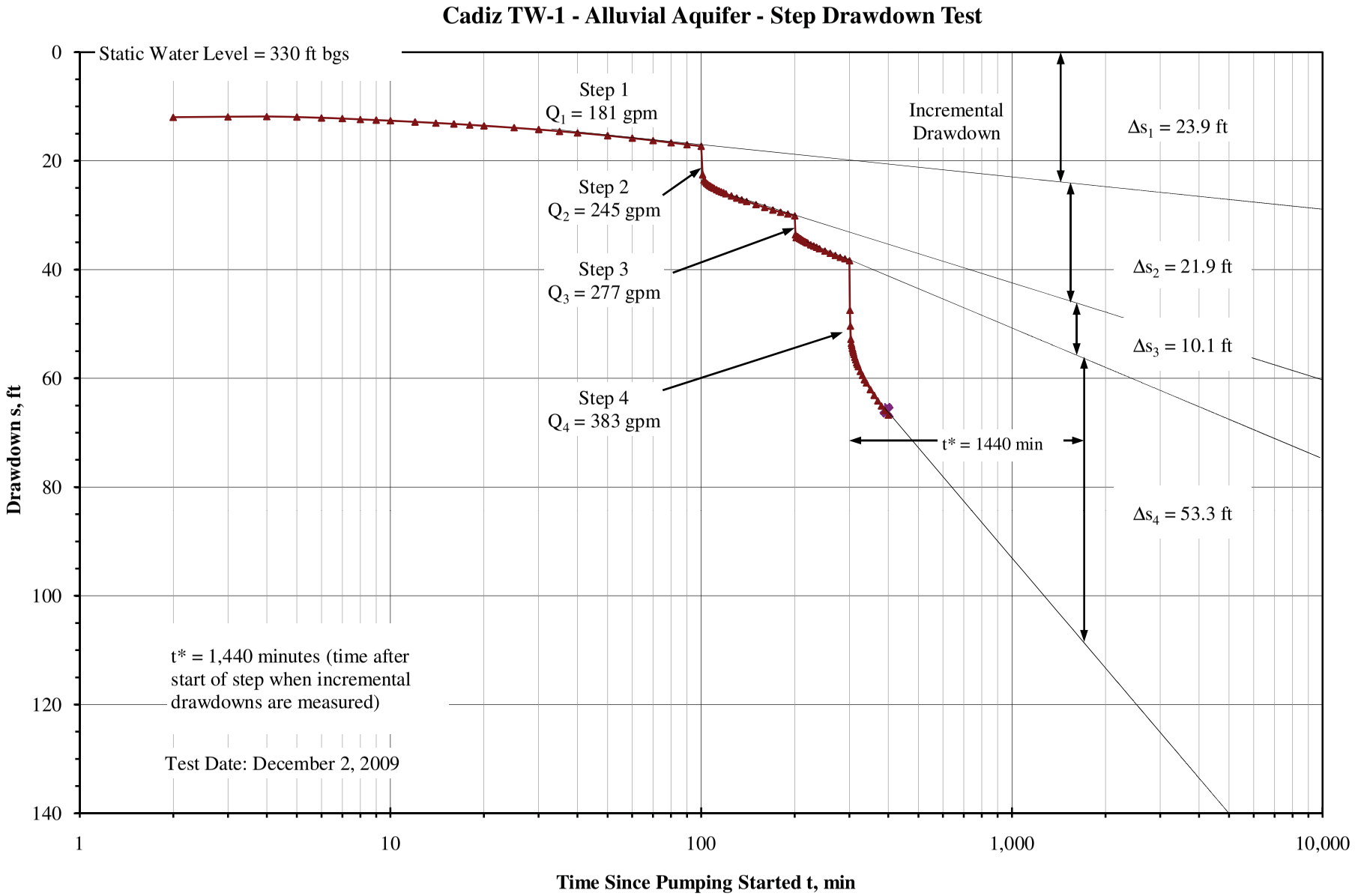

Cadiz TW-1 - Alluvial Aquifer - Step Drawdown Test
Static Water Level = 330 ft bgs
Step 1
Q1 = 181 gpm
Step 2
Q2 = 245 gpm
Step 3
Q3 = 277 gpm
Step 4
Q4 = 383 gpm
Incremental Drawdown
Δs1 = 23.9 ft
Δs2 = 21.9 ft
Δs3 = 10.1 ft
Δs4 = 53.3 ft
t* = 1440 min
t* = 1,440 minutes (time after start of step when incremental drawdowns are measured)
Test Date: December 2, 2009
Drawdown s, ft
Time Since Pumping Started t, min
0
20
40
60
80
100
120
140
1
10
100
1,000
10,000

Figure 10

Cadiz TW-1 - Alluvial Aquifer - Specific Drawdown vs. Discharge Rate

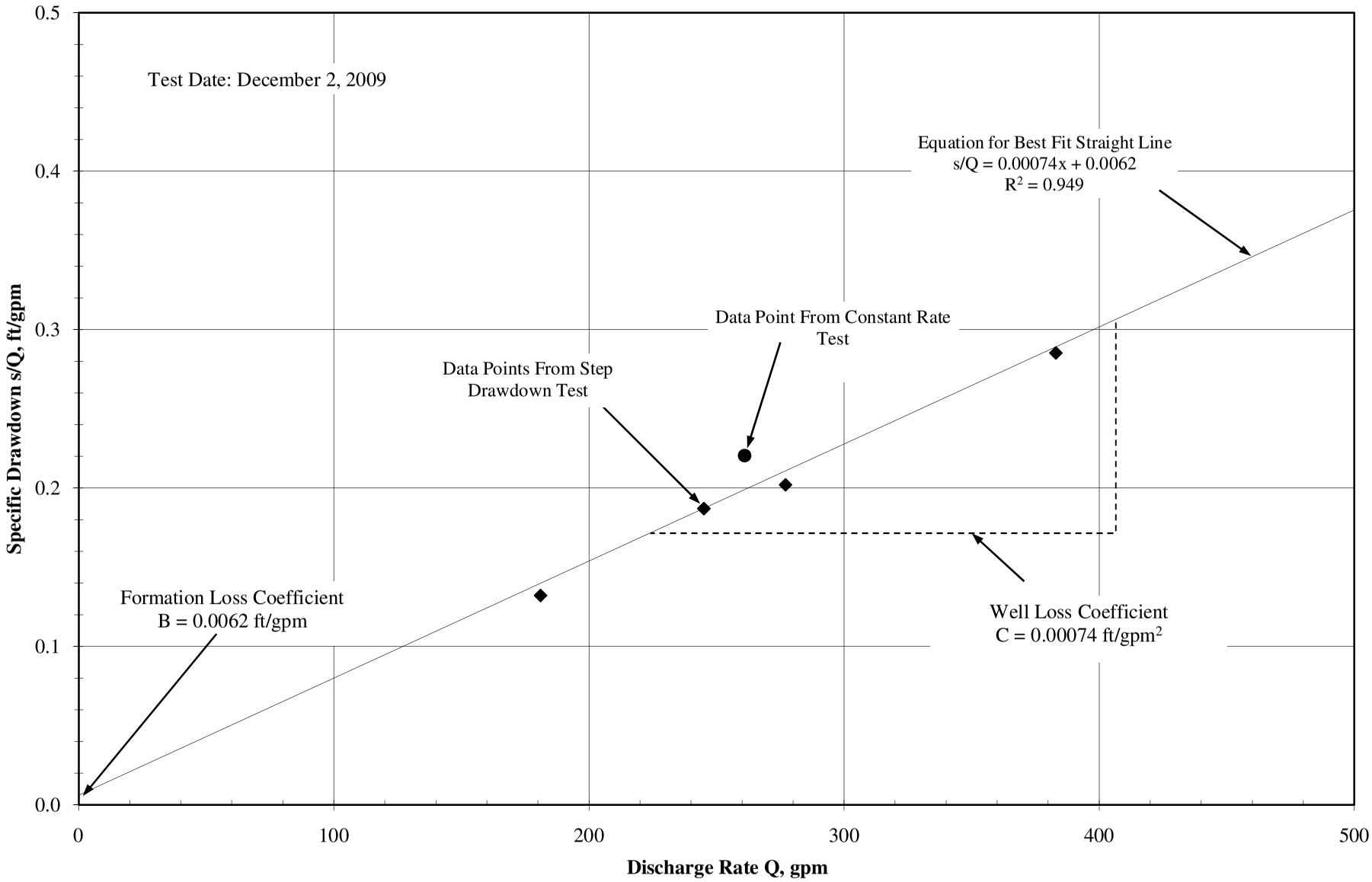


Figure 11

Cadiz TW-1 - Alluvial Aquifer - Specific Capacity and Well Efficiency Diagram

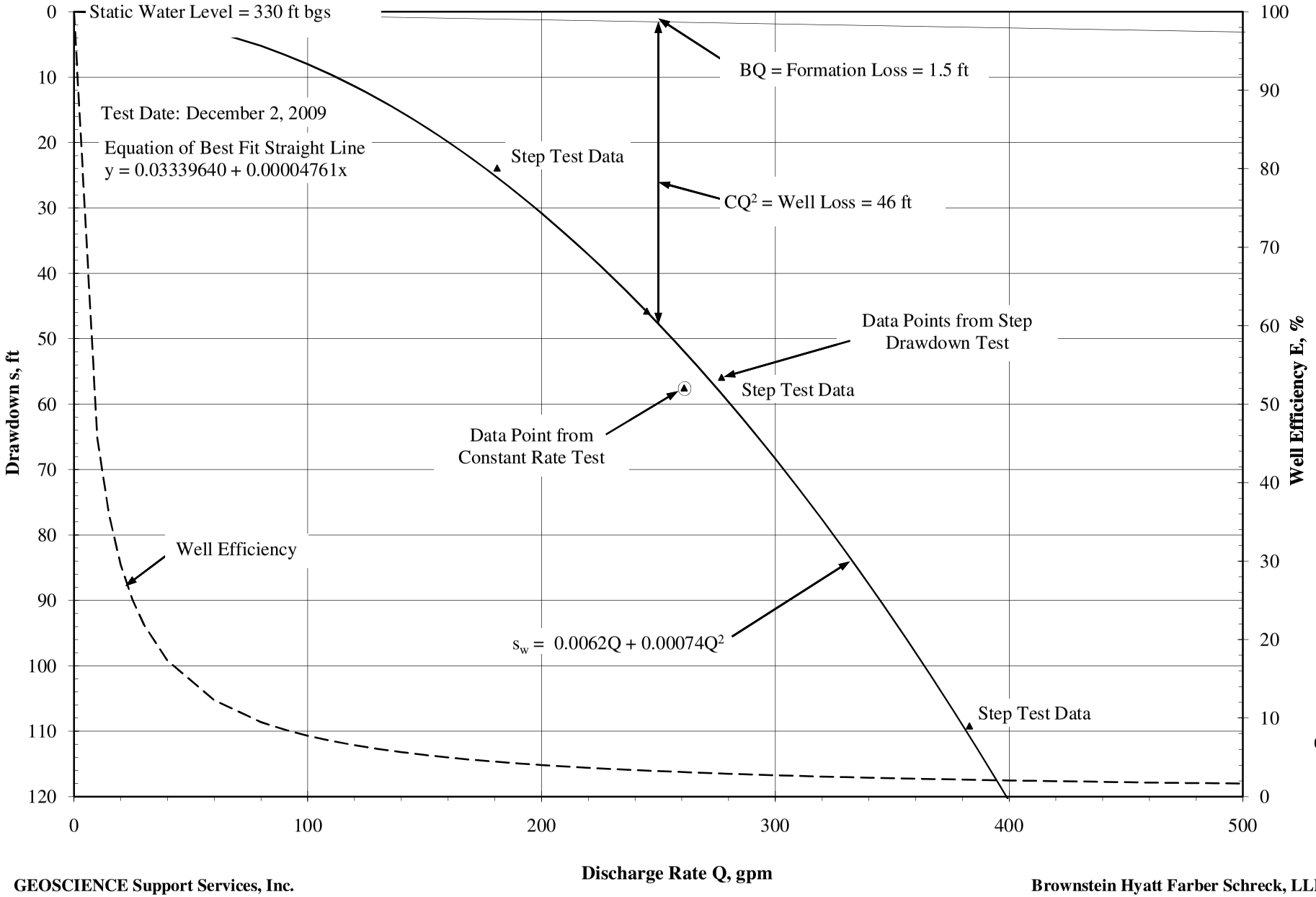


Figure 12

Cadiz TW-1 - Alluvial Aquifer - Constant Rate Test

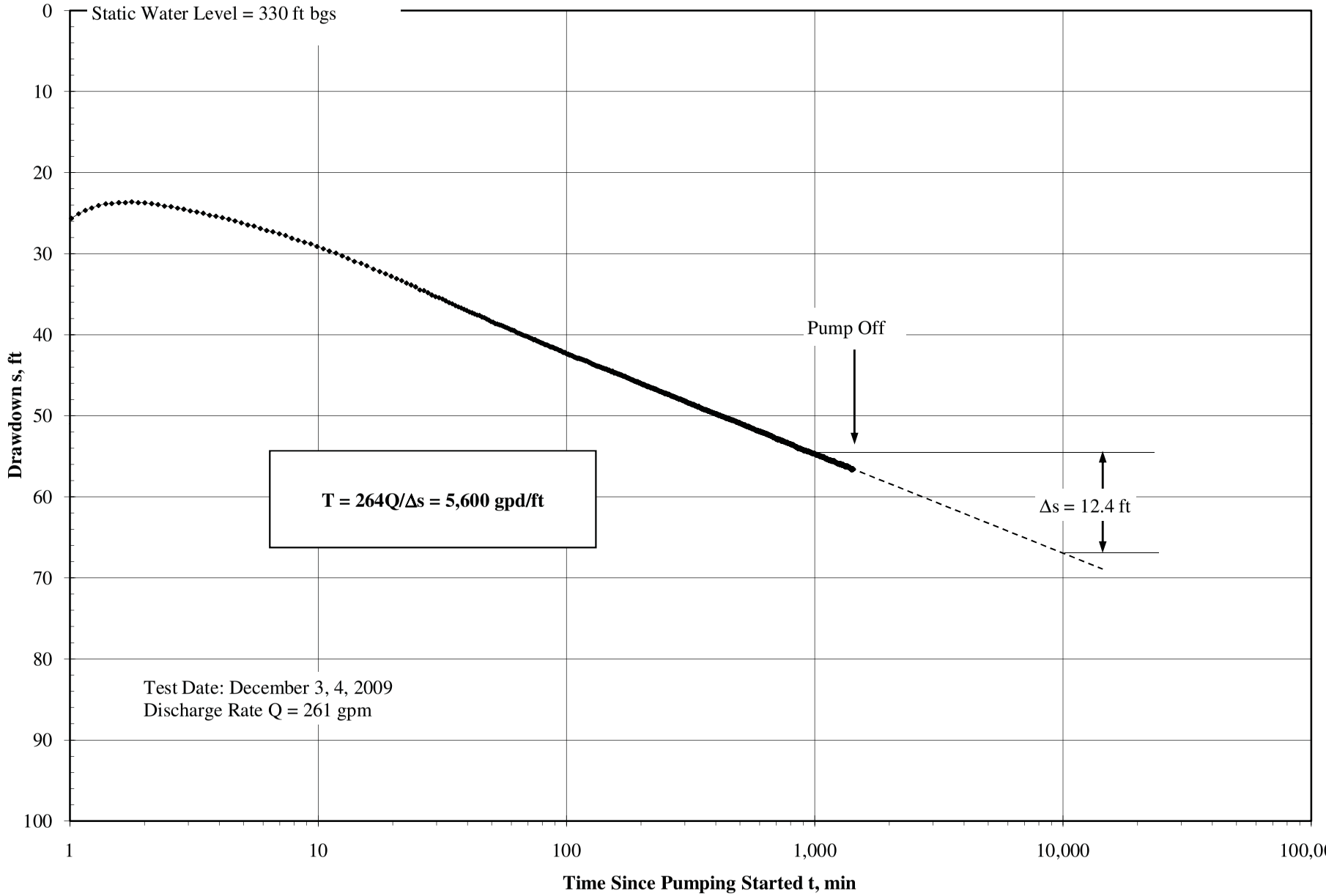


Figure 13

Cadiz MW-7a - Alluvial Aquifer - Constant Rate Test
Distance From Pumping Well TW-1 = 83 ft

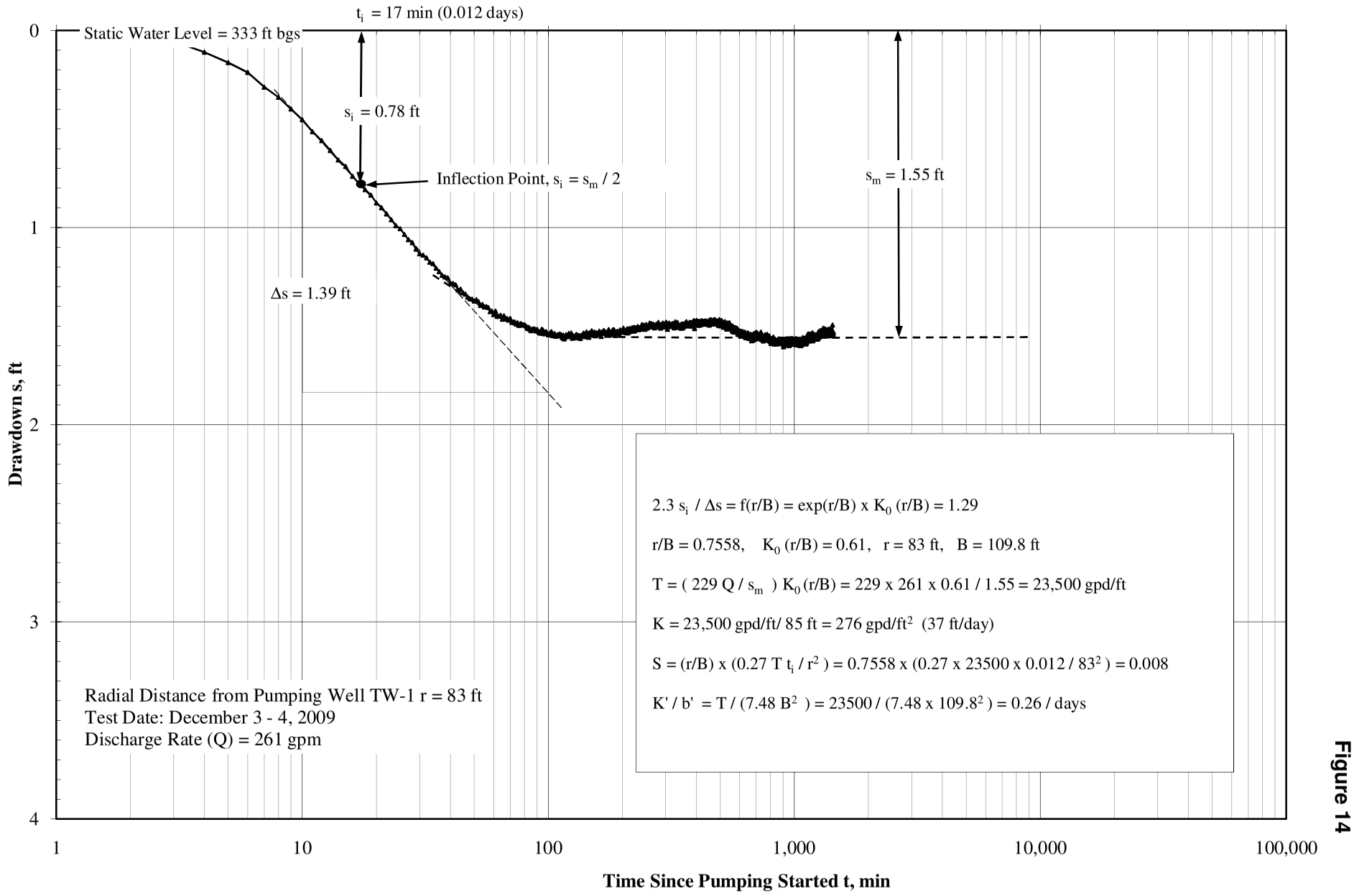


Figure 14

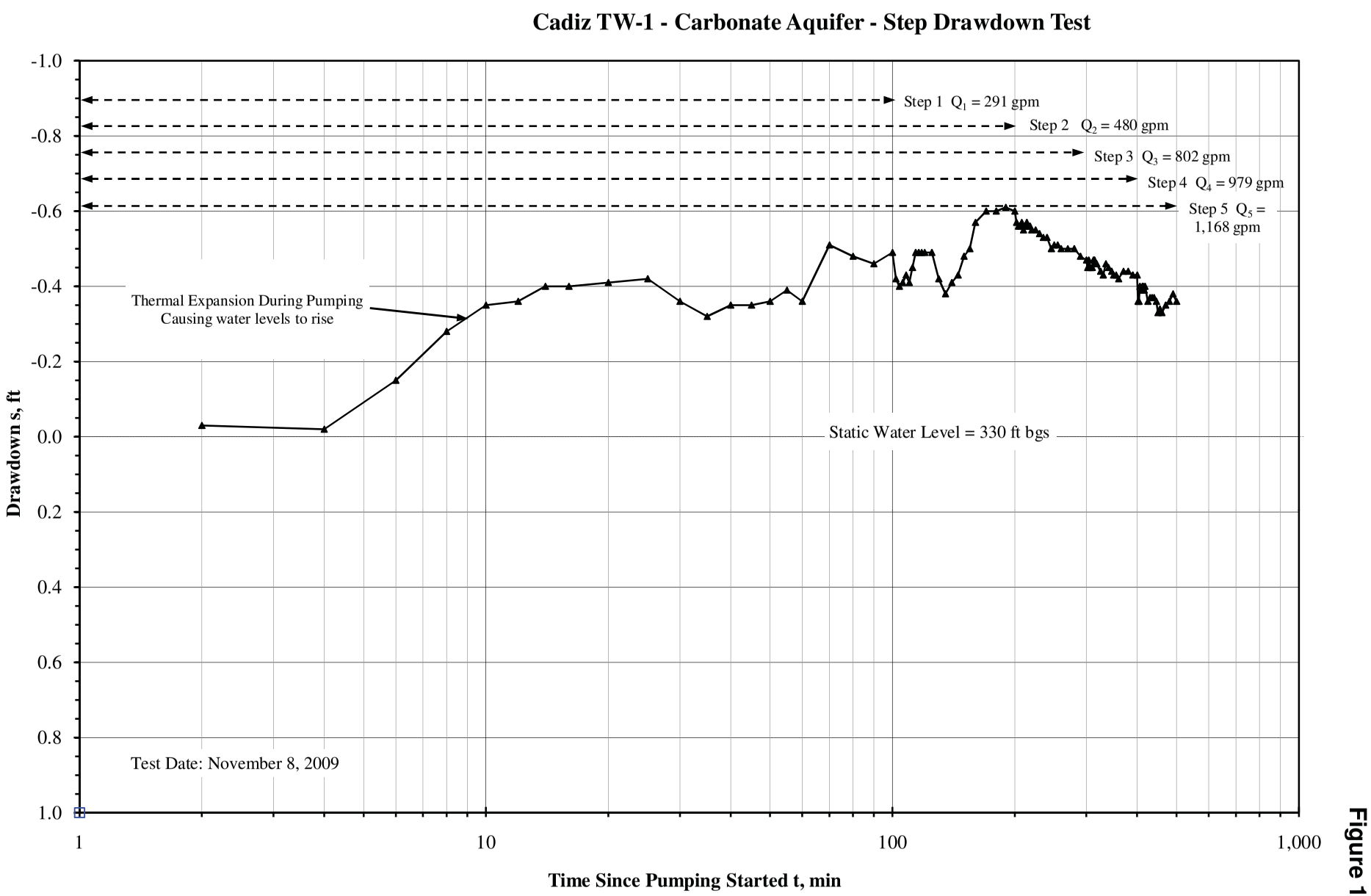
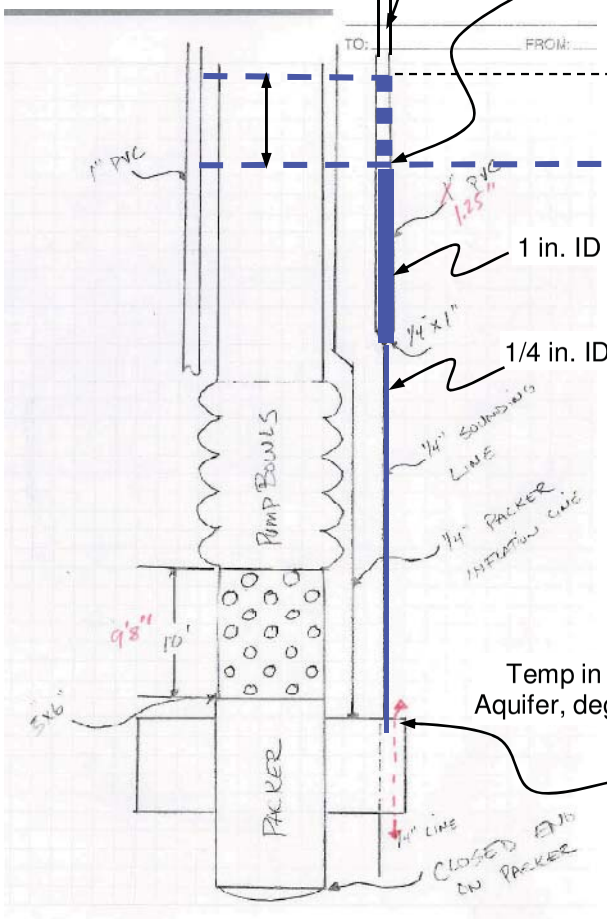

Cadiz TW-1 - Carbonate Aquifer - Step Drawdown Test
Step 1 Q1 = 291 gpm
Step 2 Q2 = 480 gpm
Step 3 Q3 = 802 gpm
Step 4 Q4 = 979 gpm
Step 5 Q5 = 1,168 gpm
Thermal Expansion During Pumping Causing water levels to rise
Static Water Level = 330 ft bgs
Test Date: November 8, 2009
Drawdown s, ft
Time Since Pumping Started t, min
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1
10
100
1,000

Figure 15

Calculation of Thermal Expansion of Water During Pumping of Carbonate Well TW-1

$$dV = \beta \times V_0 \times dT$$

Coefficient of Volume Expansion of Water (β) = 0.00021 /deg C



Temp at SWL, deg F	deg, F	69
	deg, C	20.6
Rise in Water Level in Sounding Tube Due to Thermal Expansion, in.		5.4 in. / 0.45 ft
SWL		330.5 ft bgs
1 in. ID		
1/4 in. ID		455 ft bgs
1/4 in. ID		
Temp in Aquifer, deg F		470 ft bgs
	deg, F	100
	deg, C	37.8
dT =		17.2 deg, C

Initial Volume (V_0), ft³

1 in. =	0.6790
1/4 in. =	0.0051
Total =	**0.6842** ft³

Change in Volume ($dV = \beta \times V_0 \times dT$), ft³ = **0.0025** ft³

Explanation: Initially, the ground water is approximately 100 deg F near the pump and bottom of the sounding tube. The temperature at the SWL depth is assumed to be ambient or close to ambient. During pumping, pumped water moves up the pump column and "warms" the annular space between the pump house casing and the pump column (including the sounding tubes), and due to thermal expansion, causes the water level to rise over 5 in. in the sounding tube.

Original Drawing from CH2MHill

Figure 16

Pumping Well TW-1 (Carbonates)
Constant Rate Test

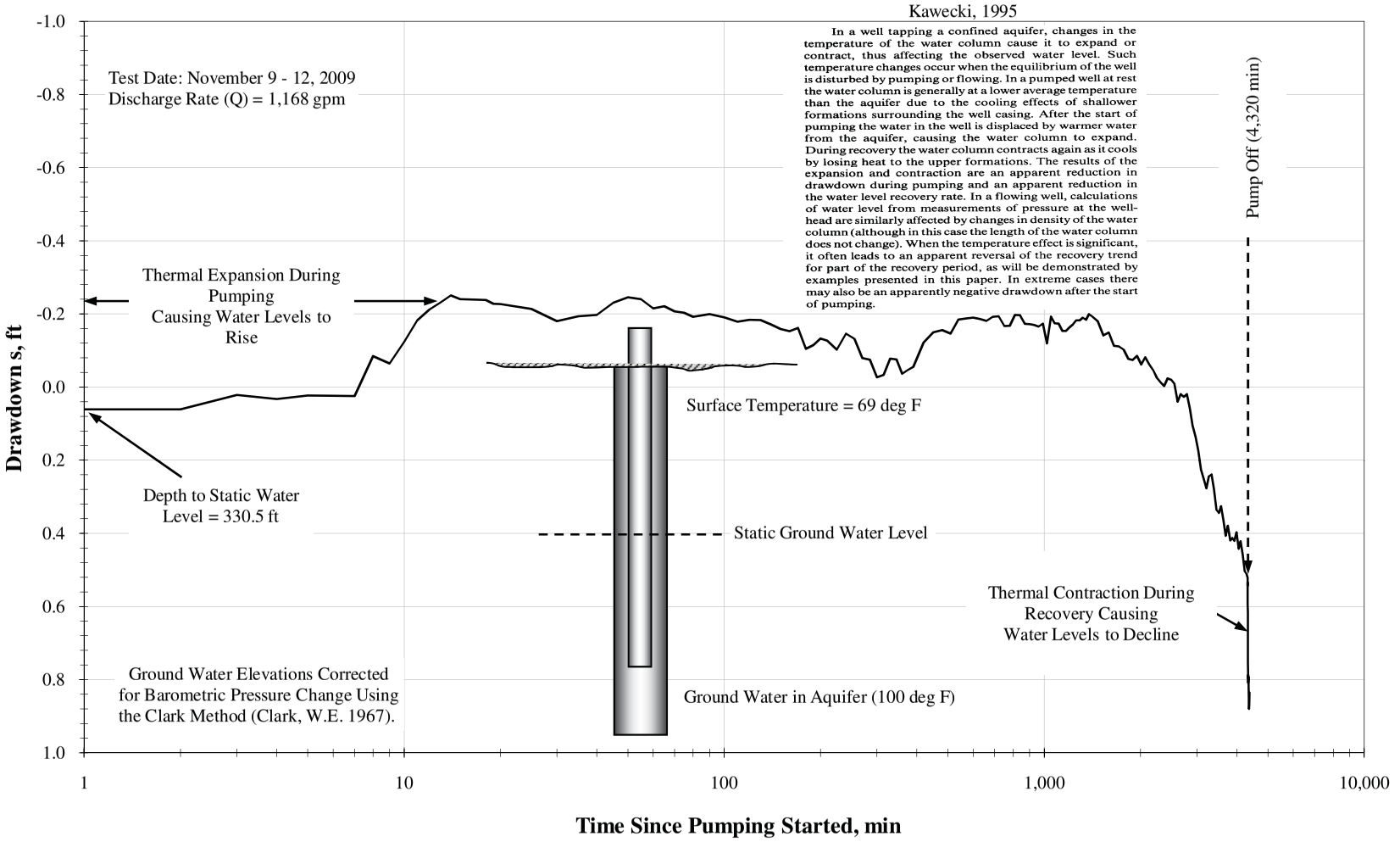


Figure 17

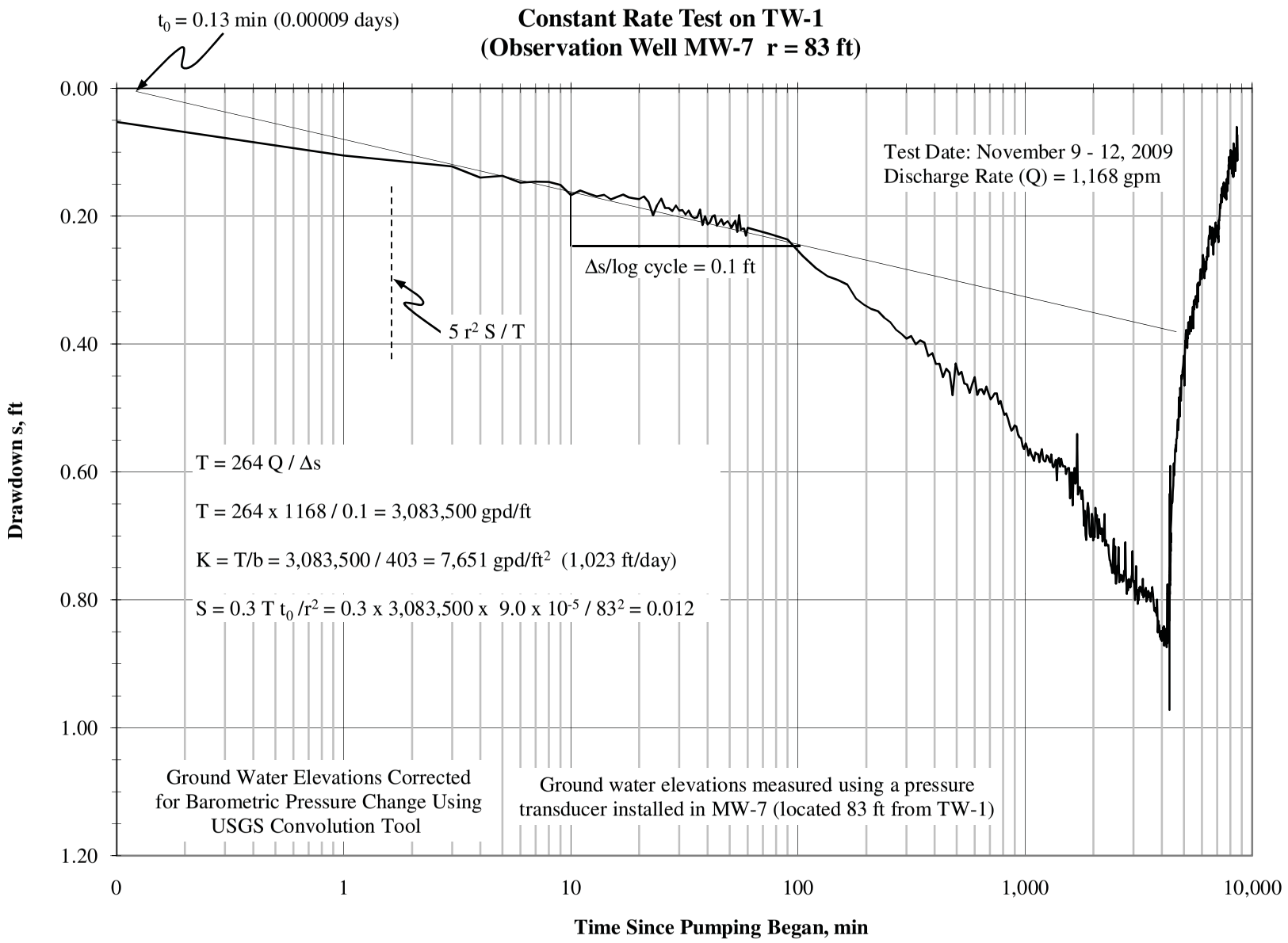

Constant Rate Test on TW-1
(Observation Well MW-7 r = 83 ft)
t0 = 0.13 min (0.00009 days)
Test Date: November 9 - 12, 2009
Discharge Rate (Q) = 1,168 gpm
Δs/log cycle = 0.1 ft
5 r2 S / T
T = 264 Q / Δs
T = 264 x 1168 / 0.1 = 3,083,500 gpd/ft
K = T/b = 3,083,500 / 403 = 7,651 gpd/ft2 (1,023 ft/day)
S = 0.3 T t0 /r2 = 0.3 x 3,083,500 x 9.0 x 10-5 / 832 = 0.012
Ground Water Elevations Corrected for Barometric Pressure Change Using USGS Convolution Tool
Ground water elevations measured using a pressure transducer installed in MW-7 (located 83 ft from TW-1)
Drawdown s, ft
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0
1
10
100
1,000
10,000
Time Since Pumping Began, min

Figure 18

Constant Rate Test on TW-1
(Observation Well MW-7 r = 83 ft)

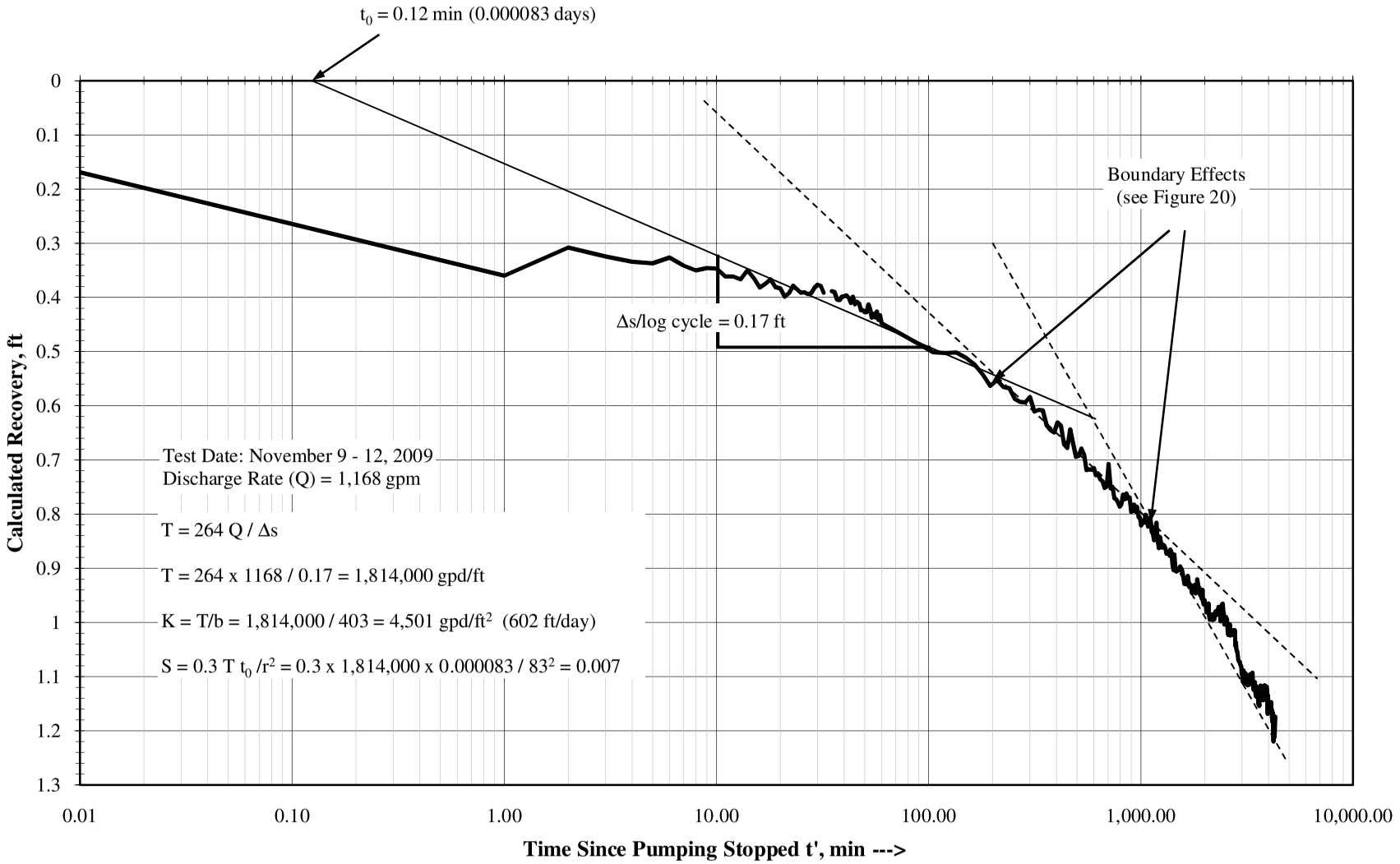
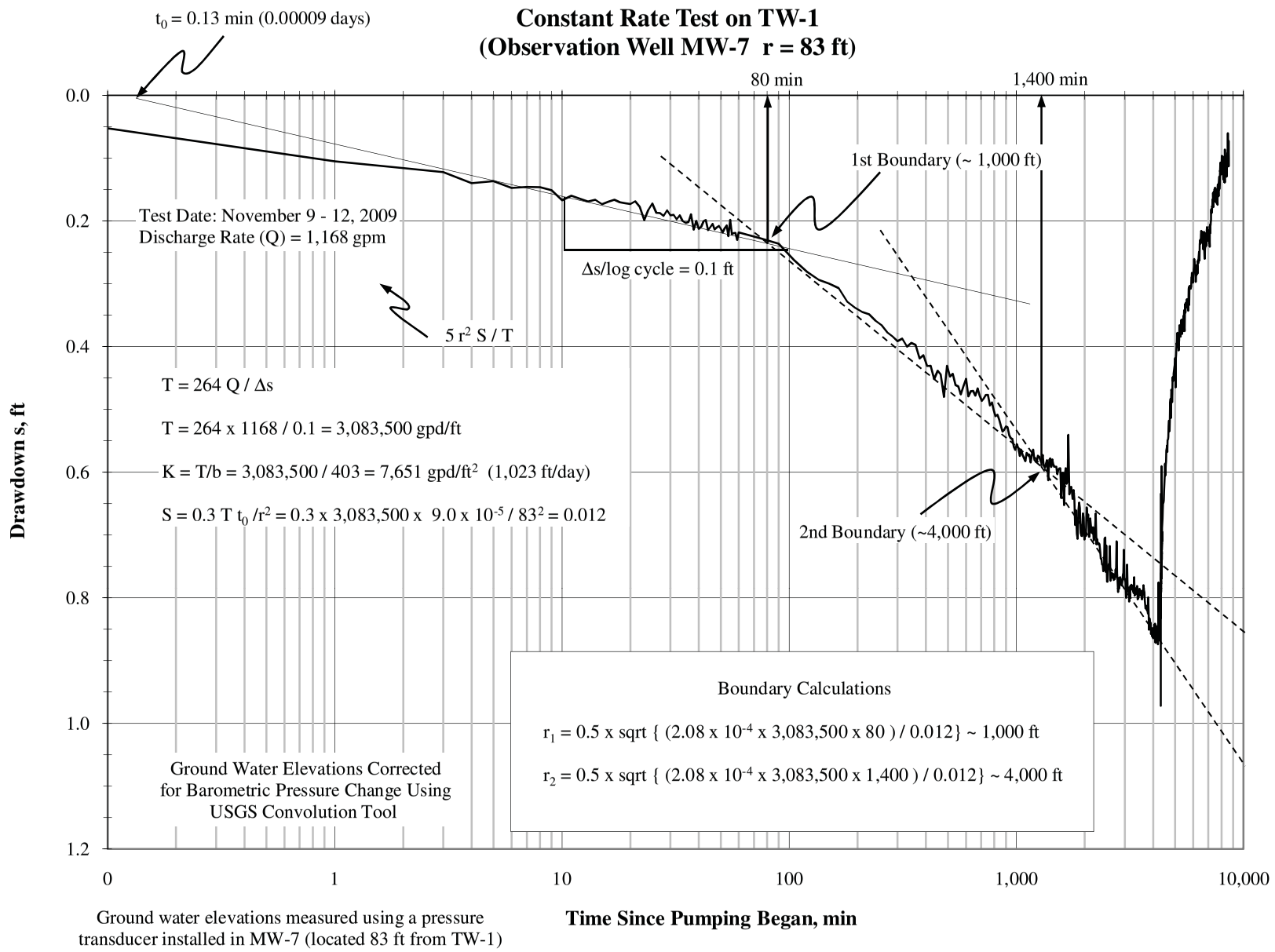


Figure 19



Ground water elevations measured using a pressure transducer installed in MW-7 (located 83 ft from TW-1)

Figure 20

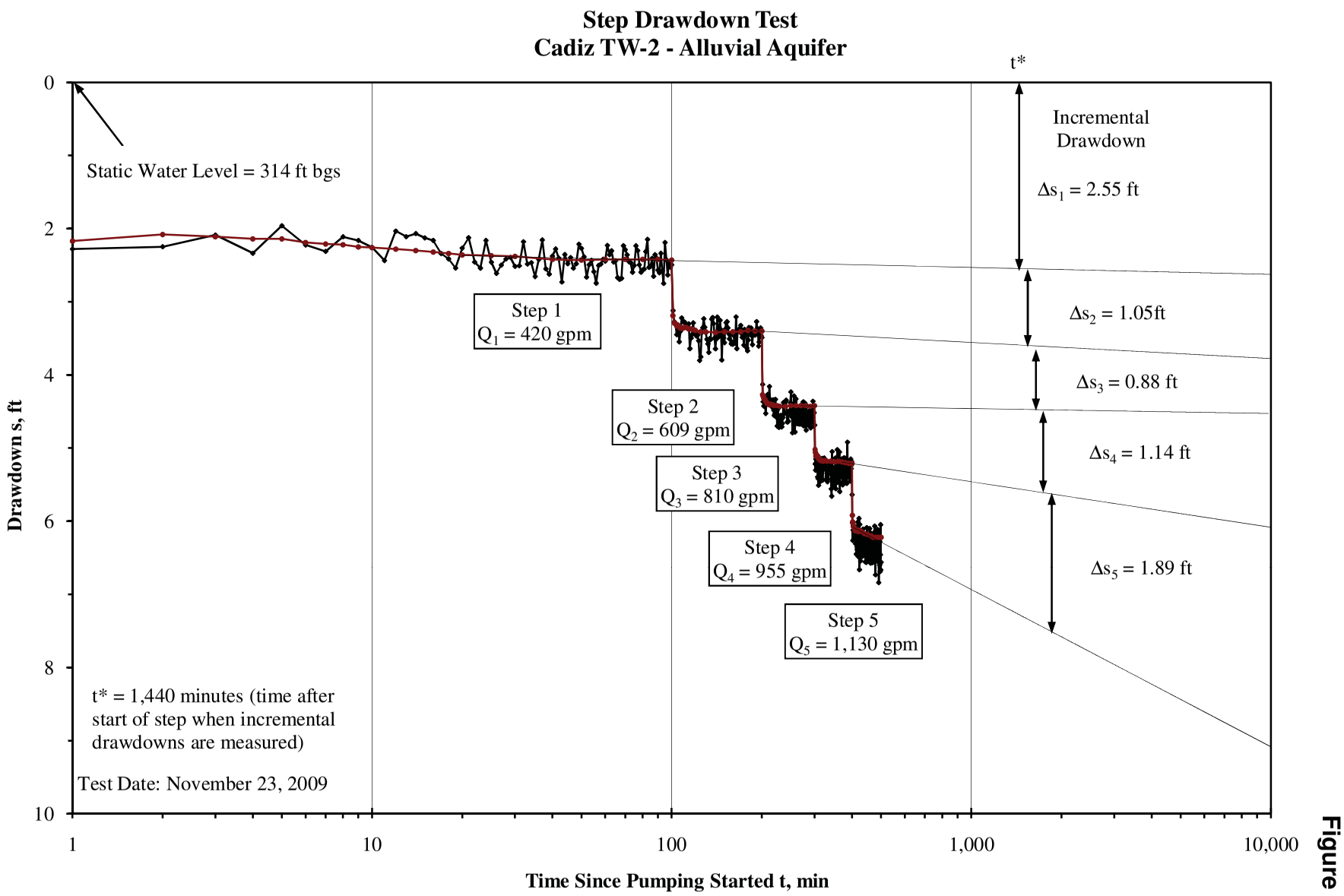

Step Drawdown Test
Cadiz TW-2 - Alluvial Aquifer
t*
Incremental Drawdown
Δs1 = 2.55 ft
Static Water Level = 314 ft bgs
Step 1
Q1 = 420 gpm
Δs2 = 1.05ft
Step 2
Q2 = 609 gpm
Δs3 = 0.88 ft
Step 3
Q3 = 810 gpm
Δs4 = 1.14 ft
Step 4
Q4 = 955 gpm
Δs5 = 1.89 ft
Step 5
Q5 = 1,130 gpm
t* = 1,440 minutes (time after start of step when incremental drawdowns are measured)
Test Date: November 23, 2009
Drawdown s, ft
0
2
4
6
8
10
1
10
100
1,000
10,000
Time Since Pumping Started t, min

Figure 21

Specific Drawdown Graph
Cadiz - TW-2 Alluvial Aquifer

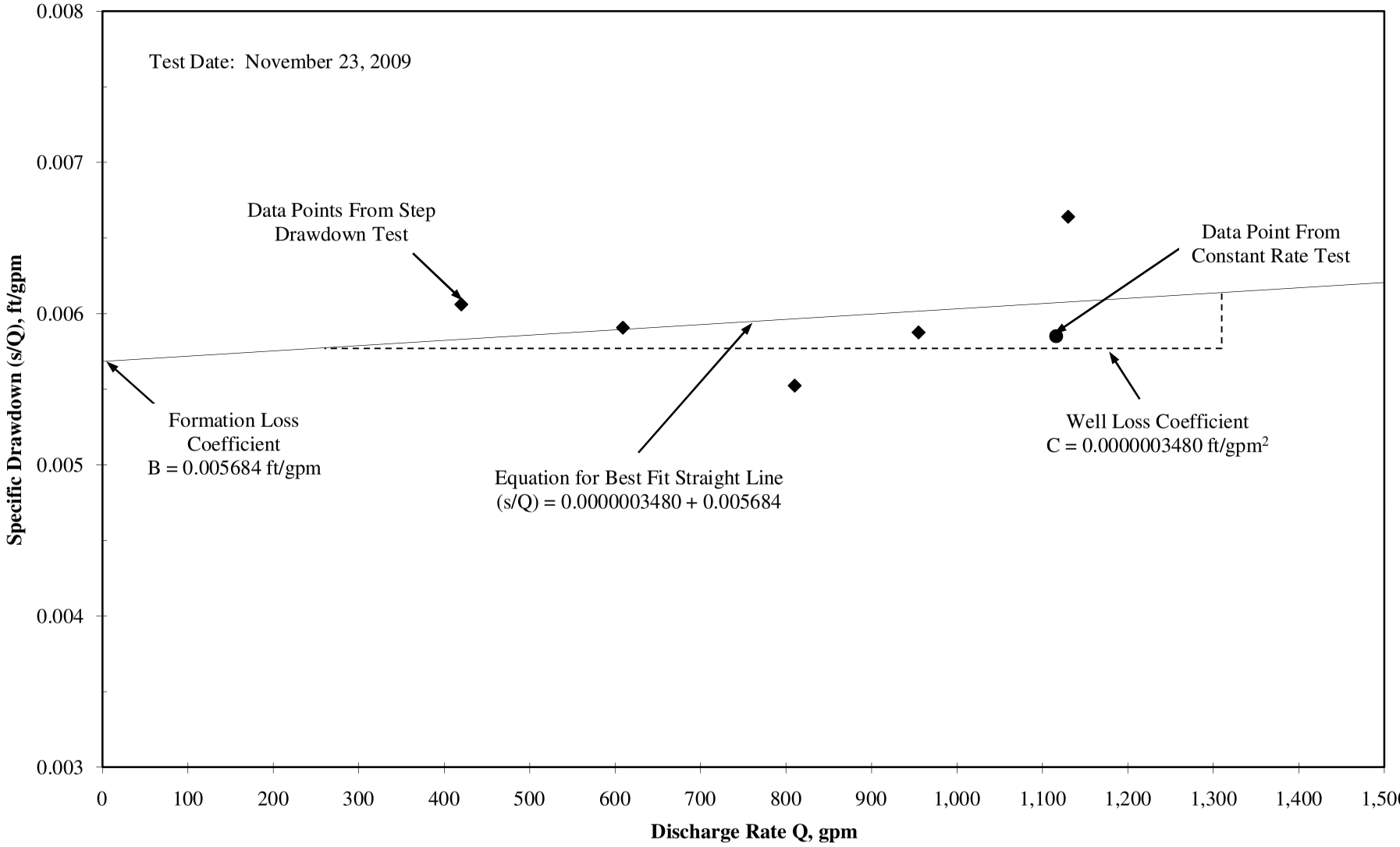


Figure 22

Equation of Best Fit Straight Line
y = 0.03339640 + 0.00004761x

Specific Capacity and Well Efficiency Diagram
Cadiz TW-2 - Alluvium

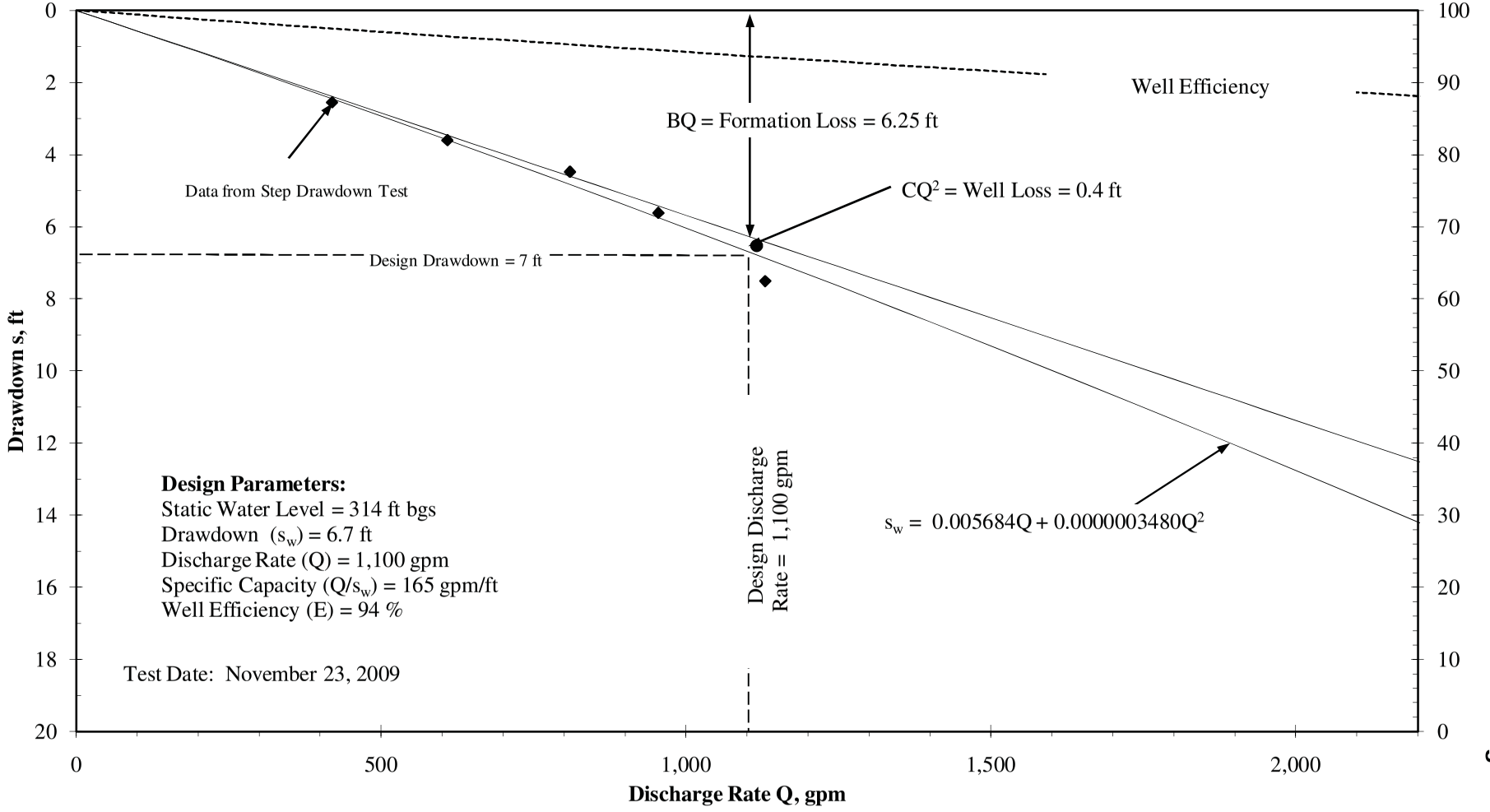


Figure 23

Constant Rate Pumping Test
Cadiz TW-2 - Alluvial Aquifer

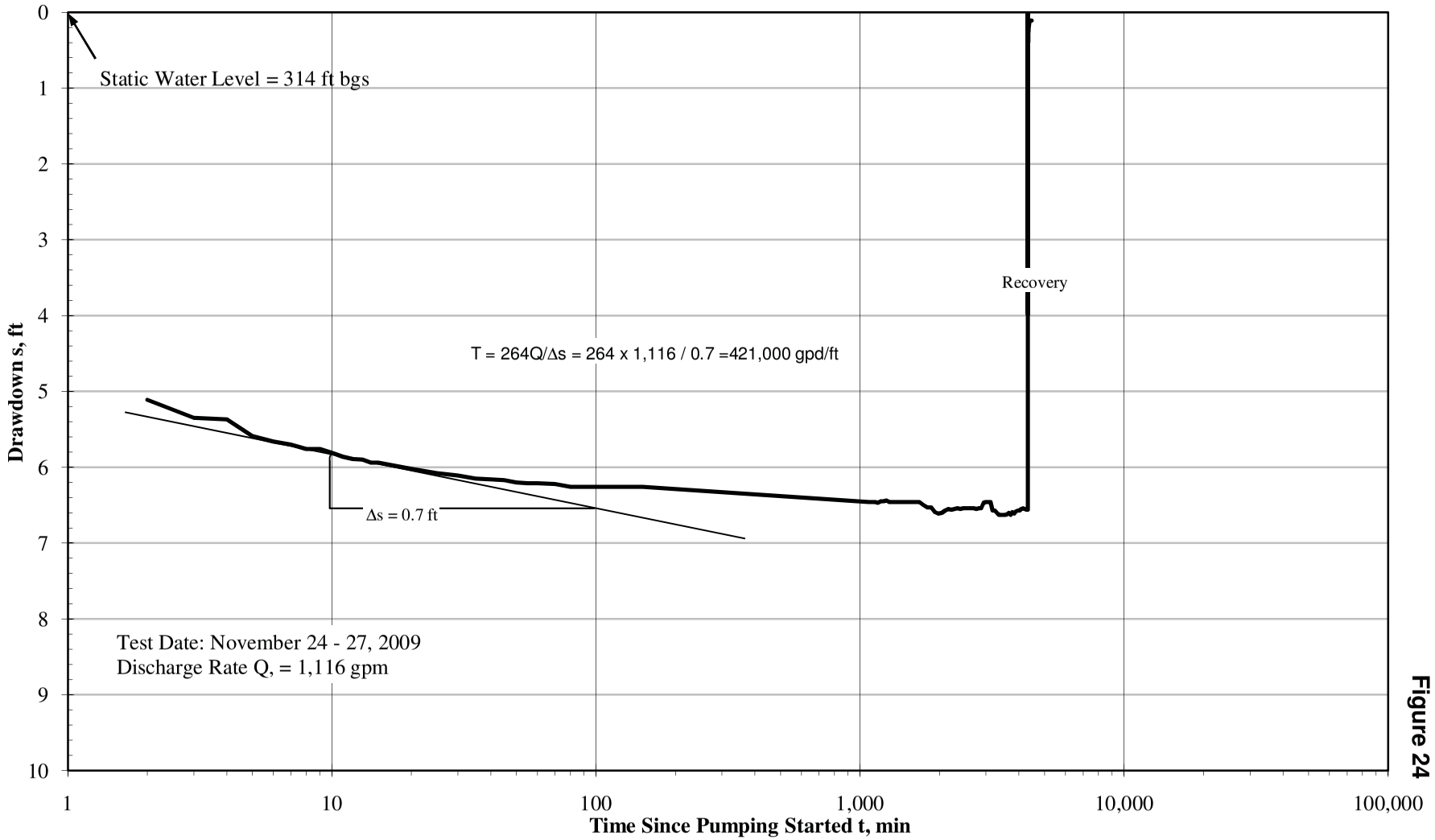


Figure 24

Calculated Recovery
Cadiz TW-2 - Alluvial Aquifer

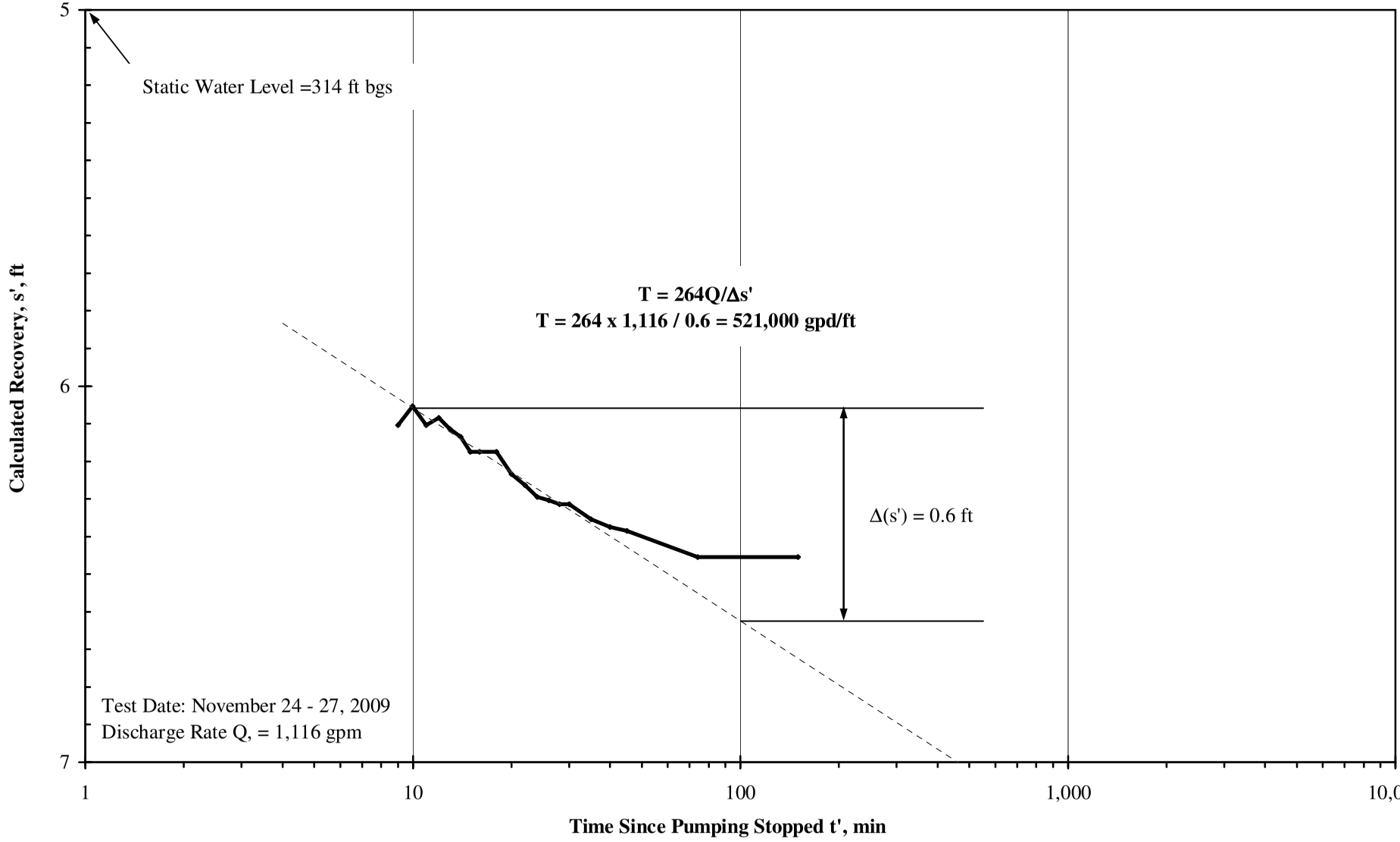


Figure 25

Calculated Recovery
Cadiz TW-2 - Alluvial Aquifer

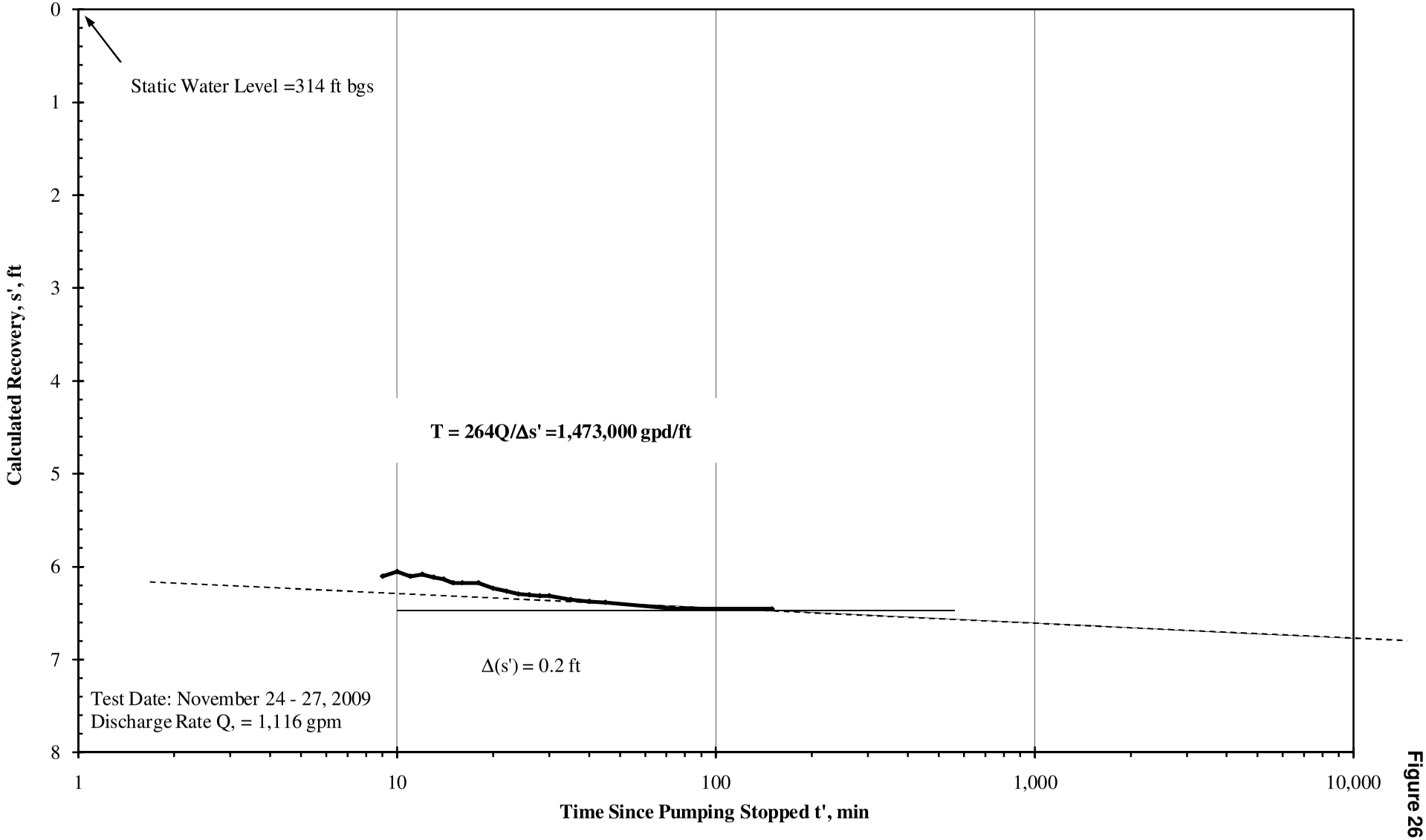


Figure 26

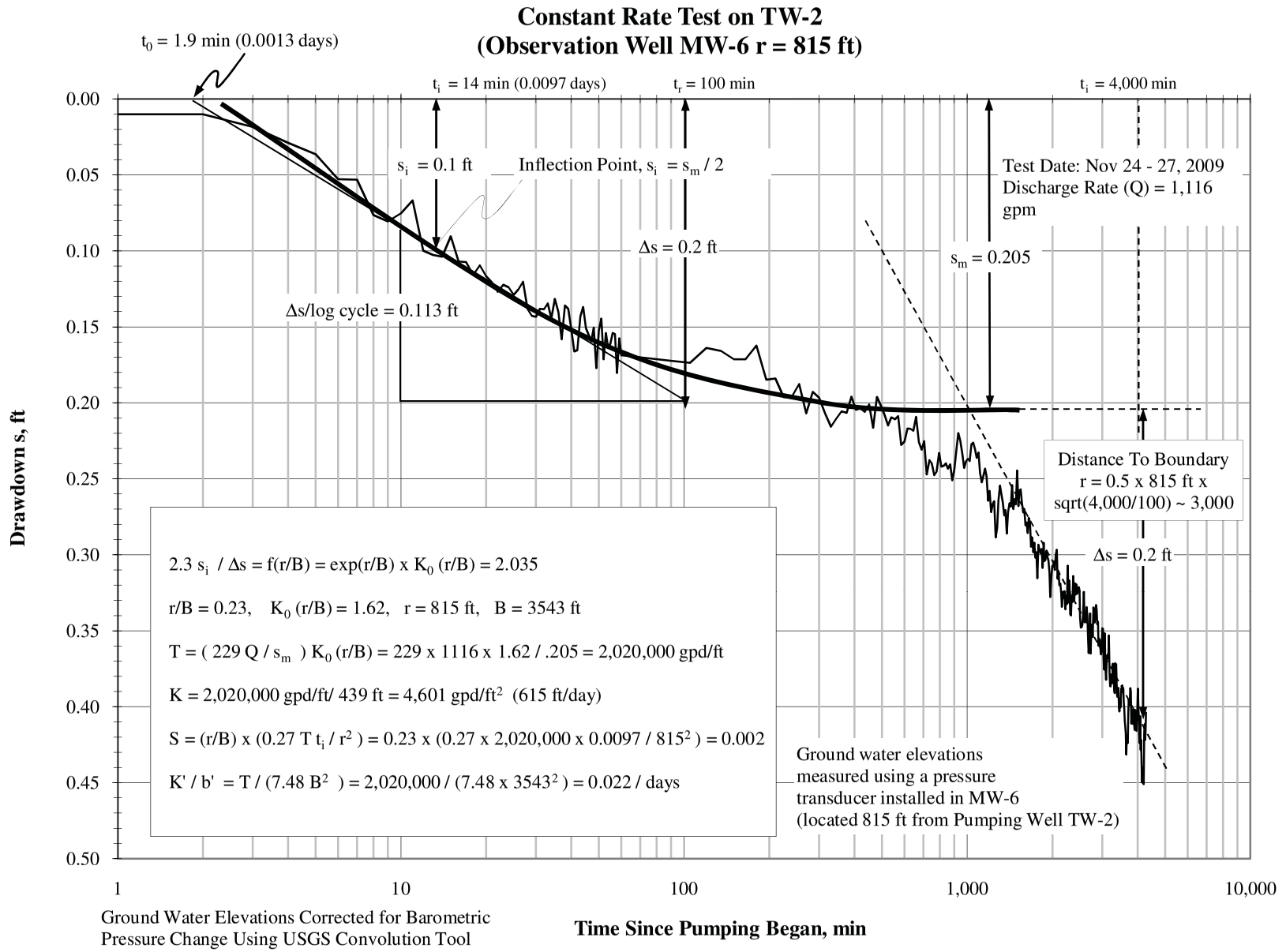

Constant Rate Test on TW-2
(Observation Well MW-6 r = 815 ft)
t0 = 1.9 min (0.0013 days)
ti = 14 min (0.0097 days)
tr = 100 min
ti = 4,000 min
si = 0.1 ft
Inflection Point, si = sm / 2
Δs = 0.2 ft
Δs/log cycle = 0.113 ft
sm = 0.205
Test Date: Nov 24 - 27, 2009
Discharge Rate (Q) = 1,116 gpm
Distance To Boundary
r = 0.5 x 815 ft x sqrt(4,000/100) ~ 3,000
Δs = 0.2 ft
2.3 si / Δs = f(r/B) = exp(r/B) x K0 (r/B) = 2.035
r/B = 0.23, K0 (r/B) = 1.62, r = 815 ft, B = 3543 ft
T = (229 Q / sm) K0 (r/B) = 229 x 1116 x 1.62 / .205 = 2,020,000 gpd/ft
K = 2,020,000 gpd/ft/ 439 ft = 4,601 gpd/ft2 (615 ft/day)
S = (r/B) x (0.27 T ti / r2) = 0.23 x (0.27 x 2,020,000 x 0.0097 / 8152) = 0.002
K' / b' = T / (7.48 B2) = 2,020,000 / (7.48 x 35432) = 0.022 / days
Ground water elevations measured using a pressure transducer installed in MW-6 (located 815 ft from Pumping Well TW-2)
Drawdown s, ft
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
1
10
100
1,000
10,000
Ground Water Elevations Corrected for Barometric Pressure Change Using USGS Convolution Tool
Time Since Pumping Began, min

Figure 27

Calculated Recovery
Cadiz Well TW-2 - Alluvial Aquifer
(Observation Well MW-6 r = 815 ft)

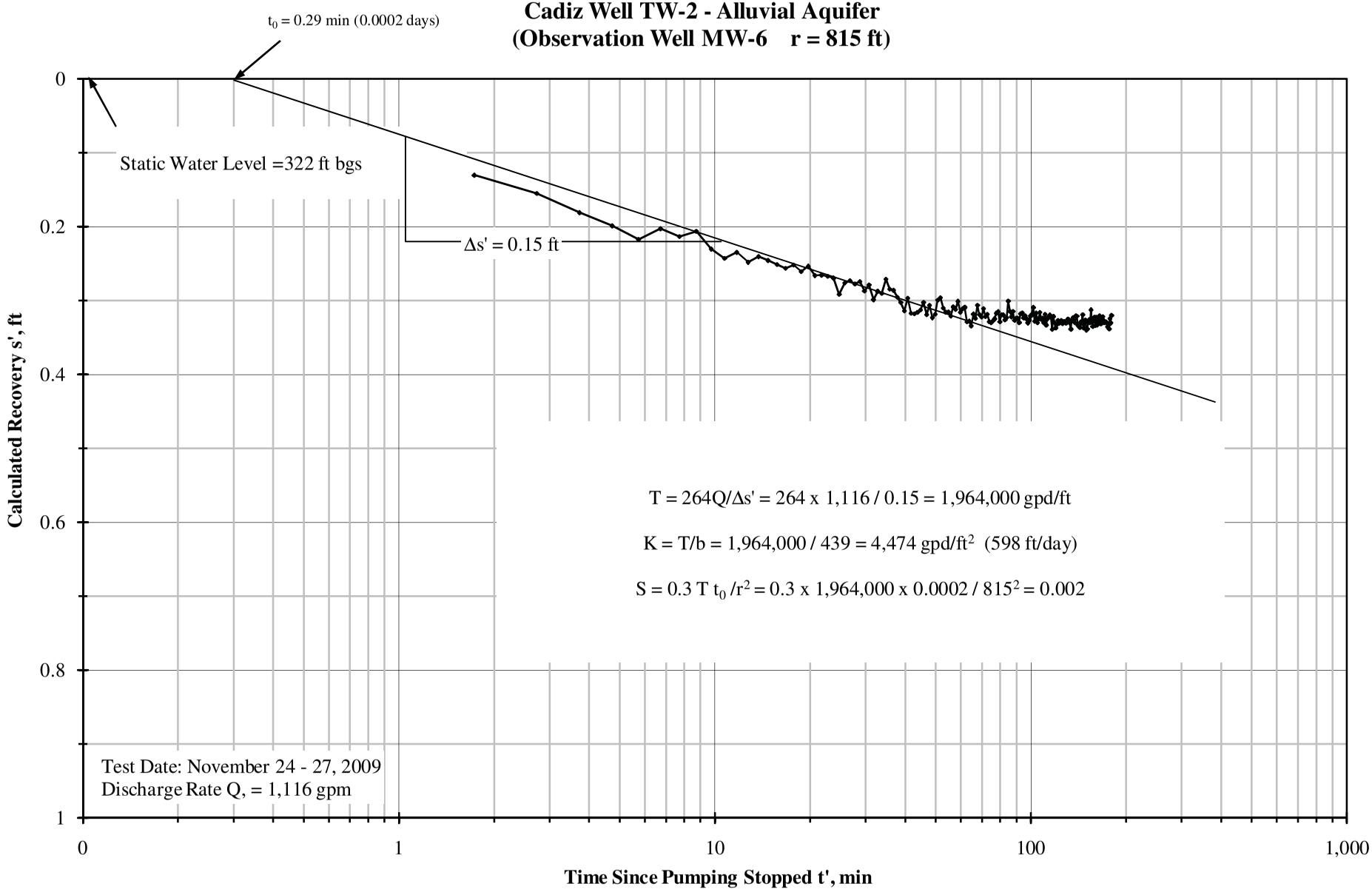
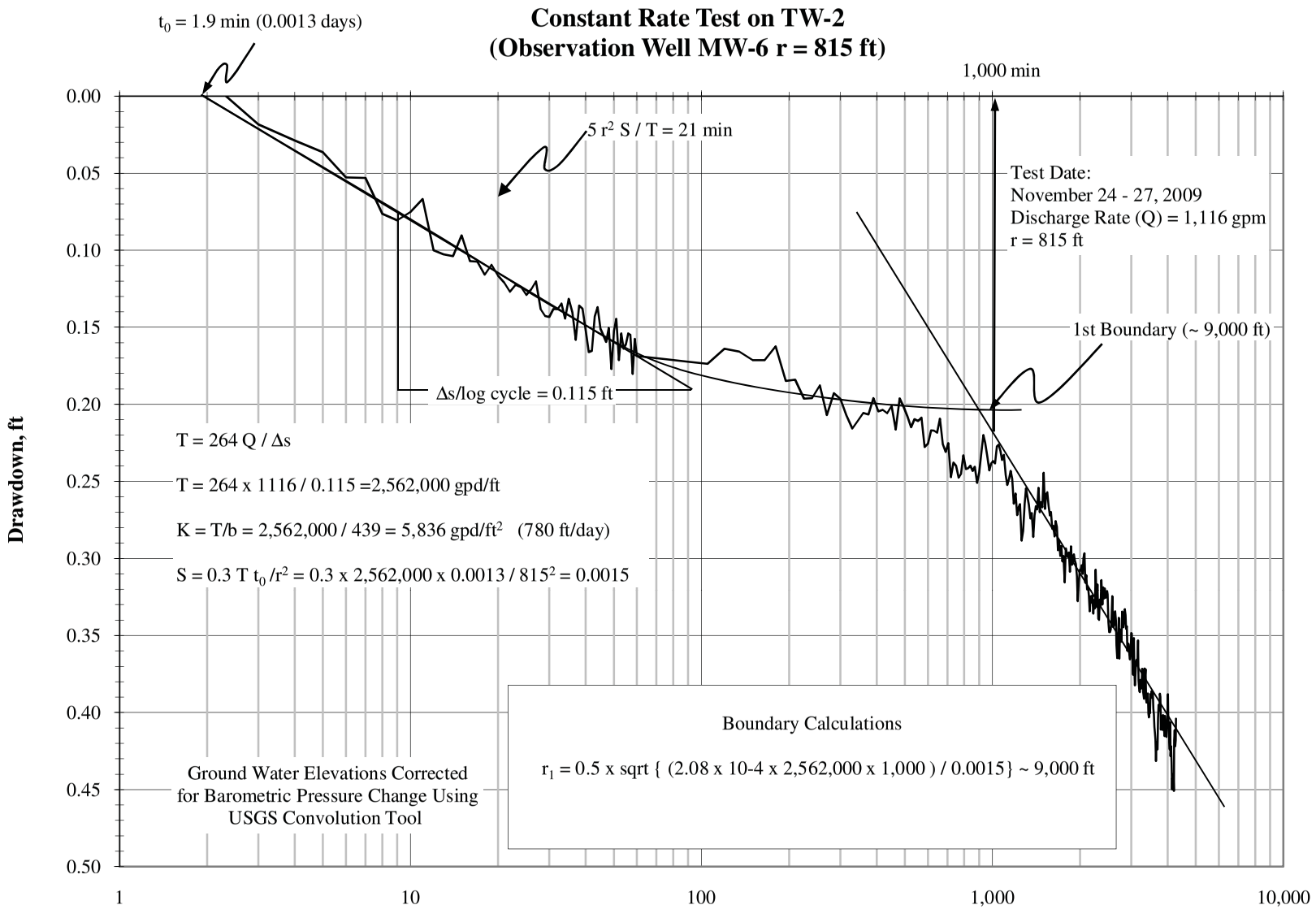


Figure 28



Ground water elevations measured using a pressure transducer installed in MW-6 (located 815 ft from Pumping Well TW-2)

Figure 29

Constant Rate Test
TW2-MW (Observation Well)

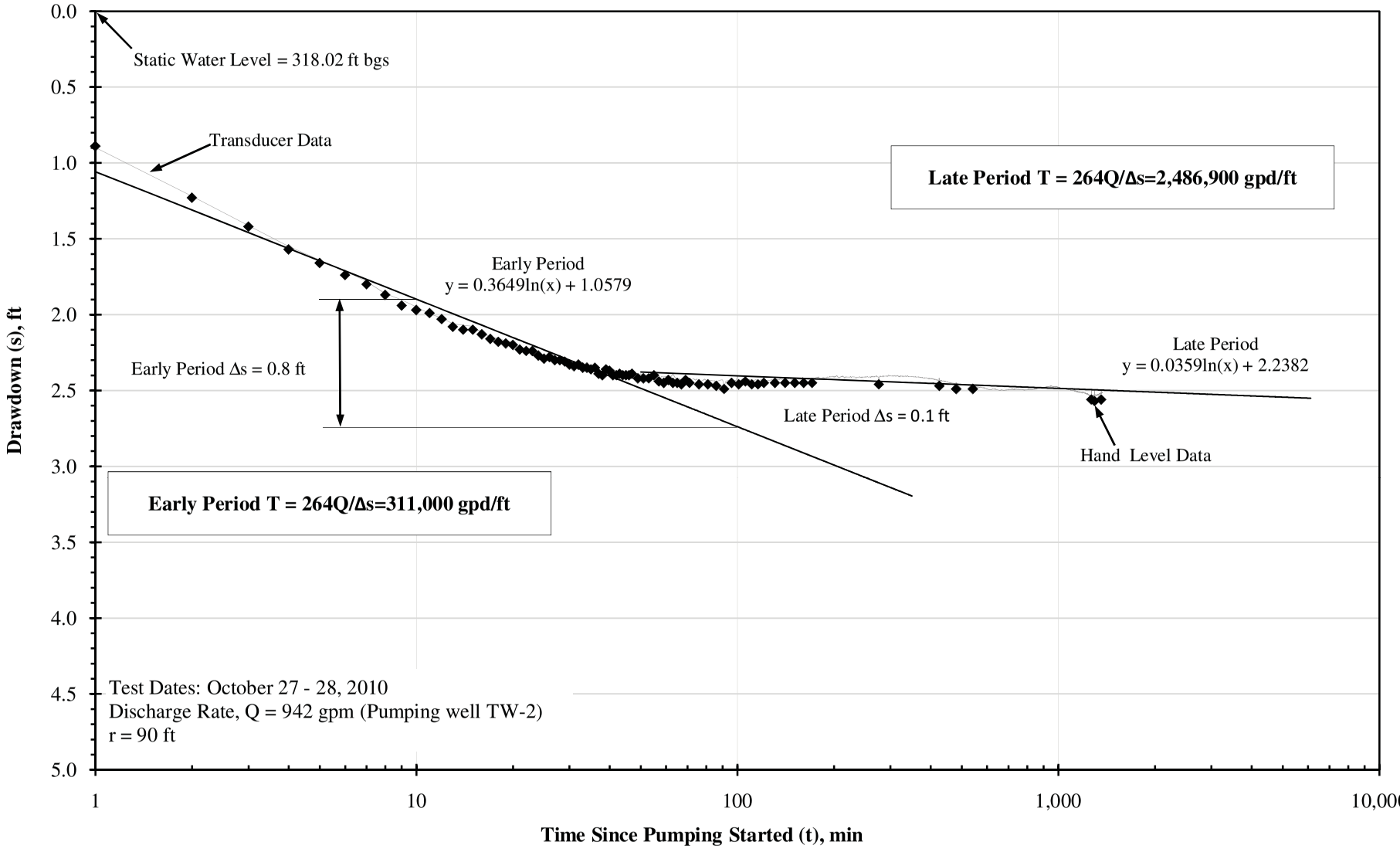


Figure 30

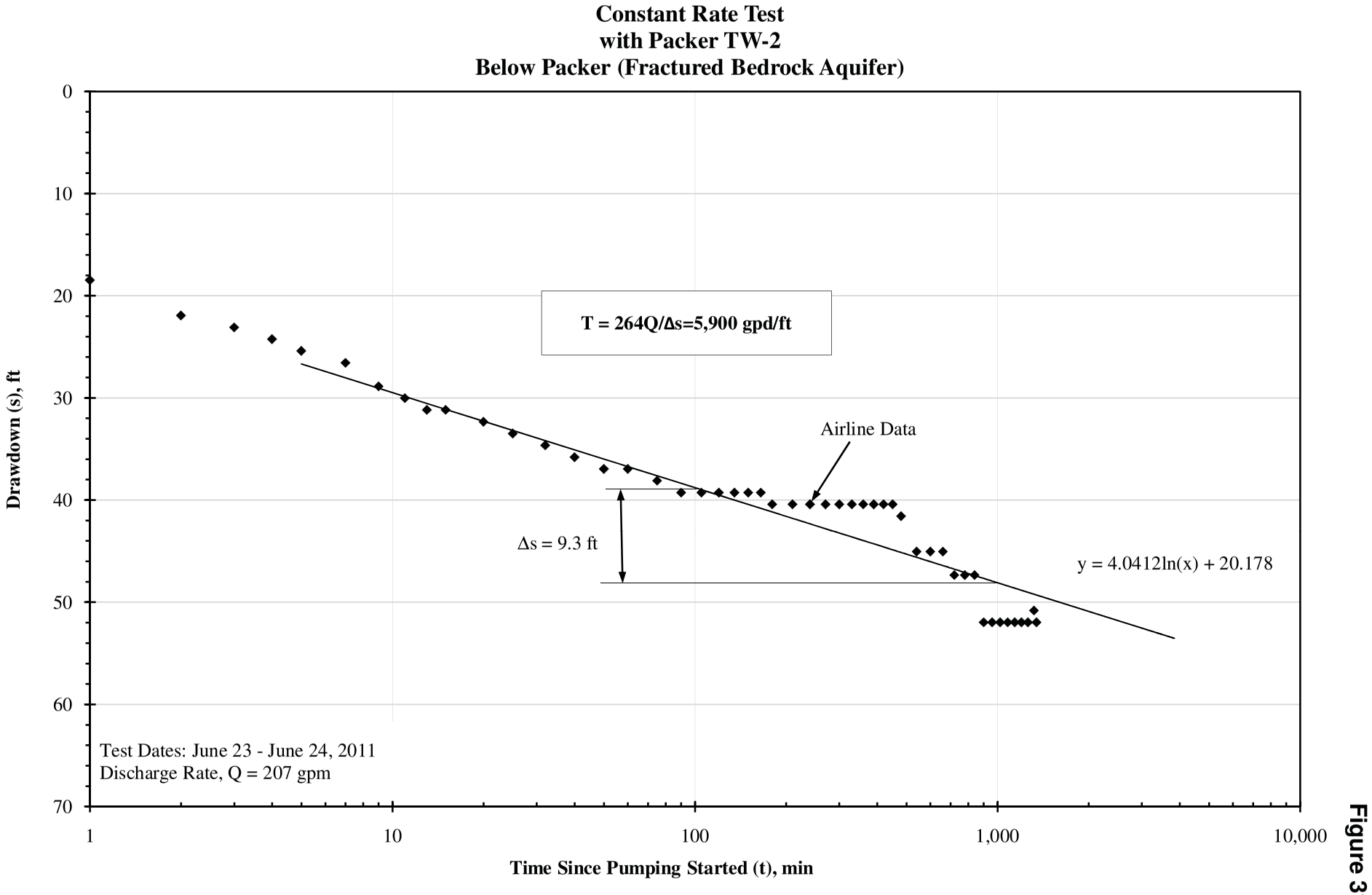

Constant Rate Test
with Packer TW-2
Below Packer (Fractured Bedrock Aquifer)
T = 264Q/Δs=5,900 gpd/ft
Airline Data
Δs = 9.3 ft
y = 4.0412ln(x) + 20.178
Test Dates: June 23 - June 24, 2011
Discharge Rate, Q = 207 gpm
Drawdown (s), ft
Time Since Pumping Started (t), min
0
10
20
30
40
50
60
70
1
10
100
1,000
10,000

Figure 31

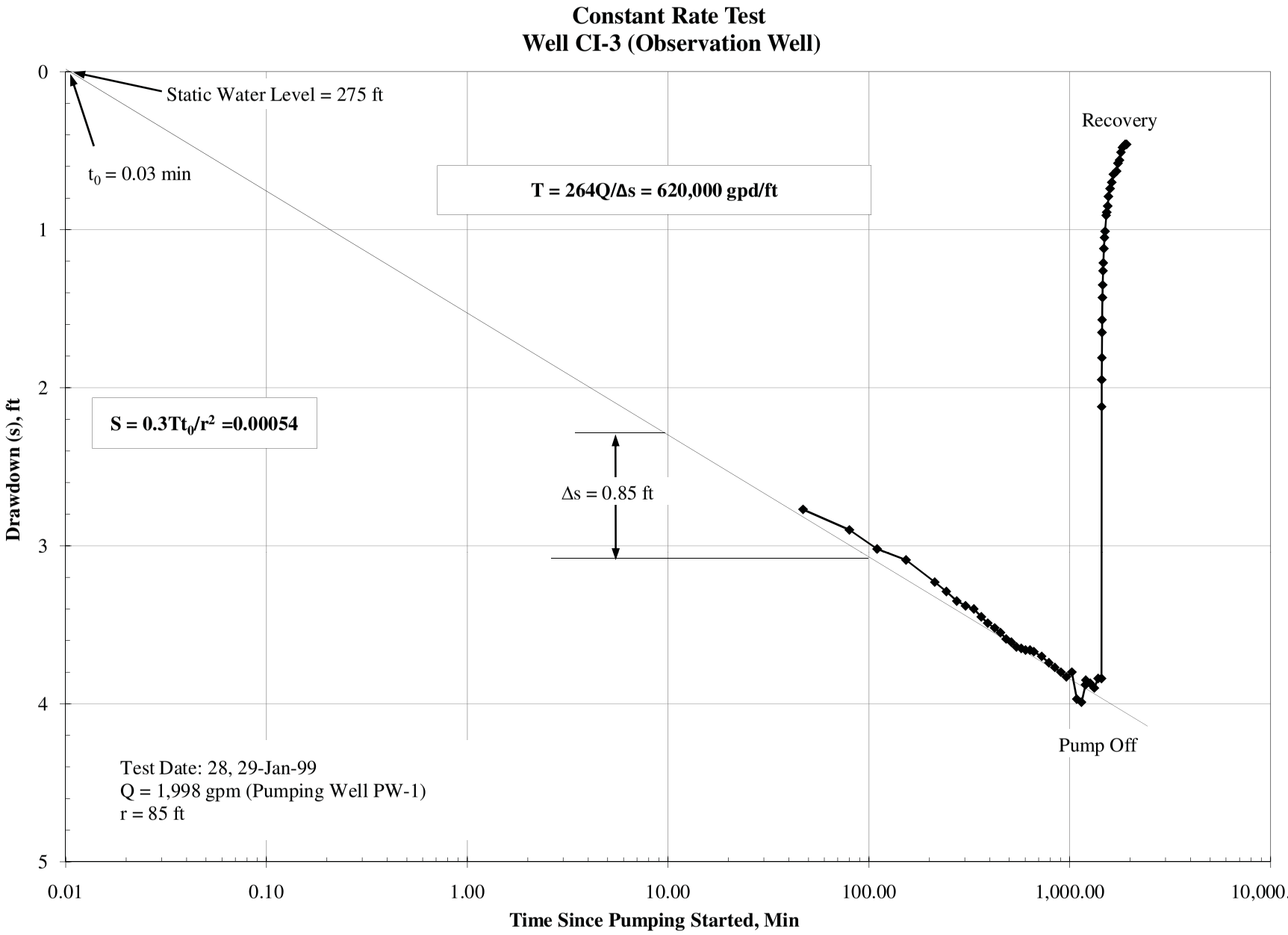

Constant Rate Test
Well CI-3 (Observation Well)
Static Water Level = 275 ft
t_0 = 0.03 min
T = 264Q/Δs = 620,000 gpd/ft
S = 0.3Tt$_0$/r^2 =0.00054
Δs = 0.85 ft
Recovery
Pump Off
Test Date: 28, 29-Jan-99
Q = 1,998 gpm (Pumping Well PW-1)
r = 85 ft
Drawdown (s), ft
0
1
2
3
4
5
0.01
0.10
1.00
10.00
100.00
1,000.00
10,000.00
Time Since Pumping Started, Min

Figure 32

TABLES

TABLE 1 - Summary of Pumping Tests and Aquifer Parameters, Fenner Gap Area **Table 1**

Well Being Analyzed	Report Figure	Aquifer	Pumping Well	Distance to Pumping Well	Type of Test	Date of Test	Discharge Rate	Type of Analysis	Formation Loss Coefficient B	Well Loss Coefficient C	Transmissivity T	Storativity S	Leakance K'/b'	Saturated Thickness b	Hydraulic Conductivity K	
				[ft]			[gpm]		[ft/gpm]	[ft/gpm^2]	[gpd/ft]		[1/day]	[ft]	[gpd/ft^2]	[ft/day]
CH-1		Fanglomerate	CH-1	-	Falling Head Test*	18-Oct-10		Bouwer-Rice						171		0.007
CH-1		Fanglomerate	CH-1		Falling Head Test*	18-Oct-10		Cooper-Bredehoeft-Papadopulos			9			171	0.052	0.007
CI-3	32	Alluvial	PW-1	85	Const. Rate	28-29 Jan-99	1,998	Jacob			620,000	0.00054		525	1,181	157.88
DT-1		Alluvial	DT-1		Step-Rate Injection Test 1* (473 to 523 ft bgs)	13-Jan-11		Theis (confined)			655			50	13.090	1.75
DT-1		Alluvial	DT-1		Step-Rate Injection Test 1* (473 to 523 ft bgs)	13-Jan-11		Jacob-Rorabaugh			302			50	6.044	0.81
DT-1		Alluvial	DT-1		Step-Rate Injection Test 1* (473 to 523 ft bgs)	13-Jan-11		Theis Recovery			214			50	4.279	0.57
DT-1		Alluvial	DT-1		Step-Rate Injection Test 2* (500 to 935 ft bgs)	15-Jan-11		Jacob-Rorabaugh			4,772			435	10.971	1.47
DT-1		Quartzite	DT-1		Step-Rate Injection Test 3* (935 to 1,137 ft bgs)	14-Feb-11		Jacob-Rorabaugh			609			202	3.014	0.4
DT-1		Quartzite-Granite	DT-1		Step-Rate Injection Test 4* (935 to 1,324 ft bgs)	17-Feb-11		Jacob-Rorabaugh			703			389	1.808	0.24
MW-6	27	Alluvial	TW-2	815	Const. Rate	24-27 Nov-09	1,116	Hantush-Leaky	Boundary at ~ 3,000 ft from TW-2		2,020,000	0.002	0.02	439	4,601	615
MW-6	28	Alluvial	TW-2	815	Calc Recovery	24-27 Nov-09	1,116	Jacob			1,964,000	0.002		439	4,474	598
MW-6	29	Alluvial	TW-2	815	Const. Rate	24-27 Nov-09	1,116	Strausberg	Boundary at ~ 9,000 ft from TW-2		2,562,000	0.0015		439	5,836	780
MW-7	18	Carbonate	TW-1	83	Const. Rate	9-12 Nov-09	1,168	Jacob			3,083,500	0.012		403	7,651	1,023
MW-7	19	Carbonate	TW-1	83	Calc Recovery	9-12 Nov-09	1,168	Jacob			1,814,000	0.007		403	4,501	602
MW-7	20	Carbonate	TW-1	83	Dist to Bound	9-12 Nov-09	1,168	Strausberg	Boundaries at ~ 1,000 ft and 4,000 ft from TW-1							
MW-7a	14	Alluvial	TW-1	83	Const. Rate	3-4, Dec-09	261	Hantush-Leaky			23,500	0.008	0.26	85	276	37
TW-1	15	Carbonate	TW-1	0	Step Drawdown	8-Nov-09	291 - 1,168	Hantush								
TW-1	10	Alluvial	TW-1	0	Step Drawdown	2-Dec-09	181 - 383	Hantush								
TW-1	11	Alluvial	TW-1	0	Specifc Drawdown	2-Dec-09	181 - 383	Hantush	0.0062	7.40E-04						
TW-1	12	Alluvial	TW-1	0	Specific Capacity	2-Dec-09	181 - 383	Hantush								
TW-1	13	Alluvial	TW-1	0	Const. Rate	3-4, Dec-09	261	Jacob			5,600					
TW-1	16	Carbonate	TW-1	0	Const. Rate	9-12 Nov-09	1,168	Thermal Expansion								
TW-1	17	Carbonate	TW-1	0	Const. Rate	9-12 Nov-09	1,168	Mace			2,832,800			403	7,029	940
TW-2	21	Alluvial	TW-2	0	Step Drawdown	23-Nov-09	420 -1,130	Hantush								
TW-2	22	Alluvial	TW-2	0	Specifc Drawdown	23-Nov-09	420 -1,130	Hantush	0.0005684	3.48E-07						
TW-2	23	Alluvial	TW-2	0	Specific Capacity	23-Nov-09	420 -1,130	Hantush								
TW-2	31	Fractured Bedrock			Contant Rate - Packer Test	23-24 Jun-11	207	Jacob			5,900			40 - 171		19.7 - 4.6
TW-2	24	Alluvial	TW-2	0	Const. Rate	24-27 Nov-09	1,116	Jacob			421,000			465	905	121
TW-2	25	Alluvial	TW-2	0	Calc Recovery	24-27 Nov-09	1,116	Jacob			521,000			465	1,120	150
TW-2	26	Alluvial	TW-2	0	Calc Recovery	24-27 Nov-10	1,116	Jacob			1,473,000			465	3,168	423
TW2-MW	30		TW-2	90	Const. Rate (Early period)	27-28 Oct-10	942	Jacob			311,000			392	793	106
TW2-MW	30		TW-2	90	Const. Rate (Late period)	27-28 Oct-10	942	Jacob			2,486,900			392	6,344	848

* Analysis conducted by CH2MHill; Exploratory Drilling, Testing, and Well Completion Report Fenner Gap Area. August 2011.

TABLE 2 - Hydraulic Conductivity of Fractured Rock

Rock Type (Conditions)	Hydraulic Conductivity (ft/day)			Reference
	Min	Mean	Max	
Granite (weathered)	1	7.5	14	Morris, D. A., and A. I. Johnson, 1967. Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U. S. Geological Survey 1948-60.
Quartzite (fractured; values from field pumping tests)	5.387E-04	1.04895	7.371	Wolff, Roger, G., 1982. Physical Properties of Rocks: Porosity, permeability, distribution coefficients, and dispersivity.
Granite-diorite-gabbro (coarse grained, fractured; data from field pumping tests)	1.332E-03	1.1907	11.907	
Igneous-metamorphic (undifferentiated, fractured; data from field pumping tests)	2.665E-04	0.240975	53.865	
Fractured Rock	9.010E-04	5.15	10.3	"Determining the Permeability of Fractured Rocks Based on Joint Mapping" by Zhang, F. 2004. Groundwater, Jul-Aug 2004, 44(4) 509-15.
Fractured Granite	2.830E-06	1.42	2.83	"Distribution of hydraulic conductivity in fractured compact granite" by Rukavikova, L., et al. 2008. http://www.cprm.gov.br/33IGC/1259273.html
Fractured Igneous and Metamorphic Rock	3.280E-03	16.40	32.8	"Groundwater and Wells" by Driscoll, F. G. 1986. Johnson Division, St Paul, MN
Fractured Igneous and Metamorphic Rock	4.230E-03	119.00	238	“Groundwater Hydrology” by Todd, D. K. and Mays L. W. 2005. John Wiley and Sons, Hoboken, NJ
Fractured Igneous Rock	2.830E-05	14.15	28.3	"Hydrogeological Characteristics of Major Fracture Zones in a Granite Batholith of the Canadian Shield" by Davidson, C.C., et al. 1993. National Ground Water Association Online Publication.
Fractured Granite	2.230E-04	0.17	0.346	"Relationship between hydraulic conductivity and fracture properties estimated from packer tests and borehole data in a fractured granite." by Hamm, S., et al. 2007. Engineering Geology, Vol. 92 Issue 1-2, pg 73-87.
Range	2.83E-6 - 4.23E-3	0.17 - 119.00	0.346 - 238	
Average	0.1	16.6	40.0	

Table 2

APPENDIX A

Soil Boring Log – TW-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Bucket Auger	Grab			None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, sand is subangular, includes <10% fines to 1/2 gravel, angular to subangular	Grab samples from Bucket Auger Rig crew
10					None		**SILTY SAND WITH GRAVEL (SM)** as above, except gravel fraction is up to 20%	
20					None		**SILTY SAND (SM)** as above	
30					None			
40					None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, subangular; includes ~5% fines to 3/4 inch gravel (angular)	
50	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 3/4), sand is fine to medium, subangular	Samples collected by direct mud rotary drilling. Note: That samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
60					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
					None			
80					None			
					None			
90					None			
					None			
100					None			
					None			
110					None		**POORLY GRADED SAND (SP)** as above	
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
140					None			
150					None			
160								
170	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
190					None		**POORLY GRADED SAND (SP)** above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
200					None			
210					None			
220					None		**WELL GRADED SAND WITH GRAVEL (SW)** fine sand to fine gravel, subangular	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
250					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
260					None			
270					None			
280					None			
290					None			
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
310					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
320					None			
330					None			
340					None			
350					None			
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
370					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
380					None			
390					None			
400					None			
410					None			
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None			
					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
440					None			
450					None			10" steel casing placed in the alluvial portion of the well. Casing is landed without a bottom in rock at ~454' bgs. Airlift swab development of the screened section of the 10-inch casing in alluvial portion of the well.
460	Dual Tube Reverse	Grab			Slight		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	Begin drilling at 454' bgs via dual tube reverse air rotary without additives.
470					Strong			Munsell color chart used for descriptions below 458' bgs.
480								10/23/2009 (14:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including crystals up to 1/8 inch, chips up to 1 inch, subangular to angular	
					Strong			
500					Moderate		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	10/23/2009 (16:09)
510					Strong			
520					Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including	10/23/2009 (22:30)
530					Strong		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	
540								10/24/2009 (06:12)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab			Strong		**DOLOMITE** light greenish gray (10BG 7/1), as chips up to 1/2 inch, abundant of alteration/secondary mineralization	
					Strong			
560					Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	10/24/2009 (16:09)
570					Strong			
580					Strong			10/24/2009 (22:20)
590					Strong			
600								10/25/2009 (09:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab			Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	
					Strong			
620					Strong			10/25/2009 (14:40)
630					Strong			
640					Strong			10/25/2009 (17:42)
650					Slight			
660								10/25/2009 (21:25)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			Moderate		**DOLOMITE** dark bluish gray (5B 4/1), cuttings are much smaller 1/64 to 1/16 inch, suggesting different hardness	
					Strong			
680					Strong			10/26/2009 (03:57)
690					Moderate		**DOLOMITE** multicolored 1/8 to 1/2 inch chips, colors range from dark bluish gray (5B 4/1), to light bluish gray (5PB 8/1)	
700					Moderate			10/26/2009 (07:56)
710					Strong			
720								10/26/2009 (12:06)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
730					Moderate		**DOLOMITE** as above, except overall sample color is darker (90%+), dark bluish gray (10B 4/1)	10/26/2009 (14:02)
740					Strong			10/26/2009 (16:25)
750					Slight			10/26/2009 (17:35)
760					Strong			10/26/2009 (20:30)
770					Strong		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
780								10/27/2009 (00:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
790					Moderate		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
800					Slight			10/27/2009 (05:14)
810					Slight			
820					Slight			10/27/2009 (08:51)
830					Slight			
840								10/27/2009 (13:24)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
850					None		**DOLOMITE** as above, except clasts are multicolored gray and orange primarily, orange and lighter colored clasts may be interbeds of shales and/or sandy limestone	10/27/2009 (15:53)
860					Slight		**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/27/2009 (17:54)
870					Moderate			
880					Slight			10/28/2009 (21:30)
890					Moderate			
900							**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/28/2009 (01:38)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
910					Strong		**SANDY LIMESTONE** dark bluish gray (10B 4/1), sand is very fine to fine in a matrix of limestone	
920					Moderate			10/28/2009 (04:53)
930					Moderate			
940					Moderate			10/28/2009 (08:24)
950					Slight			
960								10/28/2009 (12:40)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Dual Tube Reverse	Grab			Slight		**SANDY LIMESTONE** as above	
980					Slight			
990					Slight			
1000					Slight			
1010							End of Boring	Total depth of borehole = 1,002' bgs
1020								

APPENDIX B

Soil Boring Log – TW-2

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Bucket Auger	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	Grab samples from Bucket Auger Rig crew.
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** yellowish brown (10YR 5/4), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		as above, dark grayish brown (10YR 4/2), coarse sand to gravel, more well rounded (subrounded)	
30					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), fine to medium sand (60%), coarse sand to fine gravel, angular to subrounded	
40	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel, some coarse gravel (15%) (up to 55mm), subangular to subrounded, coarse sand (15%)	Sample collected by flooded reverse rotary drilling. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (5Y 4/2), fine gravel (subrounded) with coarse sand (40%)	
100					None			
110					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), subangular to subrounded	
120					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, some coarse gravel (5%)	
					None			
140					None			
150					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, sand fraction ~40%-50%, mostly coarse sand	
200					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), mostly medium to coarse sand, some fine gravel	
210					None			
220					None		as above, % fine gravel increasing (40%)	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
					None		as above, gravel fraction decreasing (20%)	
260					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some gravel (10%) and fines (5%)	
270					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), fine to coarse sand with fine gravel (30%)	
280					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some fine gravel (10%), and fines (5%)	
290					None		as above, sand is coarser	
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above	
					None			
320					None			
330					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), mostly medium to coarse sand, some fine sand, fine gravel (20%)	
340					None		**CLAYEY SAND (SC)** yellowish brown (10YR 5/4), medium to coarse sand, some fine gravel with fines (20%)	
350					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None		as above, % gravel decreasing (20%)	
380					None			
390					None		as above, trace coarse gravel	
400					None		as above, % gravel increasing (40%)	
410					None		as above, 50/50 coarse to fine gravel (40%), gravel up to 60mm (angular to subrounded), some weathered lithics	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel all fine gravel (40%)	
					None		gravel is fining, maximum diameter 10 mm, more fine sand than above (20%)	
440					None		gravel is all fine gravel (25%), trace clayey sand balls	
450					None		**POORLY GRADED SAND (SP)** dark yellowish brown (10YR 4/4), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		**SILTY SAND (SM)** yellowish brown (10YR 5/6), fine to coarse sand, trace fine gravel, fines (40%), soft, low plasticity	
470					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with some fine sand, fine gravel (40%), angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (25%), trace coarse gravel	
					None		**SILTY SAND (SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (15%)	
500					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (40%)	
510					None		as above, % gravel decreasing (20%)	
520					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
530					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, fine gravel (20%), silt (10%)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None		**SILTY SAND (SM)** brown (10YR 5/3), fine to coarse sand, silt (15%), fine gravel (10%)	
550					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, silt (10%), fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None		as above, % fine gravel increasing (30%)	
570					None			
580					None			
590					None			
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** medium to coarse sand with fine sand (10%), and fine gravel (30%) (angular to subangular)	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine to coarse gravel (70/30) angular to subrounded, with medium to coarse sand	
620					None			
630					None		as above, no coarse gravel, fines (5%)	
640					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** medium to coarse sand with silt (10%), and fine sand, fine gravel (35%) (angular to subrounded)	
650					None			
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Mud Rotary	Grab			None		**SILTY SAND WITH GRAVEL (SM)** brown (10YR 5/3), fine to coarse sand with silt (20%), and fine gravel (25%) (subangular to rounded)	
					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), with silt (10%), and fine gravel (30%) (angular to subrounded)	
680					None			
					None			
690					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel (angular to subrounded), with medium to coarse sand, trace fines and fine sand	
700					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), some fine sand and fines	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None		**LEAN CLAY (CL)** as above	
730					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand (more coarse), with fine gravel (rounded to angular), and silt	
740					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, trace fine sand and fines	
750					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (subangular to subrounded)	
760					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay with fine to coarse sand (30%)	
770					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand (10%), some weathered lithics	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, and fines (10%)	
					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay as above with fine sand to fine gravel (40%)	
800	Dual Tube Reverse				None		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), mostly fine sand, little medium sand, trace fine gravel (subrounded), trace coarse sand (subrounded)	10" steel casing landed at 799' bgs. Airlift swab/pump development and aquifer testing of the screened section of the 10-inch casing in alluvial portion of the well.
810					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), mostly medium to coarse sand (angular to subrounded), some fine gravel (subangular to subrounded), granitic and volcanic in composition	Resume drilling at 800' bgs via dual-tube reverse air rotary without additives.
820					None			
830					None		as above, mostly coarse sand, some medium sand (subrounded to subangular), little fine gravel (subangular)	
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, mostly fine to medium sand, little fine gravel (subrounded), granitics and volcanic in composition	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (10YR 4/2), mostly fine to coarse gravel (subrounded to angular), igneous, metamorphics, volcanics, angular broken clasts with oxidized surfaces, some medium to coarse sand (subangular to angular), abundant K-feldspar	
860					None		**CRYSTALLINE BEDROCK** gray (5Y 6/1), granitic, mostly quartz	Approximate alluvium-bedrock contact at 860' bgs.
870					None		light gray (5Y 7/1), granitic, quartz, weathered white feldspar with chalky consistency	
880					None		pinkish gray (5YR 6/2), quartz, less white feldspar, some K-feldspar	
890					None		light gray (5YR 7/1), granitic, weathered white feldspar with chalky consistency	
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** light gray (5YR 7/1), granitic, quartz, K-feldspar, few weathered white feldspar with chalky consistency	
					None		very pale brown (10YR 7/3), granitic, quartz, K-feldspar	
920					None		reddish brown (5YR 5/3), granitic, abundant K-feldspar and quartz, few mafics	
930					None			
940					None		white (5YR 8/1), granitic, quartz, white feldspar (some weathered), chalky consistency	
950					None		reddish brown (5YR 5/3), granitic, K-feldspar, quartz, trace mafics	
960					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Dual Tube Reverse	Grab			None			
					None			
980					None			
990					None		**CRYSTALLINE BEDROCK** white (5YR 8/1), granitic, quartz, white feldspar	
1000					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1010					None			
1020								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1030	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** pinkish gray (5YR 7/2), granitic, Fe-oxide staining, decreasing K-feldspar, weathered mafics	
					None			
1040					None			
1050					None		reddish gray (5YR 5/2), granitic, quartz, some K-feldspar, few mafics	
1060					None			
1070					None			
1080								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1090	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic, quartz, decreasing K-feldspar	
					None			
1100					None		pinkish gray (5YR 7/2), granitic, quartz, K-feldspar	
					None			
1110					None			
1120					None		red gray (5YR 5/2), granitic, increase in K-feldspar	
1130					None			
1140								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1150	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** very dark gray (5YR 3/1), diabase?, mafic, aphanitic texture	
					None		pinkish gray (5YR 7/2), granitic, quartz, white feldspar, few mafics	
1160					None			
1170					None			
1180					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1190					None			
1200					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1210	Dual Tube Reverse	Grab			None			
					None			
1220					None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic	
1230					None			
1240					None		pinkish gray (5YR 6/2), granitic, quartz weathered white feldspar with chalky consistency, decreasing K-feldspar	
1250					None		pinkish gray (5YR 6/2), granitic, some Fe-oxide staining	
1260					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1270	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** red brown (5YR 5/3), granitic, increasing K-feldspar	
					None			
1280					None		light gray (5YR 7/1), granitic, quartz, white feldspar, decreasing K-feldspar	
1290					None			
1300					None		reddish gray (5YR 5/2), granitic, increasing K-feldspar, trace mafics	
1310					None			
1320					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1330	Dual Tube Reverse	Grab			None			
					None			
1340					None		**CRYSTALLINE BEDROCK** dark red gray (5YR 4/2), granitic, quartz, K-feldspar	
1350					None		pinkish gray (5YR 7/2), granitic	
1360					None			
1370					None			
1380					None			Total depth of borehole: 1380' bgs

APPENDIX C

Soil Boring Log – TW-3

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Samples collected by dual tube reverse air rotary without additives. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes. 0'-960' logged from cuttings according to USCS. Contact between young and old alluvium (conglomerate) is unknown.
0	Stratex	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), coarse to fine gravel (angular to subrounded) with coarse to medium sand (45%) (angular to rounded), trace fine sand	
10							as above	
20							**SILTY SAND (SM)** yellowish brown (10YR 5/4),coarse to fine sand (angular to subrounded) with silt (15%), and fine gravel (10%)	
30							as above, increase in silt (25%)	
40							**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** light grayish brown (10YR 6/2), fine to coarse sand with silt and fine gravel, coarser grains (angular to subrounded), mostly granitic, some lithics and volcanics	
50							**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (10YR 6/2), coarse to fine sand with fine gravel (40%), coarse grains (angular to subrounded)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							as above, gravel is coarser, 30% fine, 15% coarse	
70	Stratex	Grab					**SILTY SAND (SM)** light brownish gray (10YR 6/2), fine to coarse sand with silt (15%), and fine gravel (10%), coarse, mostly granitic with some lithics	
80							**POORLY GRADED GRAVEL WITH SAND (GP)** brown (7.5YR 4/3), mostly fine gravel, some coarse gravel (10%), with medium to coarse sand (30%), angular to subangular, granitic and lithics	
90							as above, coarse gravel is subrounded, more medium sand	
100	Dual Tube Reverse						as above, increasing sand content	
110								
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark gray (5YR 4/1), medium to coarse sand, trace fine sand with fine gravel, granitics, lithics, subangular to subrounded	
							POORLY GRADED GRAVEL WITH SAND (GP) dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, mostly granitic with some lithics	
140							as above, gravel is larger, some coarse gravel	
150							as above, % gravel decreasing	
160							as above, gravel includes angular to subangular dolomite fragments (strong HCL reaction)	
170							**POORLY GRADED SAND WITH GRAVEL (SP)** dark gray (5YR 4/1), medium to coarse sand with fine gravel, trace coarse gravel, granitics, limestone, mudstone (subangular to rounded)	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, more fine gravel (40%), granitics and lithics (subangular to subrounded	
200							as above, gravel includes dolomite	
210							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, gravel mostly granitic, lithics, some dolomite	
220							as above	
230							as above, gravel decreasing in abundance	
240								

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), mostly granitic, lithics, and carbonates	
260							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), fine gravel (angular to subrounded) with medium to coarse sand, 50/50 granitic/carbonate fragments	
270							**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel, mostly granitics with carbonates and lithics	
280							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand, granitics and carbonates with some lithics	
290							as above, gravel mostly granitic	
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45% as above, sand decreasing to 30%	
320								
330							as above, some fine gravel likely from larger clasts (some weathered surfaces with some fresh surfaces)	
340								
350								
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (2.5Y 5/2), fine gravel (subangular to subrounded) with fine to coarse sand, mostly granitic, some carbonates and lithics	
380							as above, sand decreasing to 30%, increase in carbonates	
390							as above, dark red gray (5YR 4/2), mostly granitic	
400							as above, dark reddish brown (5YR 3/3)	
410							as above, very dark gray (5YR 3/1)	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** carbonates increasing in abundance	
440							**POORLY GRADED GRAVEL (GP)** very dark gray (N3), 95% angular carbonate fragments (possible boulder)	
450							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (angular to subrounded), with medium to coarse sand, mostly granitics and carbonates	
460							**POORLY GRADED GRAVEL (GP)** very dark gray (5YR 3/1), fine gravel (angular to subrounded), 70% lithics (possible boulder)	
470							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand (40%), trace fine sand, gravel made up of granitics, lithics, and carbonates	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
							as above, more than 50% carbonate fragments	
500							as above, carbonates decreasing to 30%	
510							as above, gravel mostly granitic (60%), with carbonates and lithic fragments (subangular to subrounded)	Rig chatter, cuttings are angular granitic fragments.
520								
530								
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45%, abundant lithics in gravel	
560							as above, 50/50 fine gravel and medium to coarse sand, mostly granitic with carbonates, lithics, and quartzite (white)	
570							as above, granitic, lithics, and carbonates, absence of quartzite	
580							as above, carbonates increasing to 30%	
590								
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (angular to subrounded), with fine gravel (subangular to subrounded), 30% granitics, carbonates, and lithics	
620							as above, some fine sand	
630							as above, gravel increasing to 45%	
640							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand (45%), granitics, carbonates, and lithics	
650							as above, gravel increasing to 60%, mostly granitics and carbonates	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), granitics, lithics increasing and carbonates	
680							as above, trace fine sand, 40% granitic, 30% carbonates, 30% lithic, trace coarse gravel	Measure water level in borehole after sitting overnight. Measured through drill pipe. DTW = 446.1' bgs
690							as above, granitics increasing to 75%, fine gravel decreasing to 30%	
700								
710							as above, fine sand increasing to 15%	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), medium to coarse sand with fine sand (15%), and fine gravel (40%) (subangular to subrounded), mostly granitic, some lithics and carbonates	
740							as above, fine sand increasing, gravel decreasing in percent and size, average size at ~ 10mm	
750							as above, sand contains quartz, feldspar, carbonates, and lithics	
760							as above, gravel increasing to 40%	Discharge water temperature at 84.5° F
770							as above, carbonates increasing in abundance, sand and gravel fraction	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (10YR 5/2), mostly medium to coarse sand, with some fine sand (angular to subrounded), fine gravel (40%), granitics, lithics, and carbonates	
800								
810							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), mostly fine gravel (angular to subrounded), with medium to coarse sand, granitics, lithics, and carbonates, trace coarse gravel	
820							**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), mostly medium to coarse sand with fine gravel (30%), lithology as above	
830							as above, gravel decreasing in size and abundance (30%)	
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, carbonates increasing in abundance	
860							as above, gravel increasing to 40%, mostly granitics and carbonates	
870							as above, gravel decreasing to 30%	
880							as above, gravel size increasing to 10-20 mm	
890								
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), fine to coarse sand (mostly medium size sand) (angular to subrounded), with fine gravel, trace coarse gravel, mostly granitics and carbonates	
920								
930							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand, granitics, carbonates, and lithics	
940								
950							as above, more fine to medium sand than above	Stop drilling with T3 rig. Set pre-collar to 960' bgs for core rig.
960								Begin HQ coring.

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Rock Core	Continuous		43			**CONGLOMERATE** yellowish brown (10YR 5/6), fine to coarse gravel and cobbles (up to 150 mm). Formation is clast-supported, little sand (fine to coarse) and trace fines (silt and clay)	
				56				
				90				
				62	Weak		sand and gravel (angular to subrounded), mostly granitics and carbonates (strong HCL reaction), moderately cemented, some sandy/silty sand interbeds, 0.25' thick interbeds	
980				100				
				100	Weak		granite cobble (110 mm)	
990				54				
				94				
1000				40				
				100			1' of sandy silt/silty sand, layer moderately cemented	
				94			granite and carbonate cobbles	
1010				85			carbonate cobble (140 mm), matrix of silty fine sand	
1020				100				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
				82			**CONGLOMERATE** as above, fine to coarse gravel and cobbles (up to 150 mm), subangular to subrounded in matrix of sand to silty sand, moderately cemented, generally cLast supported, cobbles mostly carbonate and granitics, gravel, is same composition, but includes lithics	
1030				92				
				56				
				76				
1040				60			matrix fine to medium sand, some silty lenses	
				96				
1050				76				
				76				
1060				62			granite, quartzite, and carbonate cobbles	
				100			abundant cobbles	
1070				90	None			
				100			0.5' silt layer, moderately cemented, abundant coarse gravel and cobbles	
1080								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE**	
				100	Weak		as above, matrix yellowish brown (10YR 5/4), abundant cobbles, mostly granitic, some carbonates, fine to coarse sand with silt	
				80				
1090				90	Weak			
				100	None		matrix, sandy, moderately cemented	
1100				100			matrix, silty fine sand, not cemented	
							matrix, sandy, abundant cobbles	
				100	Weak			
1110				100				
				100	Weak			
1120								
				84			matrix fine sand, soft	
							matrix, sandy, moderately cemented	
				74	Weak			
1130								
				100			mostly fine to coarse gravel, clast supported, very little matrix material	
				100	Weak			
1140								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
				100	Weak		**CONGLOMERATE** abundant cobbles (up to 200 mm), mostly carbonates and granitics, some volcanics and lithics	
1150				100				
				100	Weak		matrix fine silty sand	
1160				100	Weak		large granitic cobble (220 mm), ~1' of fine sand, few coarse sand, fine gravel fragments	
				100				
1170				100	Weak		large carbonate cobbles	
				82			sand interval, mostly fine to medium sand, some coarse sand to coarse gravel, yellowish brown (10YR 5/3)	
1180				82			coarse gravels and cobbles	
				40	Weak			
1190				70			~1' sand intervals	
				100				
1200				90	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
				50	None			
				13	None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/5), core is less cohesive than above (poor recovery)	
1210								
				0				
				63				
1220				40				
				50	None		**CONGLOMERATE** yellowish brown (10YR 5/3), cobbles (quartzite and carbonate), with fine to coarse gravel	
				60				
1230				100	None		~0.5'-1' silty sand, interval, soft, gravel/cobbles (angular to subrounded), consist of carbonates, granitics, and lithics	Telescope from HQ to NQ core pipe.
1240				68	None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/4), intervals of gravel/sand are ~1-3' thick, gravel layers are generally thicker, sand is fine to medium with silt	
				100	Weak			
1250								
				100				
1260								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** as above, increase in abundance of lithics in gravel and cobbles	
				76	Weak		~1' fine sand interval coarse sand and fine gravel matrix with cobbles (clast supported), cobbles are quartzite and lithics	
1270								
				0			**CONGLOMERATE** yellowish brown (10YR 5/4), fine gravel to cobbles with matrix of mostly coarse sand with fines	
1280				79	None			
1290				35			cobble with parallel fractures ~1" apart, fracture surface show Fe-oxide staining and slickensides	
				73	Weak		as above, carbonate cobble (strong HCL reaction), 160mm	
1300				0	None		quartzite fragment (only recovery)	
1310				0	None		loose gravel/cobble, quartzite, granitics, carbonates (strong HCL reaction)	
1320								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous		88	Weak		**CONGLOMERATE** yellowish brown (10YR 5/3), fine gravel to cobbles, with fine to coarse sand, gravel mostly carbonates and lithics, some granite ~1' sand/silty sand at 1326' bgs cobble fractured and filled with sediment	
1330				93				
				25			some gravel/cobbles have flat/planar surfaces (fracture?) and smooth	
1340				64				
				55	None			
				0			shoe recovered, loose gravel	
1350				0			loose gravel and sandy silt	
				0			loose gravel, mostly sedimentary quartzite	
				0			**CONGLOMERATE** angular to subrounded gravel in silty sand matrix	
1360				0				
				25			as above, smooth planar surface on cobble (fracture?)	
				90	Weak		cobbles of quartzite (sedimentary) and granite with gravel including, carbonates, shale, and lithics fractured quartzite cobble	
1370								
				80				
1380								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 24 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1390	Rock Core	Continuous					**CONGLOMERATE** yellowish brown (10YR 5/4), color of matrix, cobbles mostly quartzite and carbonates (strong HCL reaction), gravel to coarse sand, includes shale, some quartz, with fines (some clay)	
				84	Weak		formation is clast supported	
1400				92				
				50	None		matrix is sandier than above quartzite cobble with parallel fractures	
1410				75			matrix becomes finer	
1420				93	Weak		**SANDSTONE** yellowish brown (10YR 5/4), fine sand with silt and coarse sand to cobbles, fractured larger grains, mostly carbonates, shale, quartzite, few granitics	
1430				90			**CONGLOMERATE** transition back to (GP), granite cobble	
1440				80				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 25 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE** as above, matrix is brown (10YR 5/3), clast supported fine gravel and coarse sand with coarse gravel and cobbles, matrix is silty sand, some clay	
1450				74	None		larger grains are angular to subrounded and mostly shale, carbonate, quartzite, with some lithics and granitics, cobbles mostly carbonates (strong HCL reaction)	
1460				95	None		mostly fine gravel to coarse sand	
1470				95	None		carbonate boulder (~1.5'/~450mm), largest clast cored fractured quartzite	
1480				69	Weak		quartzite cobble, fracture filled with reddish carbonate material (strong reaction with HCL)	
				95	Weak		matrix is sandier with medium to coarse sand	
1490							**SANDSTONE** yellowish brown (10YR 5/4), mostly fine sand, some medium to coarse sand with silt and fine gravel, cobbles, fractured cobbles and fracture in sand interval (filled with clay)	
1500				78				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 26 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** brown (10YR 5/3), fine to medium sand with some coarse sand, fines mostly silt, fine gravel to cobbles include granitics, lithics/volcanics, quartzite, carbonates	
1510				100	Weak		fractured granitic cobble matrix is becoming finer quartzite cobble	
1520				94	Strong		fractured quartzite cobble with calcite growth on fracture surface resting on top of a carbonate cobble ~1' gravel zone	
1530				100	Strong		calcite cementation matrix still fine sand with silt	
1540				97	Weak		fractured cobble granite cobble (260 mm)	
1550				80	Weak		core becomes sandier (fewer fines)	
1560				91	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 27 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** yellowish brown (10YR 5/4), fine to coarse sand (angular to subrounded) with fines and fine gravel to cobbles	
1570				70	Strong		matrix becoming finer (silt and clay)	
1580				89	None		abundant volcanics in gravel very hard (fracture?), 2' silt layer with some 1" clay intervals	
1590				100	Weak		**SANDSTONE** abundant volcanics in gravel gravel abundance decreasing (sand with silt), fracture in sand	
1600				93	None		gravel zone, most gravel is subrounded, abundance of fines decreasing	
1610				87	Strong		~0.5' altered zone with calcite crystals in clayey matrix	
1620				100	None		coarse sand/gravel zone	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 28 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** yellowish brown (10YR 5/4), fine sand, some medium to coarse sand with fine gravel to cobbles, trace fines, gravel size and abundance increases at 1625' bgs	
				80				
1630					None		**SHALE** olive brown (2.5Y 4/3), fractured, sandy at 1630', clayey at 1632', shear plane at fracture (1635') with slickensides	
				0	Weak			
1640				37	None		**LIMESTONE** olive gray (5Y 4/2), sandy, some intervals, hard to scratch, no reaction with HCL, fractured with calcite formation on fracture surfaces	
				46	None			
1650								
				40	Strong			
1660				94	Variable		laminated, some intervals have strong reaction with HCL, some intervals have no reaction with HCL, Fe-oxide staining in some layers	
				46	Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands	
1670								
				70			**SHALE** olive brown (2.5Y 4/3)	
1680								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 29 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1690	Rock Core	Continuous		92	None		2' zone, highly deformed with calcite bands, and shale and limestone fragments included in fine matrix	
				80	Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands, deformed, parts easily along fine grained bedding surfaces 1689': rock becomes harder with abundant calcite veins	
				50	None		**SHALE** olive brown (2.5Y 4/4)	
1700				53	Strong		**LIMESTONE** gray (2.5Y 6/1), to dark yellowish brown (10YR 4/6), colors mottled, contains nodules (elliptical) (15-25 mm), with concentric rings (algal?) with smaller (10-15 mm), elongate objects with no rings (shell casts), calcite veins and vugs with calcite crysta	
1710				82	Strong		deformed zone containing shale fragments and limestone in a fine matrix, shear planes with slickensides 1711': transitions into shaley limestone, then limestone as above	
1720				94	Strong		1715', 1717', 1720.5', 1728' vugs with calcite crystals	
1730				95	Strong		1733-1734.5' and 1737'-1738.5' calcite matrix including rock fragments (breccia zone?)	
1740				90	Strong		vugs with calcite	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 30 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			Strong		**LIMESTONE** as above, less nodules, more calcite veins 1744'-1745': vugs with calcite (~15mm opening)	
1750				50			shale interval	
				0	Strong			
1760							increase in nodules/fossils	
				100	Strong		abundant reddish brown, mottling, circular to elongate/band forming	
1770				41	None		**SHALE** olive gray (5Y 4/2), abrupt contact, with above limestone finely laminated with some sandy carbonate rich interbeds (~10-20 mm) fracture at 1771' bgs	
1780				18	None		dark olive brown (2.5Y 3/3), some dark gray/black sandy interbeds (~10-30 mm)	
				0				
1790				18			fractured shale in fine (clay) matrix	
				33	None		very dark grayish brown (2.5Y 3/2), less fractured than above	
1800					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 31 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1810	Rock Core	Continuous		25			**SHALE** dark yellowish brown (10YR 4/4), fractured, matrix is sandy, some sandy layers (up to 50 mm thick)	
				43	Variable		gray (2.5Y 5/1) to black (2.5Y 2.5/1), some carbonate rich/sandy layers (weak HCL reaction) fractures with slickensides	
				26	Variable			
1820				35	None		**QUARTZITE** light gray (5Y 7/1), to olive brown (2.5Y 4/4), fractured with sand matrix, individual sand grains visible in hand sample	
				0	None		white soft mineralized zone (matrix) with quartzite fragments	
				0				
1830				0	None			
				0	None		finer grained, recovered rocks fragments (no matrix)	
1840				20			highly weathered/deformed zone, rock fragments (quartzite, granite), in brownish yellow (10YR 6/6), clayey sand matrix	
				0	Variable		weathered/altered rock, white/green/red, some calcite reaction and quartz greenish gray/white clayey zone with slickensides	
1850				0			**LIMESTONE/SHALE** poor recovery, all rock recovered were gravel sized fragments of olive gray shale (no HCL reaction) and gray limestone (strong HCL reaction)	
1860								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 32 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1870	Rock Core	Continuous			Variable		**LIMESTONE/SHALE** as above, poor recovery, limestone and shale fragments as loose gravel, (no matrix)	
				0				
				0				
1880				0			**GRANITE** alternating intervals of hard crystalline rock and weathered/altered zones, rock is granitic (feldspar, quartz, biotite) fracture surfaces have Fe-oxide staining and calcite crystallization	
				21				
1890				0				
				0				
1900				28			altered zones contain broken fragments of granitic rock in a clayey matrix (typically white and green), some chlorite alteration and pyrite crystallization	
				20				
1910				19				
				33				
1920				37				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 33 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1930	Rock Core	Continuous					**GRANITE** as above, contains altered zones with chlorite, very brittle	
				23				
				0				
1940				12				
							End of Boring	
1950								
1960								
1970								
1980								

APPENDIX D

Soil Boring Log – TW2-MW

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), dry, silt to medium sand (well graded fraction ~90%) with fine to 1/2" gravel, subangular	
20						**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), dry, silt to fine sand, with occasional subangular gravel to 1/2"	
30						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), silt to fine gravel, with occasional subangular gavel (1/4"-3/4")	samples are moist from here down, expected to be due to drilling fluids/circ. system required to keep borehole stable
40							
50							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), medium sand to 1/8" gravel (well graded fraction), with gravel to 3/4", all clasts are subangular	
70							
80						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
90							
100							
110							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
130							
140							
150							
160							
170							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
190							
200							
210				Slight		**SILT (ML)** brown (10YR 5/3), coarse, no plasticity, no other grain sizes	
220				None			
230							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), silt to fine gravel, silt is non cohesive, sand/gravel clasts are subangular to subrounded	
250				Moderate			
260							
270				Slight		**GRAVELLY WELL GRADED SAND (SW)** medium sand to 1/8" gravel, subangular to subrounded	
280							
290							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**GRAVELLY WELL GRADED SAND (SW)** medium sand to 1/8" gravel, subangular to subrounded	
310				None			
320				Strong			
330				None			
340				Slight			
350							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
370				Slight		**WELL GRADED SAND WITH SILT (SW-SM)** same as above, except with low plasticity silt	
380							
390				Moderate			
400				None		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
410							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
430							
440							
450							
460							
470							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
490						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, smaller clasts, subangular to subrounded, larger clasts are subangular to angular	
500						**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
510							
520							
530							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
550							
560							
570							
580							
590							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
670							
680							
690							
700							
710							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
730							
740							Total depth of borehole = 740' bgs
750							
760							
770							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX E

Soil Boring Log – CH-5

GEOSCIENCE

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		Slight		**POORLY GRADED SAND WITH SILT (SP-SM)** very pale brown (10YR 7/3), dry, loose (surface) 90% is coarse silt to very fine sand (e.g. aeolian)	
10						**POORLY GRADED SAND WITH GRAVEL (SP)** as above, except dry, loose, with ~20% fine to 1/2" gravel (subangular)	
20							
30							
40							
50		Grab				**POORLY GRADED SAND (SP)** brown (10YR 5/3), with coarse silt (no low plasticity), sand is very fine to fine sand, wet (from drilling method)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel	
70							
80							
90							
100							
110							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
130							
140							
150							
160							
170							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
190							
200						**WELL GRADED GRAVEL (GW)** same as above, except dominant grain size is gravel (fine to 3/4"), subrounded to subangular	
210						**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel	
220							
230							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
250							
260							
270							
280							
290							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
310							
320							
330						**WELL GRADED SAND WITH SILT (SW-SM)** same as above, except with non-cohesive silt	
340						**WELL GRADED SAND (SW)** brown (10YR 5/3), multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel	
350	Rock Core	Continuous		Strong on Matrix		**FANGLOMERATE** well cemented, moist to dry, matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized, up to 3" to 4", clasts include multi-colored igneous intrusive and extrusive (volcanics), matrix is very pale brown (10YR 7/3) to brown (10YR 5/4)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), well cemented, matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized, up to 3" to 4", clasts include multi-colored igneous intrusive and extrusive (volcanics)	
370							
380							
390						less consolidated/cemented, matrix can be disaggregated with moderate force	
400				Moderate on Matrix - Slight on Clasts		at 401', 6" granitic cobble at 403', 1' granitic cobble	
410						at 409.5, shattered, metamorphic rock with staining on surface of break, more consolidated	
						several 6" to 1' thick gravel zones (% gravel > % sand)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous		Strong on Matrix - Slight / Moderate on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized	
430						429-431' - vugs in matrix, suggesting dissolved carbonate	
440						very hard, can be disintegrated with a hammer, pits/vugs in core suggest weathered out carbonates at 449.5' (also secondary mineralization), 458', 458.5' and 461'	
450				Strong on Matrix - Strong on Clasts			
460							
470				Strong on Matrix		carbonate clast at 474', ~10-30% of gravelly cobble clasts are carbonates	

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), very hard cobble at 480'	
						heavily cemented interval from 478-490'	
490						moderate to strong cementation, carbonate clasts ~20-40% (gravel/cobbles)	
500							
510							
520							
						at 525' calcite (?) crystals to 1/8" on face of carbonate clast	
530							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized	
550							
560							
570							
580							
590						at 595' small crystals on face of clast	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized 2' diameter granitic boulder 604-606'	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), most clasts are cobbles, gravels up to 2"	
670							
680							
690							
700							
710				Strong on Matrix - Slight on Clasts			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized softer than above	
730							
740							
750							
760							
770							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4)	
790						matrix composed of fines to coarse sand/fine gravel (well graded), hard to firm (alternating within several feet/core run), cementation various from weak/moderate to strong, occasional boulders/cobbles every 2-3 feet, otherwise gravels to 2" - 3" (angular to subangular)	
800							
810							
820							
830						dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
850							
860							
870				Moderate to Strong			
880							
890							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
900	Rock Core	Continuous		Moderate to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
910				None		911-916', dry, mottled clay layer, very hard	
920				Moderate to Strong			
930				Slight to Moderate			
940				None to Slight			
950							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 17 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
960	Rock Core	Continuous		None to Slight		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above firm sand with occasional gravel, sand is very fine to fine sand with <5% gravel up to 2"	
970							
980						984-990' - very hard interval	similar to what was seen in CH-1 above granitics
990							cannot be broken by hand, possibly buried weathered surface (?)
1000							
1010							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1020	Rock Core	Continuous		None to Slight		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
1030							
1040				Slight to Strong		hard, possibly old weathering/exposed surface, matrix appears to be primarily fine to medium sand, includes coarse sand, gravels, cobbles	
1050							
1060				Moderate to Strong			
1070							

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 19 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1080	Rock Core	Continuous		Moderate to Strong		**DECOMPOSED GRANITE** heavily decomposed, white/gray with abundant yellow to rust colored residuum, remnants of large crystals to 1/2" diameter	
1090							
1100							
1110				None to Slight (slight on fracture surfaces)			
1120							
1130							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

PROJECT NUMBER: 386303.AA.05 **Sheet** 20 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1140	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**DECOMPOSED GRANITE** heavily decomposed, white/gray with abundant yellow to rust colored residuum, remnants of large crystals to 1/2" diameter *(Soil Description Repeated)*	
1150						more competent less weathered	
1160							
1170						highly weathered	
1180							
1190							Total borehole depth = 1191' bgs

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX F

Soil Boring Log – DT-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		Moderate		**GRAVELY POORLY GRADED SAND (SP)** very pale brown (10YR 7/4), dry, coarse silt to fine sand with >5% fine to 1/4" gravel, angular to subangular, loose	10' stratex 0-65' bgs (12/16/2010) 10" stratex added 65-165' bgs (1/10/2011-1/11/2011)
10				Slight		**WELL GRADED GRAVEL (GW)** dry, medium sand to 1" gravel, subrounded to subangular	
20							
30							
40							
50							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Stratex	Grab		Slight		**WELL GRADED GRAVEL (GW)** dry, medium sand to 1" gravel, subrounded to subangular *(Soil Description Repeated)*	
70							
80							
90							
100							
110						**POORLY GRADED SAND (SP)** light brownish gray (10YR 6/2), very fine to fine sand with up to 5% fine gravel (subrounded)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Stratex	Grab		Slight		**POORLY GRADED SAND (SP)** light brownish gray (10YR 6/2), very fine to fine sand with up to 5% fine gravel (subrounded) *(Soil Description Repeated)*	
130						**WELL GRADED SAND WITH GRAVEL (SW)** fine to very coarse sand with gravel to 3/4", coarse grained fragments are subrounded	
140							
150							
160							
170	Dual Tube Reverse	Grab					

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab				**WELL GRADED SAND WITH GRAVEL (SW)** fine to very coarse sand with gravel to 3/4", coarse grained fragments are subrounded *(Soil Description Repeated)*	
190				Slight			
200							
210				Moderate			
220							
230				Slight		**POORLY GRADED SAND (SP)** pale brown (10YR 6/3), very fine to medium sand (90% very fine to fine sand), <5% fine gravel (subrounded)	1/12/2011 1918

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Slight		**POORLY GRADED SAND (SP)** pale brown (10YR 6/3), very fine to medium sand (90% very fine to fine sand), <5% fine gravel (subrounded) *(Soil Description Repeated)*	
250							1/11/2011 2021 1/11/2011 2025
260						**WELL GRADED SAND WITH GRAVEL (SW)** sand is fine to coarse, gravel is fine to 1/8", subrounded	
270							1/11/2011 2148 1/11/2011 2153
280							
290						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, subrounded to subangular	1/11/2011 2400 1/12/2011 0100

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND WITH GRAVEL (SW)** sand is fine to coarse, gravel is fine to 1/8", subrounded	
310							1/12/2011 0220 1/12/2011 0230
320							
330						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, subrounded to subangular	1/12/2011 0400 1/12/2011 0410
340						**WELL GRADED SAND WITH SILT (SW-SM)** light yellowish brown (10YR 6/4), sand is fine sand to 1/8" gravel	
350							1/12/2011 0520 1/12/2011 0600

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND WITH SILT (SW-SM)** light yellowish brown (10YR 6/4), sand is fine sand to 1/8" gravel *(Soil Description Repeated)*	
370							1/12/2011 0720 1/12/2011 0730
380							
390							1/12/2011 0830 1/12/2011 0830
400							
410				Moderate		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded	1/12/2011 1030 1/12/2011 1130

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Dual Tube Reverse	Grab		Moderate		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded *(Soil Description Repeated)*	
430							1/12/2011 1202 1/12/2011 1304
440							
450							1/12/2011 1538 1/12/2011 1546
460							
470							1/12/2011 1654 1/12/2011 1710

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Dual Tube Reverse	Grab		Slight		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded *(Soil Description Repeated)*	
490							1/12/2011 1932 1/12/2011 2109
500							
510							1/12/2011 2224 1/12/2011 2232
520						**SILTY SAND (SM)** yellowish brown (10YR 5/4), sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity	1/12/2011 2325 1/13/2011 1300
530							1/13/2011 1332 1/13/2011 1343

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Dual Tube Reverse	Grab		Slight		**SILTY SAND (SM)** yellowish brown (10YR 5/4), sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity *(Soil Description Repeated)*	
550						**WELL GRADED SAND WITH SILT (SW-SM)** sand is fine sand to 1/4" gravel, coarse sand and gravel clasts are angular to subangular	1/13/2011 1509 1/13/2011 1516
560						**SILTY SAND (SM)** sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity	
570						**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular	1/13/2011 1631 1/13/2011 1639
580							
590							1/13/2011 1806 1/13/2011 1845

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
610							1/13/2011 2007 1/13/2011 2013
620							
630							1/13/2011 2152 1/13/2011 2200
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
670							1/14/2011 0105 1/14/2011 0115
680							
690							1/14/2011 0220 1/14/2011 0300
700							
710							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
730							1/14/2011 0525 1/14/2011 0530
740							
750							1/14/2011 0720 1/14/2011 0735
760							
770							1/14/2011 1025 1/14/2011 1045

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
790							
800							
810							
820							
830						- fine sand to 1/4" gravel, subrounded to subangular	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
850							
860							
870						- medium sand to 1/4" gravel, subangular to subrounded	
880							
890							

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
900	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
910							
920							
930				None		**QUARTZITE** some staining (iron?) on some surfaces suggesting fracturing	Samples below 925' are not recent alluvial deposits or soil. However samples are described according to the USCS classification system for consistency with other project lithologic logs. When possible, geologic formation names are indicated.
940						yellow (10YR 8/6), grains are medium sand to 1/4" gravel, all angular shards two primary colors, yellow (10YR 7/6) and dark grayish brown (10YR 4/2), medium sand to 1/4" gravel sized angular shards	
950						dark yellowish brown (10YR 4/6), fine sand to fine gravel sized subangular to angular shards, abundant quartz light gray (10YR 7/2), 40% very fine to medium sand sized, subangular to angular shards, 5% fine to 1/4" gravel sized shards, abundant quartz color is significantly different, very dark grayish brown (10YR 3/2) and not much quartz, mostly mafic minerals	Even though cuttings are described as 'sands' or 'gravels', it is an indication of grain size distribution only. A sedimentary depositional environment should not be inferred by the use of the USCS nomenclature from 925' to TD.

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 17 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
960	Dual Tube Reverse	Grab		None		**QUARTZITE** brown (10YR 5/3), fine sand to fine gravel sized subangular to angular shards	
970						light gray (10YR 7/1), very fine to coarse sand sized subangular to angular shards with up to 5% fine to 1/2" gravel sized pieces dark gray (10YR 4/1)	
980						light red (2.5YR 6/6)	
990						light reddish brown (2.5YR 7/3)	
1000						light reddish brown (2.5YR 7/4), 98% very fine to fine sand sized particles with up to 2% 1/5" gravel sized clasts	
1010							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 18 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1020	Dual Tube Reverse	Grab		None		**QUARTZITE** reddish brown (2.5YR 5/4)	
1030							
1040						light yellowish brown (2.5Y 6/4)	
1050							
1060							
1070							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1080	Dual Tube Reverse	Grab		None		**QUARTZITE** light yellowish brown (2.5Y 6/4)	
1090							
				Strong		weak red (2.5YR 5/2)	
1100							
				None		light reddish brown (2.5YR 6/4), almost 100% very fine to medium sand sized sands/clasts	
1110							
				Slight			
1120							
				None			
1130							
				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1140	Dual Tube Reverse	Grab		Slight		light reddish brown (2.5YR 6/3), very fine to coarse sand sized shards/clasts	
1150				Moderate		light reddish brown (2.5YR 6/4), 98% very fine to fine sand sized particles	
1160				Slight		reddish brown (2.5YR 5/4), very fine to coarse sand sized, subangular to angular shards/clasts	
1170							
1180							
1190							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1200	Dual Tube Reverse	Grab		Slight		reddish brown (2.5YR 5/4), very fine to coarse sand sized, subangular to angular shards/clasts	
1210							
1220							
1230						higher proportion of medium to coarse sand sized particles	
1240							
1250						light reddish brown (2.5YR 6/3)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 22 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1260	Dual Tube Reverse	Grab		Slight			
1270				Moderate			
1280				Slight		**GRANITE** gray (2.5Y 5/1), comes out as sand sized particles, salt and pepper look	Contact with Jurassic granite (Jgr)
1290						color has more red: reddish brown (2.5YR 5/3)	
1300				Moderate			
1310				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 23 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1320	Dual Tube Reverse	Grab		None		**GRANITE** reddish brown (2.5YR 5/3), cuttings are sand sized particles	
1330						yellowish brown (10YR 5/4)	
1340							
1350						reddish brown (5YR 5/4)	
1360							
1370				Strong		mix of greenish black (5GY 2.5/1) and yellowish brown (10YR 5/4)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1380	Dual Tube Reverse	Grab		Slight		**GRANITE** mix of greenish black (5GY 2.5/1) and yellowish brown (10YR 5/4)	
						yellowish brown (10YR 5/4)	
1390							
						mix of greenish black (10GY 2.5/1) and yellowish brown (10YR 5/4)	
1400							
						mix of very dark grayish green (5G 3/2) and yellowish brown (10YR 5/4)	
1410							
						yellowish brown (10YR 5/4)	
1420				None			
1430							
				Slight		reddish brown (5YR 5/3)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 25 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1440	Dual Tube Reverse	Grab		Slight		**GRANITE** reddish brown (5YR 5/3), cuttings are sand sized particles	
1450							
1460				None		yellowish brown (10YR 5/4)	
1470						yellowish brown (10YR 5/4)	
1480							
1490							Total borehole depth = 1500' bgs

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX G

Soil Boring Log – TW-2B

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Samples collected by dual tube reverse air rotary without additives. Note: Samples appear to be artificially sorted due to the drilling method, and probably do not accurately represent the full range of grain sizes.
0	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** pale brown (10YR 6/3), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		**POORLY GRADED SAND WITH SILT (SP-SM)** brownish yellow (10YR 6/6), mostly fine sand, little medium sand, trace fine gravel (subrounded)	
30					None		**POORLY GRADED GRAVEL WITH SAND (GP)** gray (10YR 5/1), fine to coarse gravel, angular to subangular	
40					None		as above, dark grayish brown (10YR 4/2), fine gravel, little coarse gravel, subangular to subrounded, some fine to coarse sand	
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		as above, grayish brown (2.5Y 5/2), fine gravel (subrounded) with coarse sand (40%)	
100					None		**POORLY GRADED SAND WITH GRAVEL (SP)** grayish brown (2.5Y 5/2), medium to coarse sand with fine gravel (40%), subangular to subrounded	
110					None			
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Dual Tube Reverse	Grab			None			
					None			
140					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
150					None			
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (2.5Y 6/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, brown (10YR 5/3), sand fraction ~ 40%-50%, mostly coarse sand	
200					None			
210					None			
220					None			
230					None		**POORLY GRADED SAND WITH GRAVEL (SP)** pale brown (10YR 6/3), mostly medium to coarse sand, some fine gravel	
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
					None			
260					None			
270					None			
280					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel, angular, medium to coarse sand, angular	
290					None			
300					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab			None			
					None			
320					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light gray (10YR 7/2), mostly medium to coarse sand, some fine sand, fine gravel (15%)	
330					None			
340					None			
350					None		as above, yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None			
380					None			
390					None		as above, % gravel decreasing (20%)	
400					None			
410					None			
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, % gravel increasing (40%)	
					None			
440					None			
450					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		as above, brown (7.5YR 4/2), fine to coarse sand, increase in fine gravel, angular	
470					None		as above, dark grayish brown (10YR 4/2), medium to coarse sand with some fine sand, fine gravel, angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel	
					None			
500					None		**POORLY GRADED SAND WITH GRAVEL (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel (40%)	
510					None			
					None			
520					None		as above, % gravel decreasing (20%)	
530					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
550					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand, fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None			
570					None		as above, % fine gravel increasing (30%)	
580					None		as above, medium to coarse sand with fine sand (10%), and fine gravel (25%) (angular to subangular)	
590					None			
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab			None			
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 4/3), fine gravel, angular to subrounded, with medium to coarse sand	
620					None			
630					None			
640					None			
650					None		**POORLY GRADED SAND (SP)** brown (10YR 4/3), medium to coarse sand, and fine sand, trace fine gravel (angular to subrounded)	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (15%) (angular to subrounded)	
					None			
680					None			
690					None			
700					None		as above, very dark brown (10YR 2/2), medium to coarse sand, trace fine sand, fine gravel (angular to subrounded)	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand (more coarse), with fine gravel (rounded to angular)	
					None			
740					None			
750					None		as above, fine to coarse sand, little fine gravel, angular to subangular	
760					None			
770					None			
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, fine to coarse sand, little fine gravel, angular to subangular	
					None			
				100			**CONGLOMERATE** very pale brown (10YR 7/3), gravel and cobbles of granitic and volcanic origin, coarse grained, moderately weathered	Stop drilling with T3 rig. Set pre-collar to 798' bgs for core rig. Begin HQ core.
800	Rock Core	Continuous		31	None			
				42				
				70				
810				33			**CRYSTALLINE BEDROCK** white (N8) to greenish gray (5GY 6/1), quartz, white feldspar, granitic, coarse grained, moderately weathered, weathered white feldspars with chalky consistency, slightly to highly weathered, fractures throughout	
				0				
820				0				
				19				
				21			some chlorite alteration	
				8			chlorite alteration	
830				0				
				0				
				0				
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous		31	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, presence of K-feldspar, coarse grained, slightly to highly weathered, fractures throughout, weathered white feldspar, highly weathered feldspar at 849.5'	
				22				
				0				
				0				
850				0				
				11				
				7				
							increase in K-feldspar, presence of Fe-oxide	
860				0				
				20				
				0			light reddish brown (5YR 6/4), granitic, quartz, K-feldspar, coarse grained, moderately weathered, Fe-oxide stained	
870				33				
				0				
				0				
880				46				
				0				
				0				
890				0				
				25				
				19				
900				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Rock Core	Continuous		0	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, some K-feldspar, coarse grained, slightly to highly weathered, fractures throughout	
				0				
				10				
				13				
				24				
920				25				
				0				
				0				
				0				
930				0				
				0				
				0				
				0				
940				0				
				38				
				0			weathered white feldspar (no reaction with HCL)	
				14				
950				50				
				100	Strong		mafic interval (952'-955'), brown (7.5YR 5/2), mafics, calcite veins (HCL strong reaction), fine grained, clays with void-filling calcite at top contact	
				37				
960				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Rock Core	Continuous		30	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, slightly to highly weathered, fractured throughout	
				26				
				55				
				0				
980				23				
				38			highly weathered/altered, abundant chlorite	
				76				
990				60				
				63				
1000				55			2' altered chlorite zone	
				85				
1010							End of Boring	
1020								

APPENDIX H

Soil Boring Log – CH-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), dry, sand is fine to medium, sample has some non-plastic silt (~5%)	
10						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), dry, sample is fine sand to 1" gravel, 10% of sample is fine sand to fine gravel, all clasts are subangular to angular	
20							
30							
40							
50						decrease in coarse gravel	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Stratex	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), sample is fine sand to 1" gravel, increase in gravel to 10%, all clasts are subangular to angular	
70							
80							
90							
100							
110							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Stratex	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), sample is fine sand to 1" gravel, 10% gravel, all clasts are subangular to angular	
130							
140							
150							
160							
170		Grab				**WELL GRADED GRAVEL WITH SAND (GW)** dry, coarse sand to 1" gravel, 90% of sample is coarse sand to 1/4" gravel, subangular to angular	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		None		**WELL GRADED GRAVEL WITH SAND (GW)** dry, coarse sand to 1" gravel, 90% of sample is coarse sand to 1/4" gravel, subangular to angular *(Soil Description Repeated)*	
190						**WELL GRADED SAND WITH SILT (SW-SM)** brown (10YR 5/3), very fine sand to coarse sand, subangular, silt is low plasticity	
200							
210							
220							
230							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab				**WELL GRADED SAND WITH SILT (SW-SM)** brown (10YR 5/3), very fine sand to coarse sand, subangular, silt is low plasticity *(Soil Description Repeated)*	
250							
260				None		**SILTY SAND (SM)** brown (10YR 5/3), sand is very fine to coarse sand with <5% gravel (1/8"-5/8"), subangular to angular	
270							
280							
290				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**SILTY SAND (SM)** brown (10YR 5/3), sand is very fine to coarse sand with <5% gravel (1/8"-5/8"), subangular to angular *(Soil Description Repeated)*	
310						**WELL GRADED GRAVEL (GW)** coarse sand to 1/2" gravel, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	these samples may be "washed" to some degree due to the drilling method
320							
330							
340						**WELL GRADED GRAVEL WITH SILT (GW-GM)** yellowish brown (10YR 5/4), coarse sand to 1/2" gravel with silt, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	
350							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (GW)** coarse sand to 1/2" gravel, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	sample from 360-398' appear to be heavily washed and coarse biased
370							
380							
390							
400	Rock Core	Continuous		Slight to Moderate		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), weakly cemented/consolidated, composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	begin coring, core can be easily broken with a hammer into smaller pieces, these pieces do not disintegrate in to individual grains, gravel
410							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous		Slight to Moderate		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), grain size ranges from fine to medium sand, slightly less cemented/consolidated than above	
430							
440				Moderate		gravel increase to 5-10%	
450							
460							
470							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous		Slight to Moderate		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	
490							
500				Moderate			
510				Slight to Moderate			
520						several large clasts of heavily weathered/vuggy rock	transition from Quaternary alluvium to Miocene fanglomerate
530				Moderate to Strong			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous		Moderate to Strong		**POORLY GRADED SAND (SP)** composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	
550				Slight to Moderate			
560				Moderate to Strong			
570				Strong		Distinctive contact, very hard and well cemented, possibly contact metamorphism	
580							
590						interbed of gravel/sand	contact with Jurrasic granite (Jgr)

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**GRANITE** fractured granite, fracture frequency is ~6"-1'	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**GRANITE** fractured granite, fracture frequency is ~6"-1', calcite mineralization on fracture surfaces	
670							
680							
690							
700						garnet minerals integrated into rock	
710						breciatted cake white pulverized	Total borehole depth = 711' bgs

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX I

Soil Boring Log – CH-4

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab				**POORLY GRADED GRAVEL WITH SAND (GP)** light yellowish brown (10YR 6/4), fine to coarse gravel (70%) with fine to coarse sand, gravel is granitic, volcanic, lithics, some silt fragments	
10						sand is mostly medium to coarse, some carbonate fragments	
20						brown (10YR 5/3), sand mostly coarse	
30				Weak		**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (10YR 6/2), fine to coarse sand with gravel (most fine), most gravel granitic and lithic, some volcanic (rounded to subrounded)	
40						**POORLY GRADED GRAVEL WITH SAND (GP)** gray (10YR 5/1), fine gravel with coarse to medium sand, gravel (subround to subangular), volcanics and granitics	
50	Dual Tube Reverse	Grab				**POORLY GRADED SAND (SP)** grayish brown (10YR 5/2), mostly medium coarse sand, some fine gravel	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND WITH GRAVEL (SP)** same as above except, percentage of fine gravel increases	
70						**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (10YR 4/2), fine to coarse gravel with medium to coarse sand, gravel (subround to subangular), volcanic, lithics, granitics	
80						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with fine gravel, gravel as above	
90						percentage of gravel increases, some coarse gravel	
100						all gravel is fine gravel	
110						some fine sand/silt	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab				**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with fine gravel, percentage of gravel increases	
130				Weak			
140							
150						dark grayish brown (10YR 4/2), fine to coarse sand with fine gravel, gravel (subrounded to subangular), mostly volcanics/lithics	below 150' difficult to distinguish reaction to HCL on individual grains of medium sand and smaller grain sizes
160				Weak			
170							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with some fine gravel	
190				None		abundant fragments of black volcanic rock (from larger cobble)	
200							
210							
220				Weak			
230						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), percentage of fine sand and fine gravel increases	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), mostly medium to coarse sand with fine gravel (subround/subangular)	
250							
260							
270						percentage of fine sand increases	
280							
290						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), increase in fine gravel, gravel is mostly volcanic (subangular)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), fine to coarse sand with some fine gravel	
310						percentage of fine sand decreases and fine gravel increases	
320							
330							
340							
350	Rock Core	Continuous		None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/6), interbedded strongly to weakly cemented sands and gravels, coarser intervals generally have stronger cementation	start coring at 348'
				Strong			

SAMPLE TEST. 386303CADIZ.GPJ, CADIZLIBRARY.GLB. 8/17/11

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Rock Core	Continuous		None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/6), interbedded strongly to weakly cemented sands and gravels, coarser intervals generally have stronger cementation, gravels are round to subround, majority of large clasts are volcanic, some lithics, granitics, and carbonate clasts	
				Weak			
370				None			
380				Weak			
390				None to Strong		stronger HCL reaction in sandy intervals, weak or no reaction in gravelly interval	
				None to Weak		~ 0.5' weakly cemented sand lense (no reaction) sand and fine gravel (round/subround), gravel still mostly volcanic clasts	
400				Weak		well cemented sand and gravel	
410						~0.5' clay/silt interval (hard)	412-418', core difficult to break by hand, requires hammer

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous		None to Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4) to brown (10YR 5/3), interbedded sands and gravels, coarser intervals, have stronger reactions with HCL, large gravel/cobbles are mostly volcanic (up to 4"), some granitic lithic and carbonate clasts	420-480', core generally hard to break unless otherwise noted
				Weak to Strong			
430				None to Strong			
				Strong		mostly medium/coarse sand with gravelly interbeds (~2-4")	
440				None to Strong		silty interval (~1') at 448', becomes coarser with more gravel/cobbles (up to 7")	
450				Strong		cobbly interval	
				Weak to Strong		~1' coarse sand interval, sugary texture on grains, no fines in matrix	
460						abundant volcanic gravel	
470				Strong		1' fine to medium sand, less cemented	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** same as above, gravel/cobble beds (beds up to 1'), some well cemented lenses (1-2") with all medium to coarse sand (no matrix)	480-540', generally difficult to break core by hand unless otherwise noted
				Weak to Strong			
490						coarse sand and fine gravel	
						more friable, 1' fine/medium sand	
500				Strong			
510						at 509-511' - interbeds of coarse sand with no matrix, well cemented 2' fine to coarse sand, percentage gravel increasing (now conglomerate)	
						at 516' carbonate cobble	
520				Weak to Strong		gravel/cobble mostly volcanic (round to subround), up to 4"	
530				Strong		2" vug formed by dissolved gravel fragment (strong reaction in cavity)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** interbedded sands and gravels, larger clasts, predominantly volcanic	540-600', core is hard to break by hand unless otherwise noted
550						3' (at 553') silt/fine sand interval with strong reaction to HCL, sand is more friable than coarse intervals, still requires significant pressure to break	
				Weak to Strong			
560				Strong			
				None to Strong		medium to coarse sand, cemented, little to no fines as matrix	
570				Strong		1' fine sand, more friable, strong reaction to HCL fine to coarse sand with gravel, cemented and finer matrix	
580				Weak to Strong		580-589', increase in gravel with fine to coarse sand	
590				Strong		at 590' 2' friable fine sand with cobble	

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous		Weak to Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** interbedded, sands and gravel/cobbles, large clasts mostly volcanic, round to subround, some carbonate, granitic and lithics	600-660', core is hard to break unless otherwise noted
610				Strong		613-616' cobbly interval 2-3" beds of coarse sand/gravel with sugary texture and calcite crystals, no fines (sand are silt) as matrix	
620						620-628' abundant visible crystallization and sand/gravel grains	
630				Weak to Strong			
				Strong			
				Weak to Strong		at 636' 7" volcanic cobble, calcite crystals in vessicles 637-640' friable medium sand, fines downward into silt (weak reaction), 1" white hard fine grained interval at 639' (strong reactions)	
640							
				Strong		645-660 increasing gravel and cobbles	
650							
				Weak to Strong		at 656' 1' clayey gravel (weak reaction)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4) to brown (10YR 4/3), interbedded sand and gravel/cobbles, some silt beds	660-720', core hard to break unless otherwise noted
670				Weak to Strong		at 671' 7" volcanic cobble with calcite crystal vessicles 674.5-676' friable medium sand with weak reaction	
680				Strong		683-686' friable medium sand, interval 686-688' silt with strong reaction 687-688' silt has vertical sand banding (clastic dikes?)	
690				Weak to Strong		at 691.5' 1" white cemented layer (fine grained) 694-701' coarse sand/gravel with clayey matrix	
700						701.5-703' silt interval (hard, strong reaction) includes 1" white cemented layers	
710						709-715' matrix of sand/gravel is clayey	
				Strong		719-721' fine sand/silt interval (strong reaction) some ~1" white cemented intervals	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH SILT (SP-SM)** dark yellowish brown (10YR 4/6), to brown (10YR 5/3), interbedded fine sand and silt with 1" white cemented fine grained interbeds (strong reaction)	reaction to HCL varies in silt/sand layers
				None to Strong			
730				Strong			
				None to Strong		at 734', transition to coarse sand and gravel, poorly consolidated angular/subangular sand grains, gravel is subround to subangular, mostly granitic (pink and white) with some carbonates, no volcanic clasts	granitic fragments look similar to underlying rock
740				Strong			
750				None to Strong		silt/clay intervals 0.5-1' thick	
				None to Weak		**DECOMPOSED GRANITE** red (2.5YR 5/6), to light reddish brown (2.5YR 6/4), mottled color texture, transition into decomposed granite, highly altered, (beaks easily), some slickensides at 762'	
760				None to Strong			
770				None to Weak		at 771', white (10YR 8/1) fractured granite, some reaction on fracture surfaces	
				None			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Rock Core	Continuous		None		**GRANITE** white (2.5YR 8/1), to reddish brown (2.5YR 4/4), fractured with highly altered/deformed zones	calcite crystals on granite fragment
				None to Strong			
790				None		at 789' slickensides altered zone	
800				Weak		802-804' dark green and white altered zone	
				None		807-808' transition from white to reddish granite, fractured with fines/slickensides on fracture surface, weak reaction on fracture surface	
810				None to Weak		808-820' fractured reddish granite	
820						at 820' transition back to white granite that is highly altered/deformed, some red granite fragments	
830						at 832' still highly altered, compend granite fragments (50/50 white/red)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 15 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Rock Core	Continuous		None to Weak		**GRANITE** white (10YR 8/1) to reddish brown (2.5YR 4/4), highly weathered/altered with slickensides on fracture surfaces, no reaction on competent granite, some finer grained weathered interval or fracture, surfaces have weak reaction	strong reaction in fine weathered/altered zone
850							
860							Total borehole depth = 860' bgs
870							
880							
890							

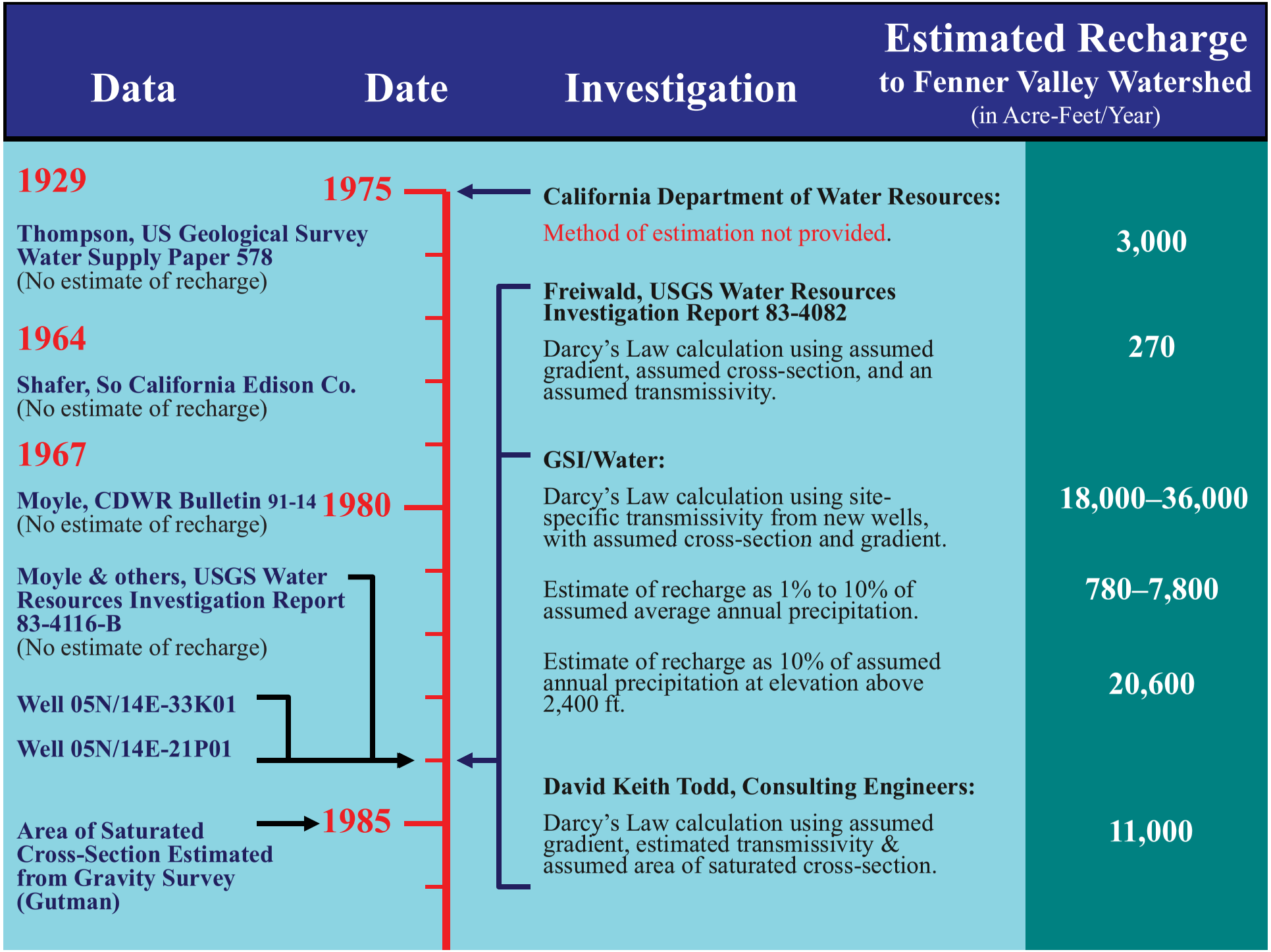
SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

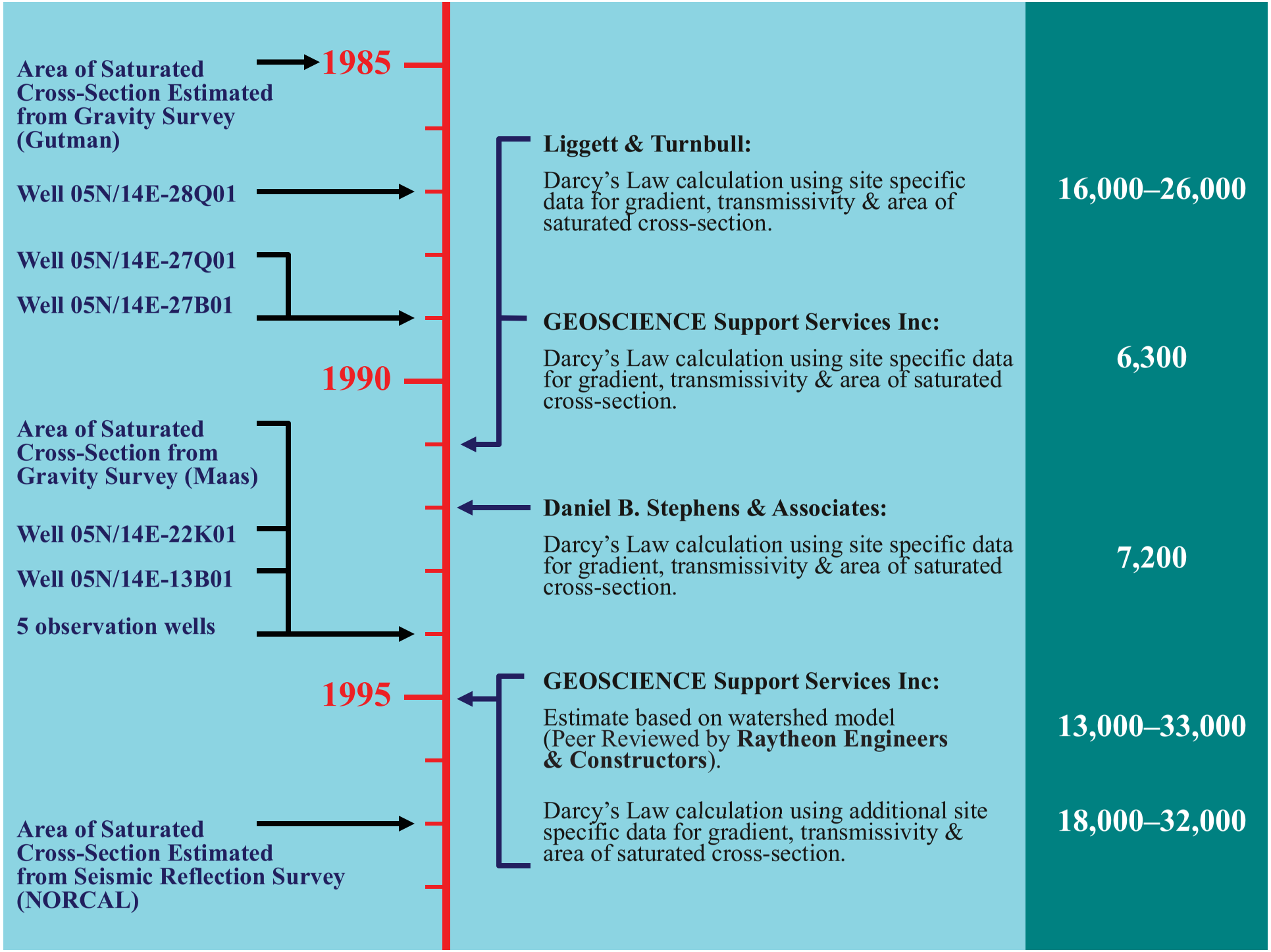
APPENDIX D

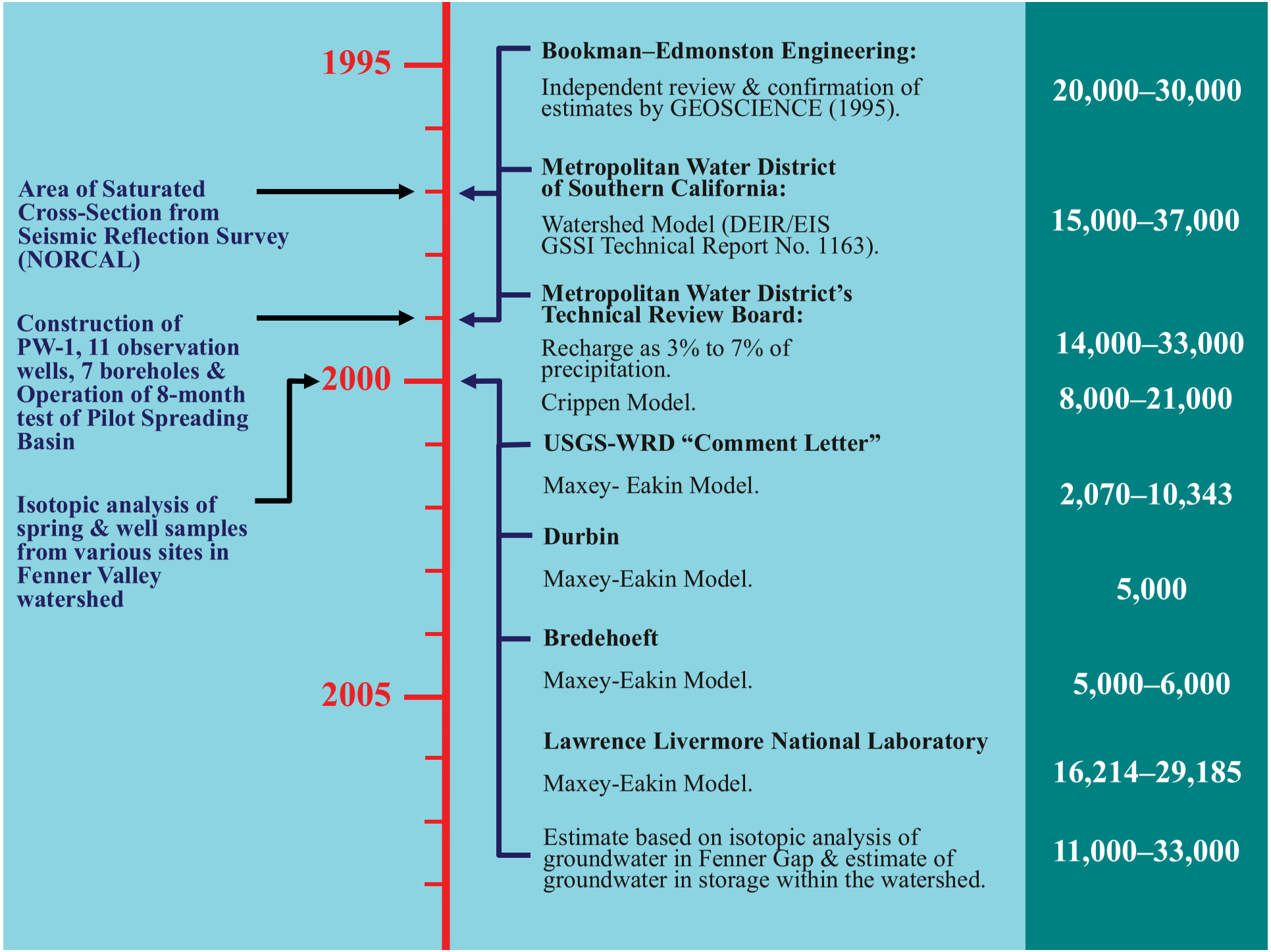
Timeline- Chronology for

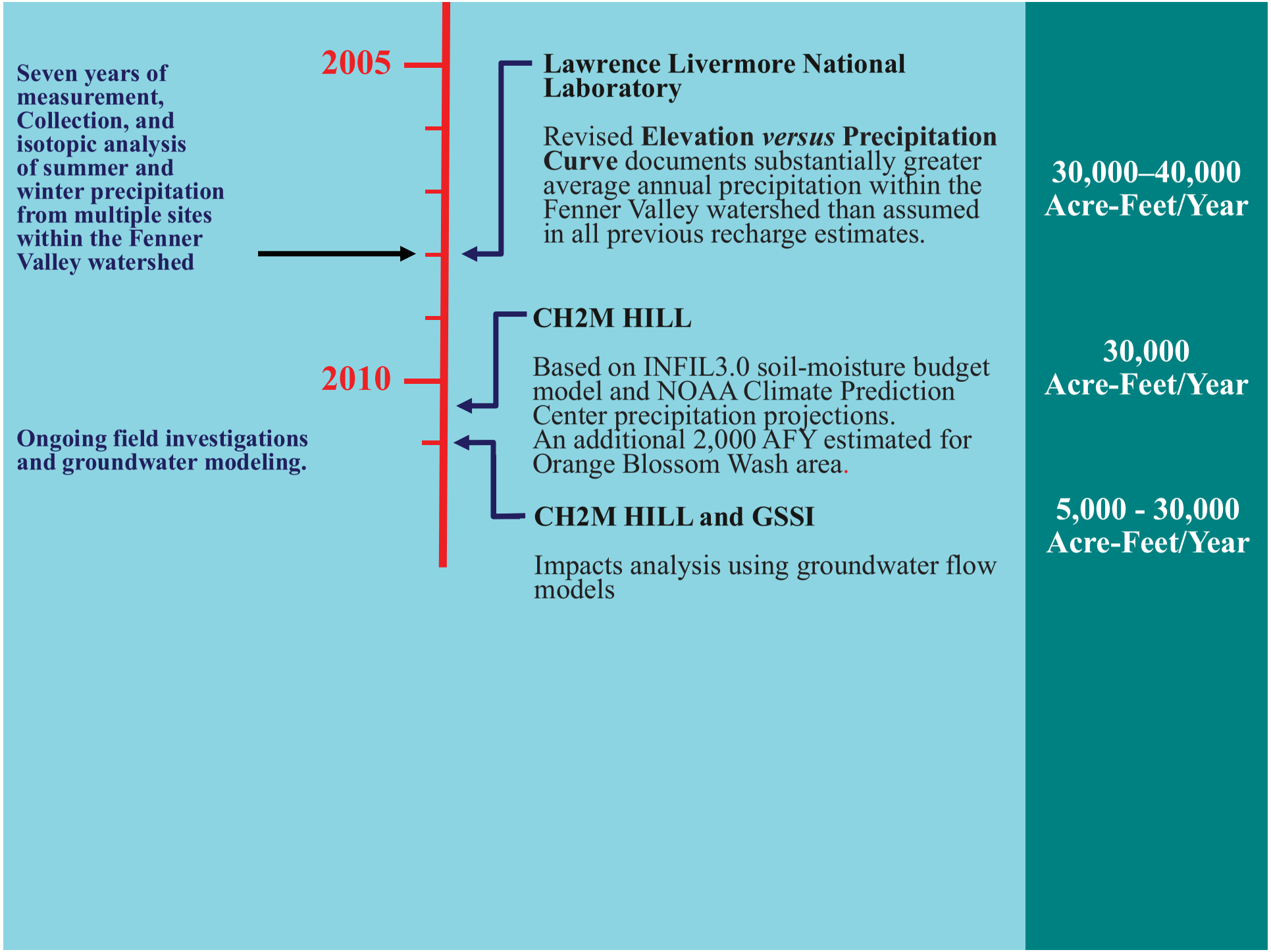
Estimates of Natural Recharge to the Cadiz Project Area

GEOSCIENCE


Data
Date
Investigation
Estimated Recharge
to Fenner Valley Watershed
(in Acre-Feet/Year)
1929
Thompson, US Geological Survey Water Supply Paper 578
(No estimate of recharge)
1964
Shafer, So California Edison Co.
(No estimate of recharge)
1967
Moyle, CDWR Bulletin 91-14
(No estimate of recharge)
Moyle & others, USGS Water Resources Investigation Report 83-4116-B
(No estimate of recharge)
Well 05N/14E-33K01
Well 05N/14E-21P01
Area of Saturated Cross-Section Estimated from Gravity Survey (Gutman)
1975
1980
1985
California Department of Water Resources:
Method of estimation not provided.
3,000
Freiwald, USGS Water Resources Investigation Report 83-4082
Darcy's Law calculation using assumed gradient, assumed cross-section, and an assumed transmissivity.
270
GSI/Water:
Darcy's Law calculation using site-specific transmissivity from new wells, with assumed cross-section and gradient.
18,000–36,000
Estimate of recharge as 1% to 10% of assumed average annual precipitation.
780–7,800
Estimate of recharge as 10% of assumed annual precipitation at elevation above 2,400 ft.
20,600
David Keith Todd, Consulting Engineers:
Darcy's Law calculation using assumed gradient, estimated transmissivity & assumed area of saturated cross-section.
11,000


Area of Saturated Cross-Section Estimated from Gravity Survey (Gutman)
1985
Well 05N/14E-28Q01
Well 05N/14E-27Q01
Well 05N/14E-27B01
1990
Area of Saturated Cross-Section from Gravity Survey (Maas)
Well 05N/14E-22K01
Well 05N/14E-13B01
5 observation wells
1995
Area of Saturated Cross-Section Estimated from Seismic Reflection Survey (NORCAL)
Liggett & Turnbull:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
16,000–26,000
GEOSCIENCE Support Services Inc:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
6,300
Daniel B. Stephens & Associates:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
7,200
GEOSCIENCE Support Services Inc:
Estimate based on watershed model (Peer Reviewed by Raytheon Engineers & Constructors).
13,000–33,000
Darcy's Law calculation using additional site specific data for gradient, transmissivity & area of saturated cross-section.
18,000–32,000


1995
2000
2005
Area of Saturated Cross-Section from Seismic Reflection Survey (NORCAL)
Construction of PW-1, 11 observation wells, 7 boreholes & Operation of 8-month test of Pilot Spreading Basin
Isotopic analysis of spring & well samples from various sites in Fenner Valley watershed
Bookman–Edmonston Engineering:
Independent review & confirmation of estimates by GEOSCIENCE (1995).
20,000–30,000
Metropolitan Water District of Southern California:
Watershed Model (DEIR/EIS GSSI Technical Report No. 1163).
15,000–37,000
Metropolitan Water District's Technical Review Board:
Recharge as 3% to 7% of precipitation.
14,000–33,000
Crippen Model.
8,000–21,000
USGS-WRD "Comment Letter"
Maxey- Eakin Model.
2,070–10,343
Durbin
Maxey-Eakin Model.
5,000
Bredehoeft
Maxey-Eakin Model.
5,000–6,000
Lawrence Livermore National Laboratory
Maxey-Eakin Model.
16,214–29,185
Estimate based on isotopic analysis of groundwater in Fenner Gap & estimate of groundwater in storage within the watershed.
11,000–33,000


Seven years of measurement, Collection, and isotopic analysis of summer and winter precipitation from multiple sites within the Fenner Valley watershed
2005
Lawrence Livermore National Laboratory
Revised Elevation versus Precipitation Curve documents substantially greater average annual precipitation within the Fenner Valley watershed than assumed in all previous recharge estimates.
30,000–40,000 Acre-Feet/Year
CH2M HILL
2010
Based on INFIL3.0 soil-moisture budget model and NOAA Climate Prediction Center precipitation projections.
An additional 2,000 AFY estimated for Orange Blossom Wash area.
30,000 Acre-Feet/Year
Ongoing field investigations and groundwater modeling.
CH2M HILL and GSSI
Impacts analysis using groundwater flow models
5,000 - 30,000 Acre-Feet/Year

APPENDIX E

Hydrographs for Transient Model Calibration

With Natural Recharge of 32,000 acre-ft/yr

GEOSCIENCE

APPENDIX E

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

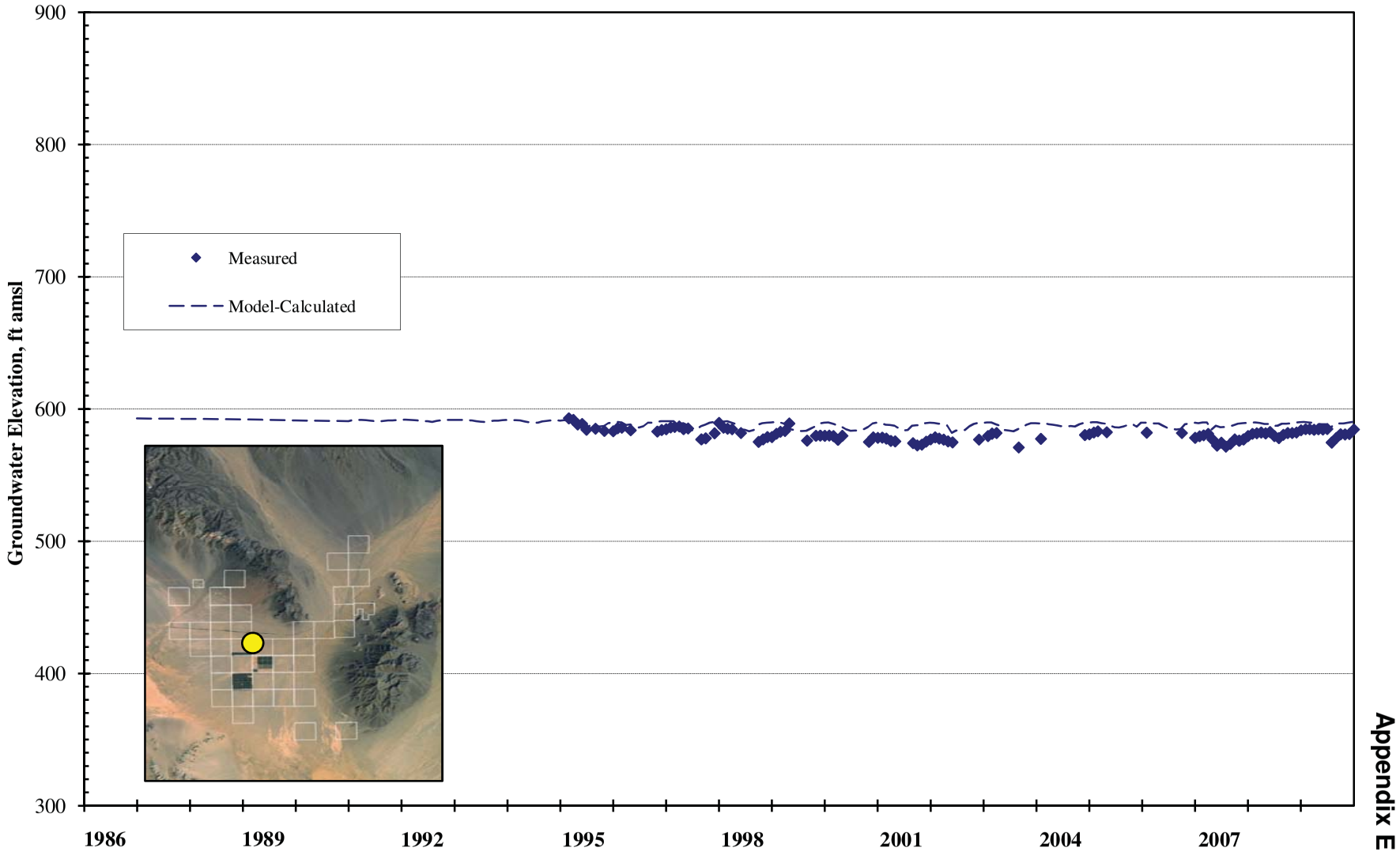
WITH NATURAL RECHARGE OF 32,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N E-1
Hydrograph for Cadiz Well 21S E-2
Hydrograph for Cadiz Well 22 ..... E-3
Hydrograph for Cadiz Well 27N E-4
Hydrograph for Cadiz Well 27S E-5
Hydrograph for Cadiz Well 28 ..... E-6
Hydrograph for Cadiz Well 33 ..... E-7
Hydrograph for Cadiz Dorm Well E-8
Hydrograph for Cadiz Labor Well E-9
Hydrograph for Cadiz Park Well E-10
Hydrograph for Cadiz Well 6N/15E-01 ..... E-11
Hydrograph for Cadiz Well 6N/15E-29 ..... E-12
Hydrograph for Cadiz Well 5N/14E-13 ..... E-13
Hydrograph for Well SCE 5 ..... E-14
Hydrograph for Well SCE 9 ..... E-15
Hydrograph for Well SCE 10 ..... E-16
Hydrograph for Well SCE 11 ..... E-17
Hydrograph for Well SCE 17 ..... E-18
Hydrograph for Well SCE 18 ..... E-19
Hydrograph for Well CI 1 ..... E-20

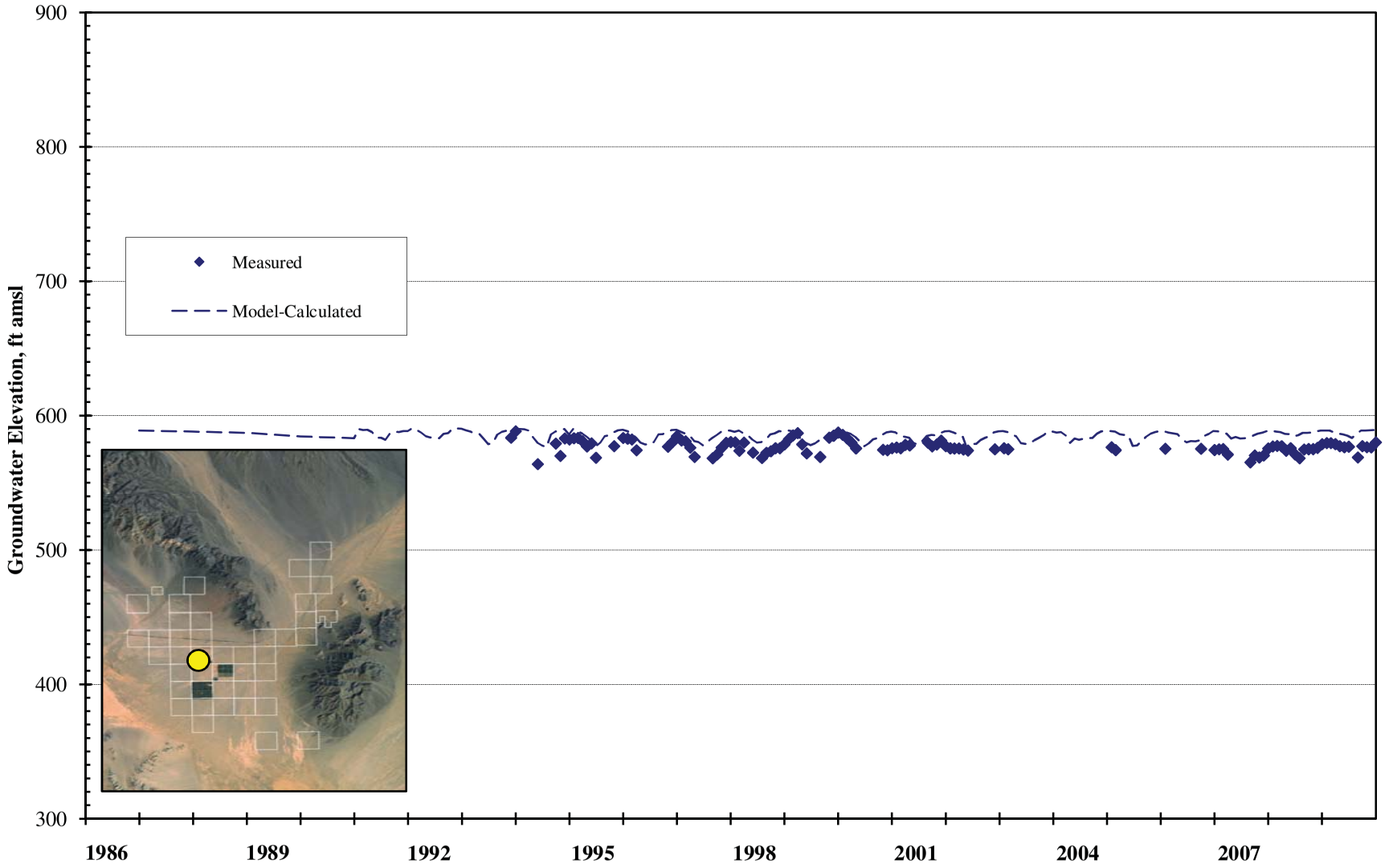
Hydrograph for Well CI 2 ..... E-21
Hydrograph for Well CI 3 ..... E-22
Hydrograph for Well MW 1 ..... E-23
Hydrograph for Well MW 2 ..... E-24
Hydrograph for Well MW 3 ..... E-25
Hydrograph for Well MW 5 ..... E-26
Hydrograph for Well MW 6 ..... E-27
Hydrograph for Well MW 7 ..... E-28
Hydrograph for Well MW 7A E-29

Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



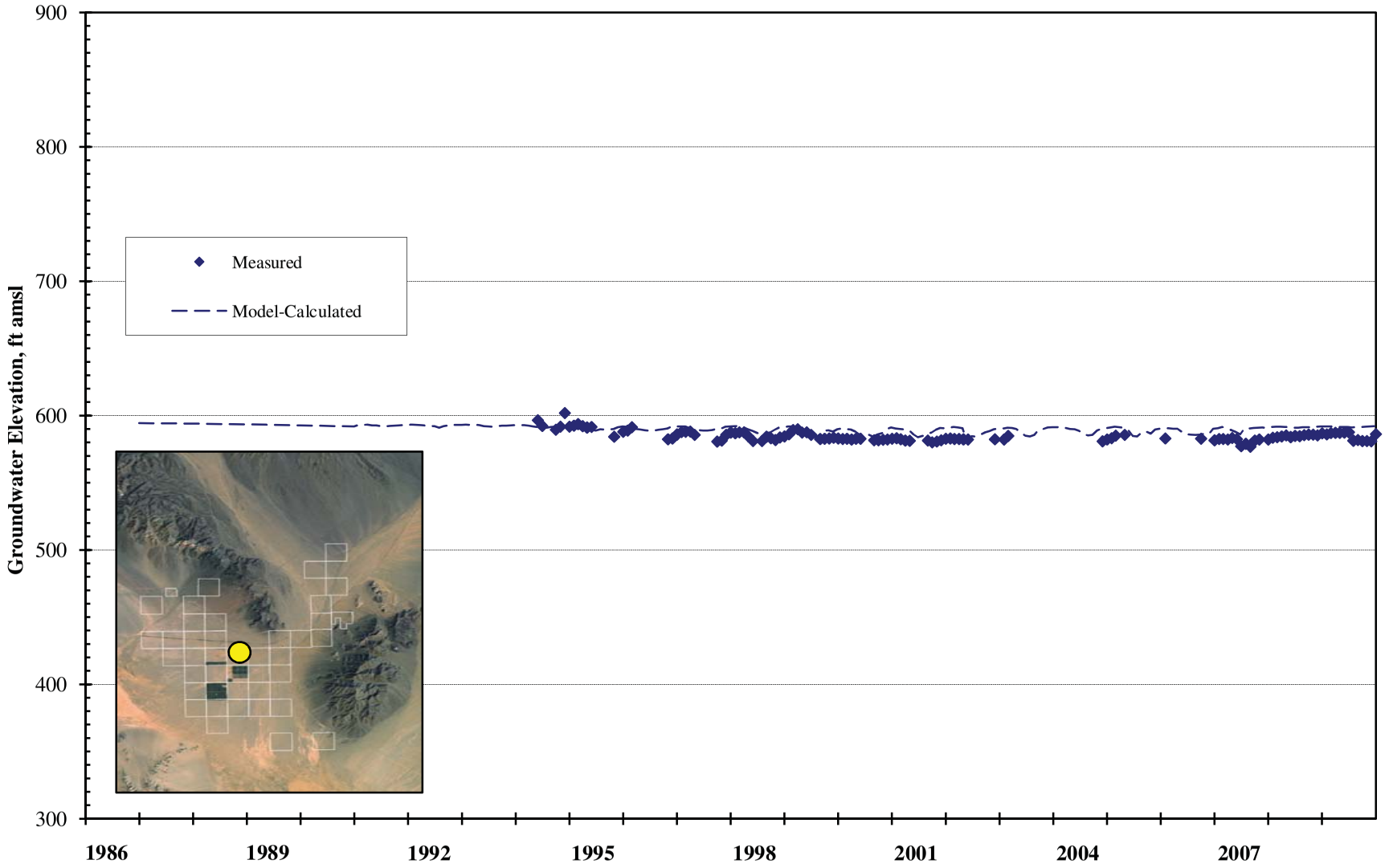
Appendix E

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



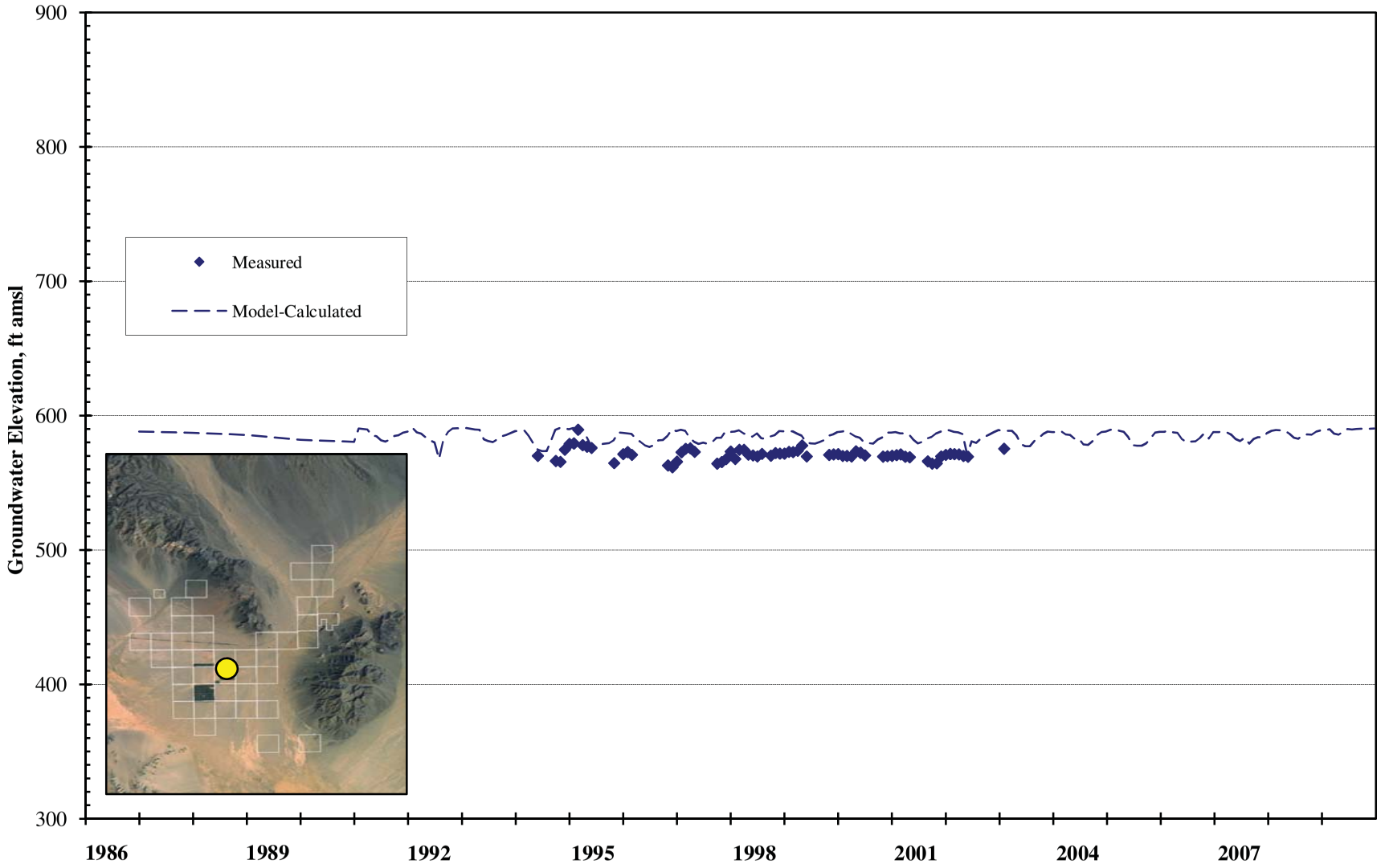
Appendix E

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



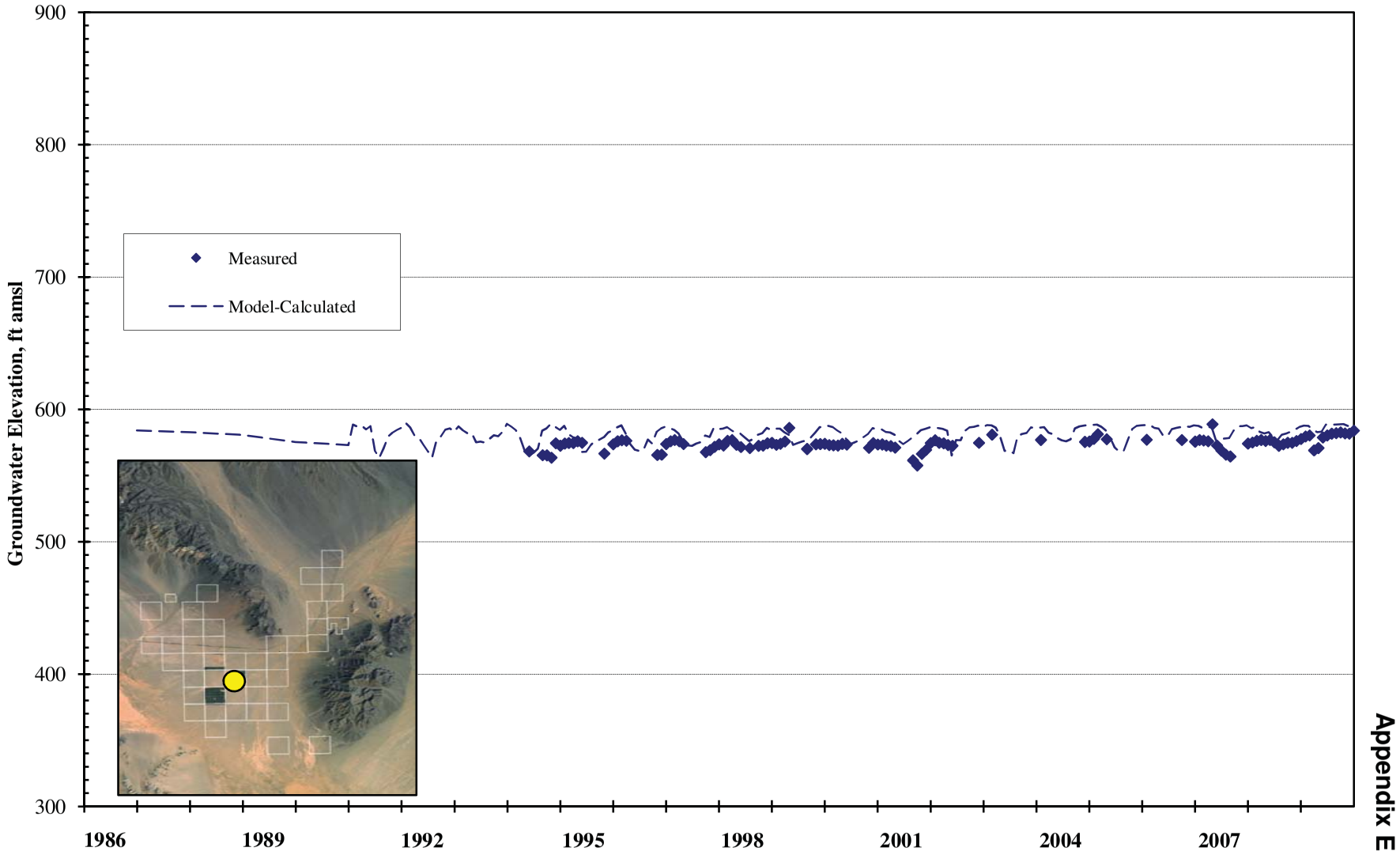
Appendix E

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



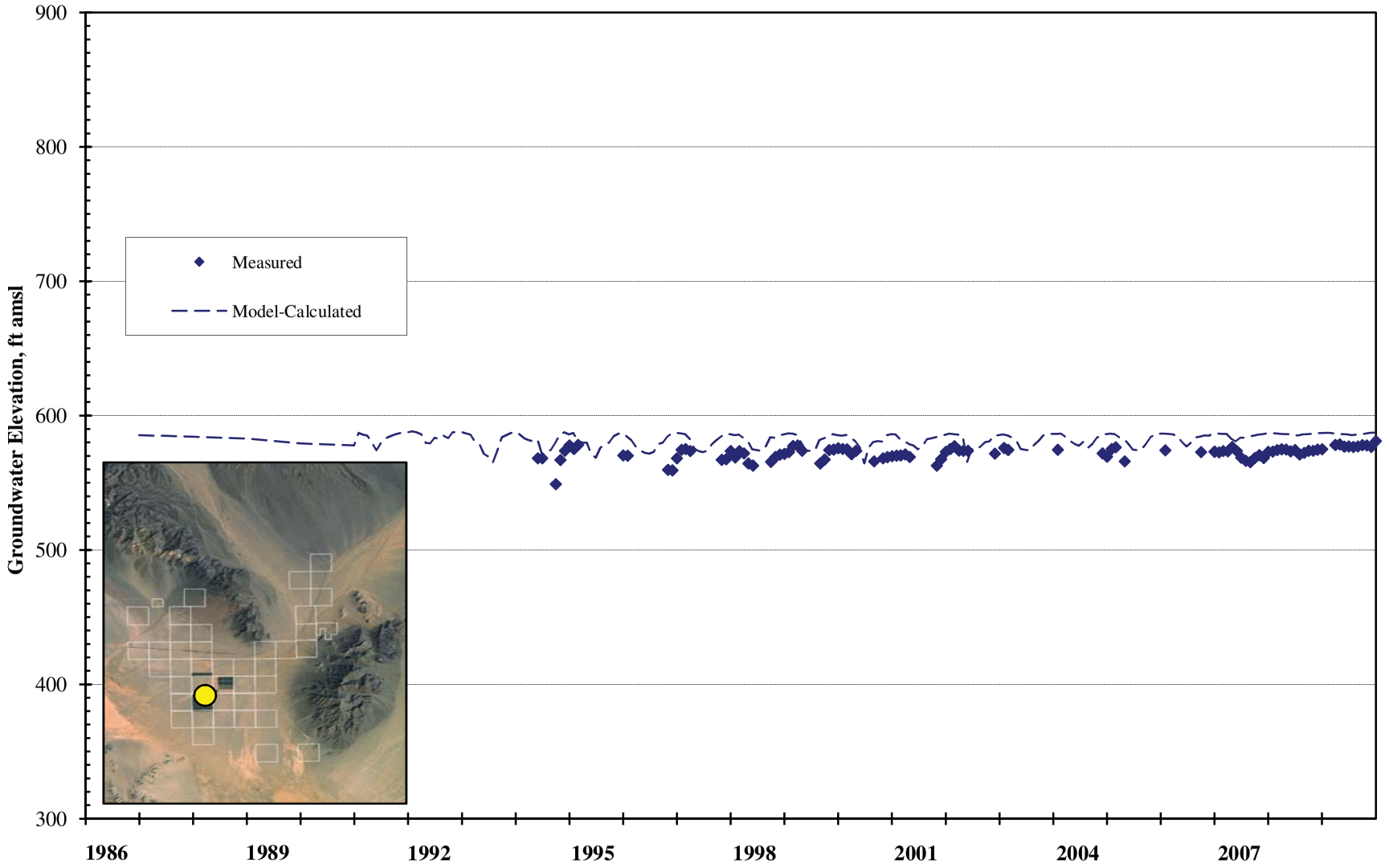
Appendix E

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



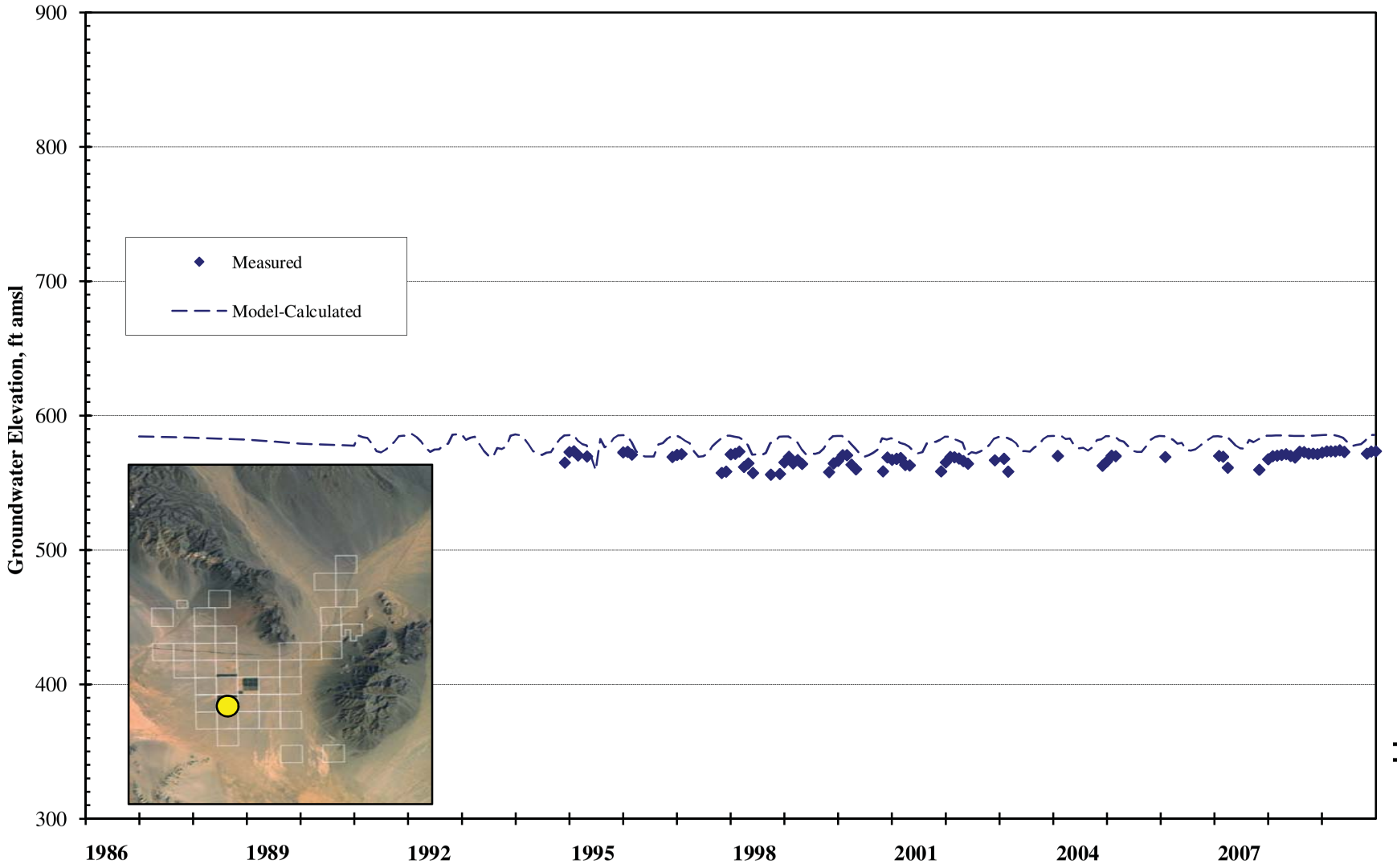
Appendix E

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



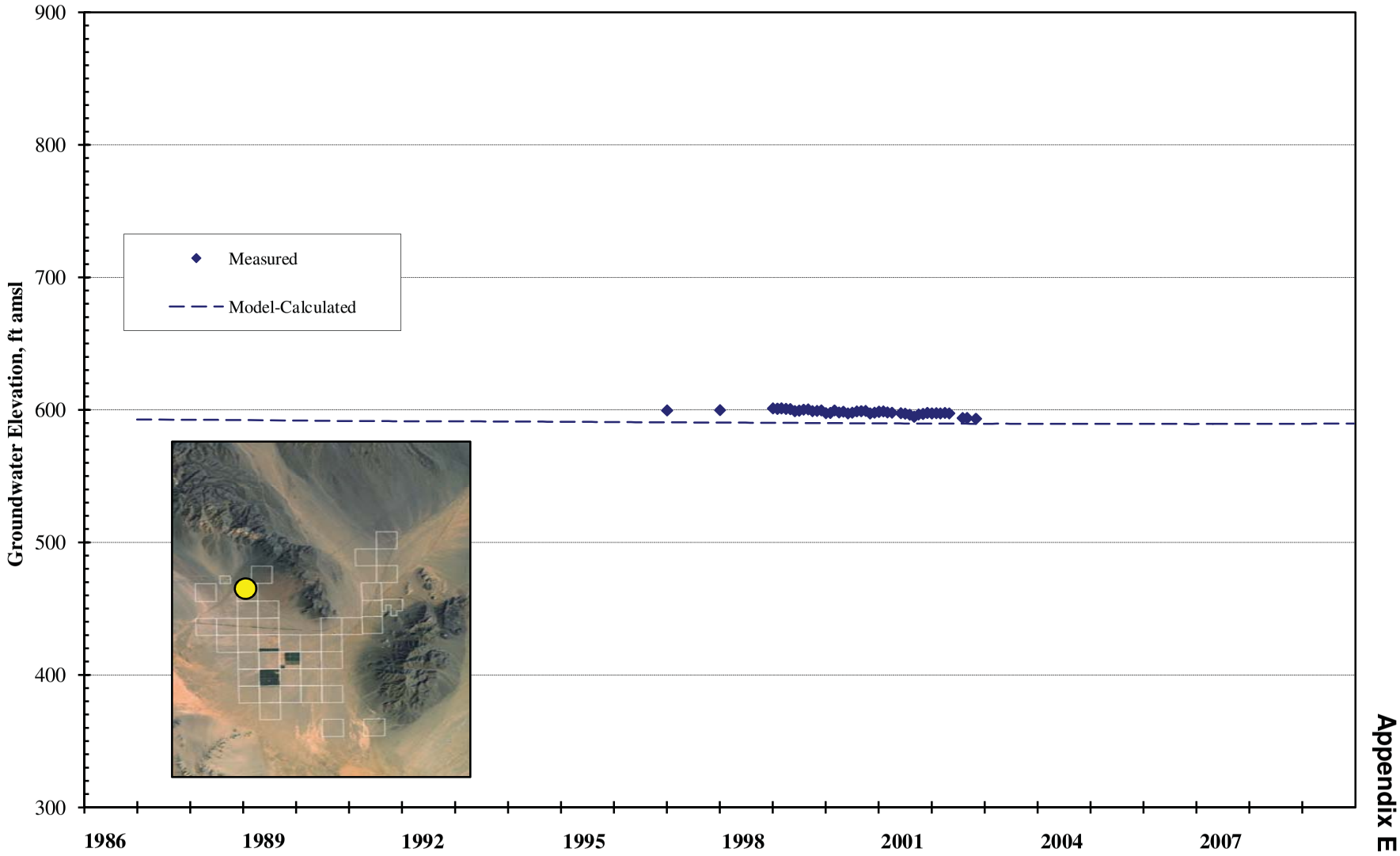
Appendix E

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



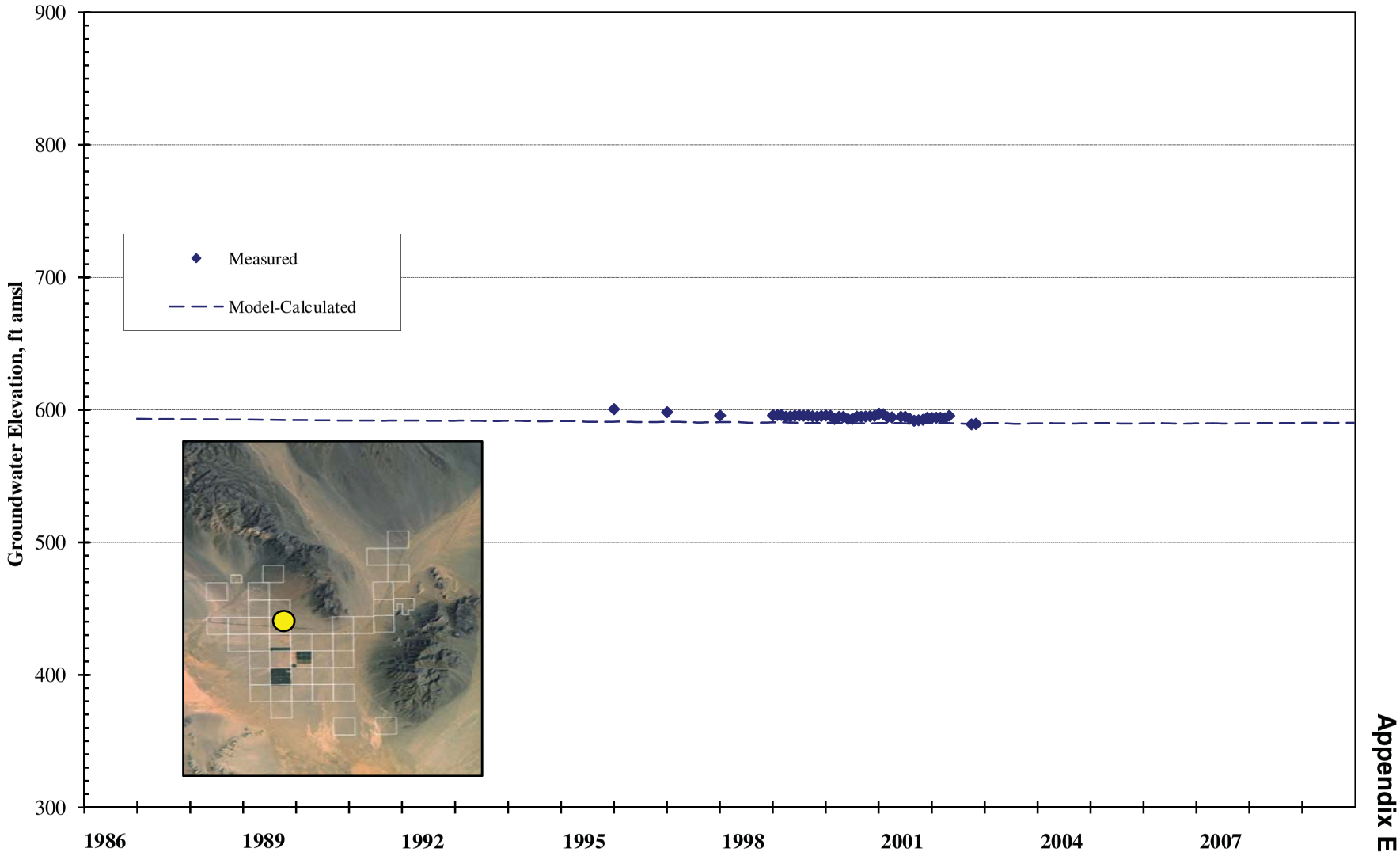
Appendix E

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



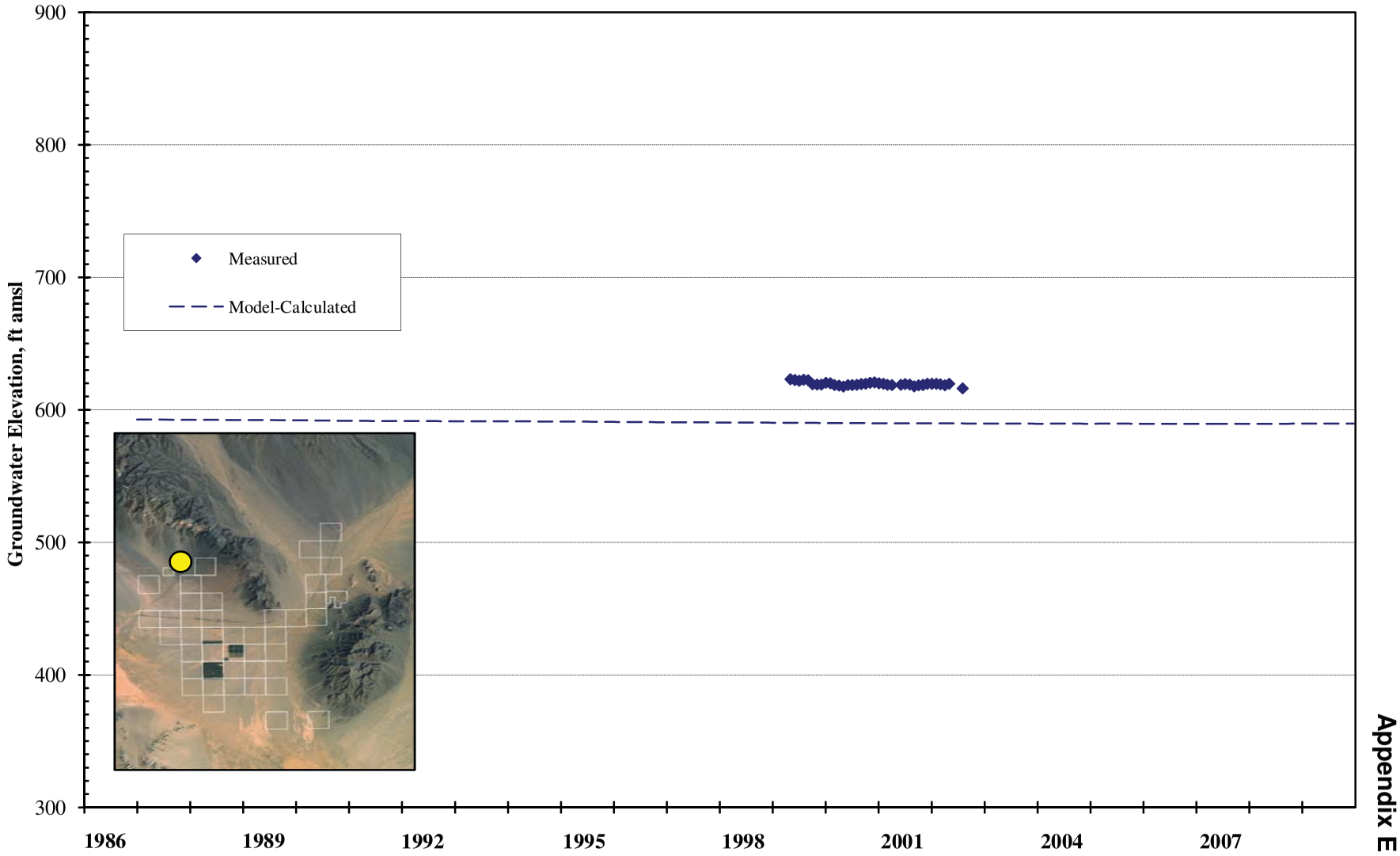
Appendix E

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



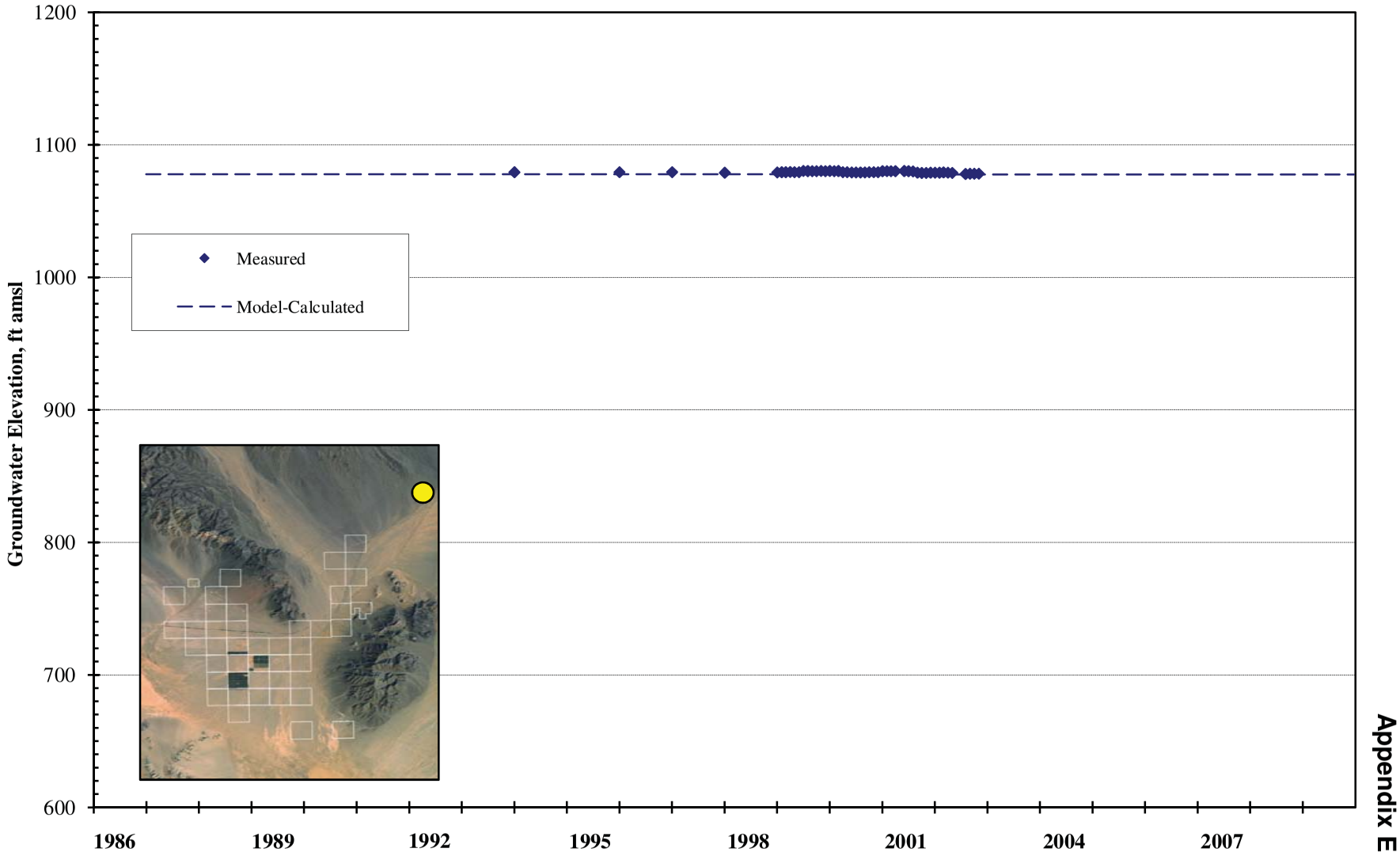
Appendix E

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



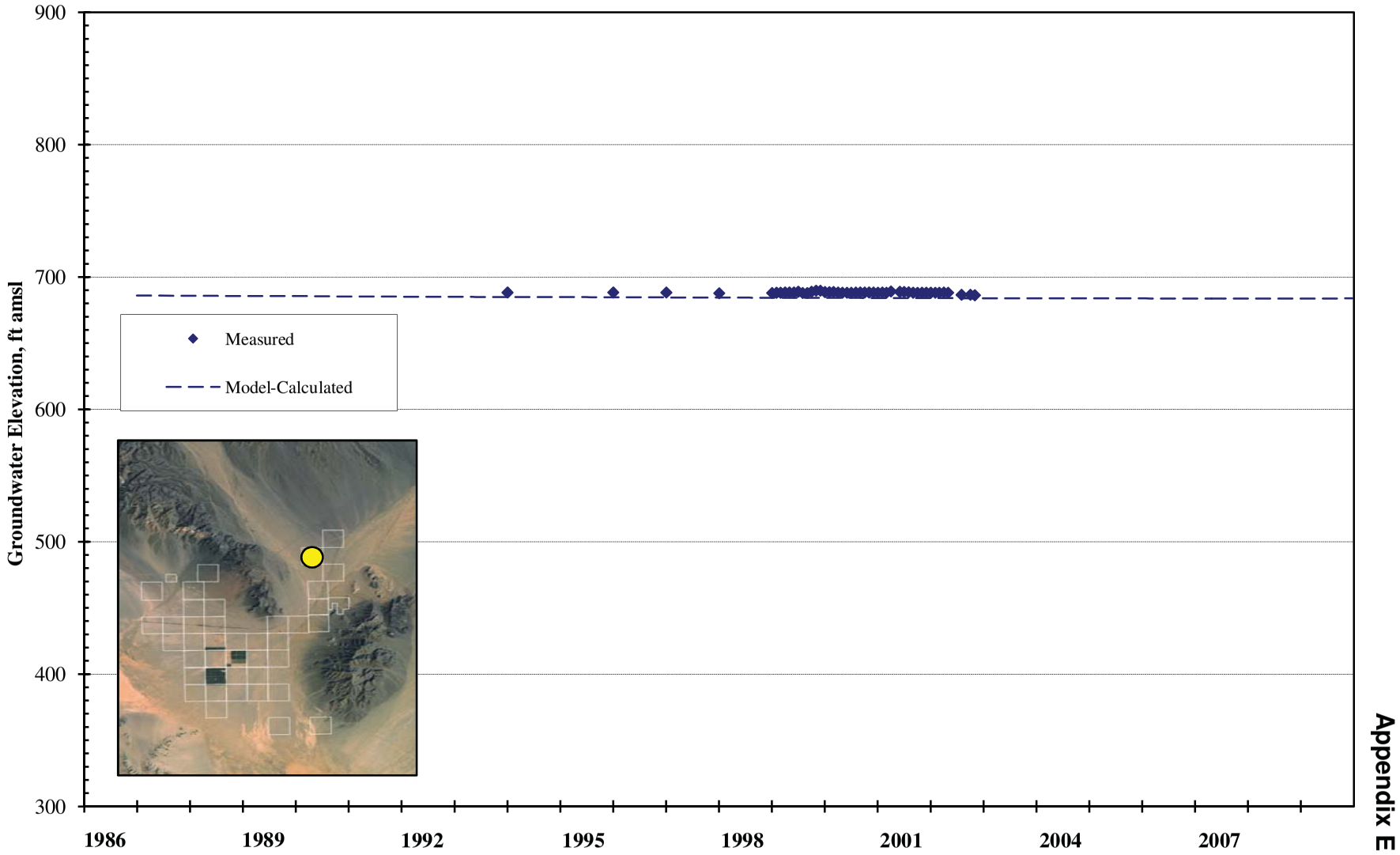
Appendix E

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



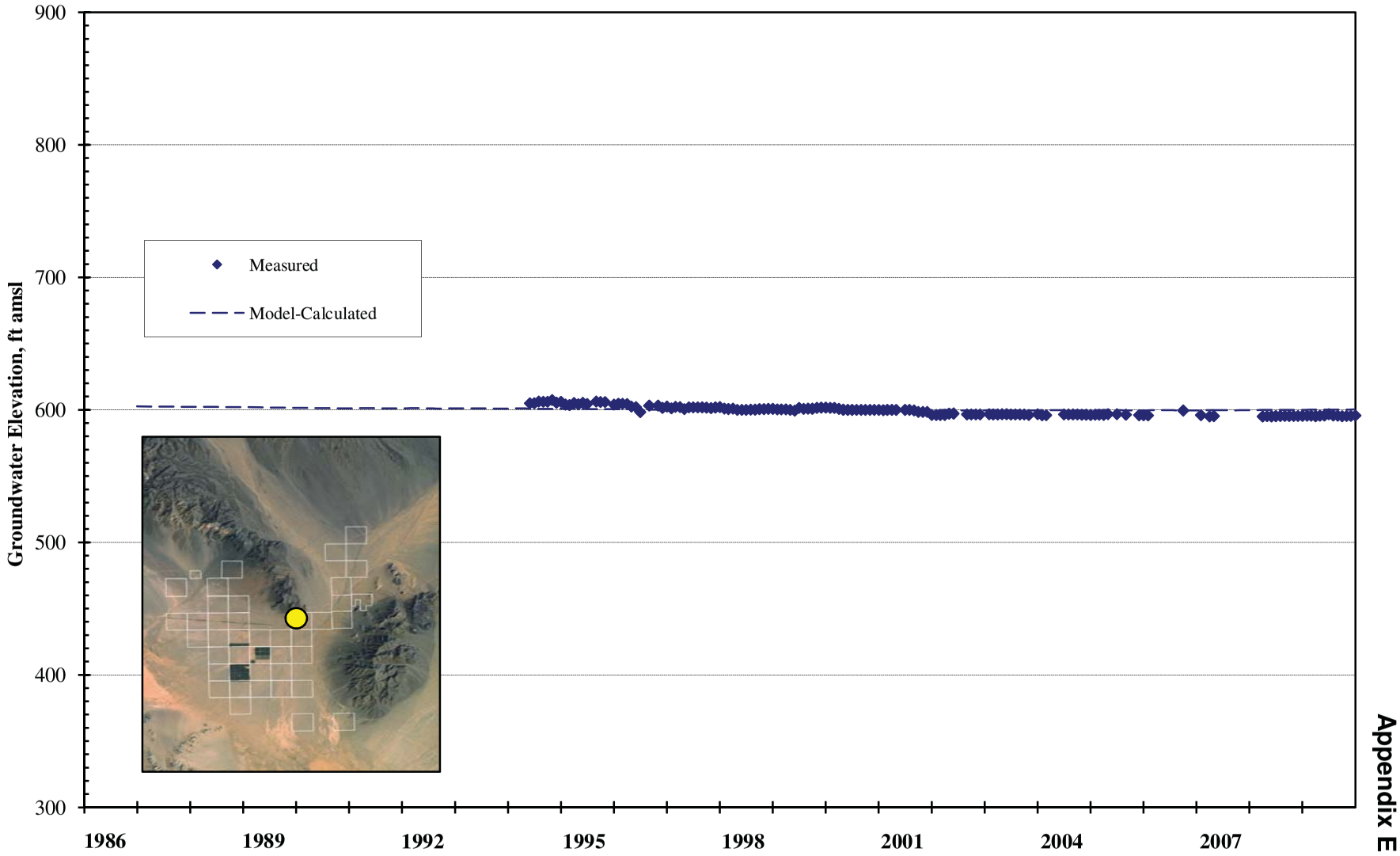
Appendix E

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



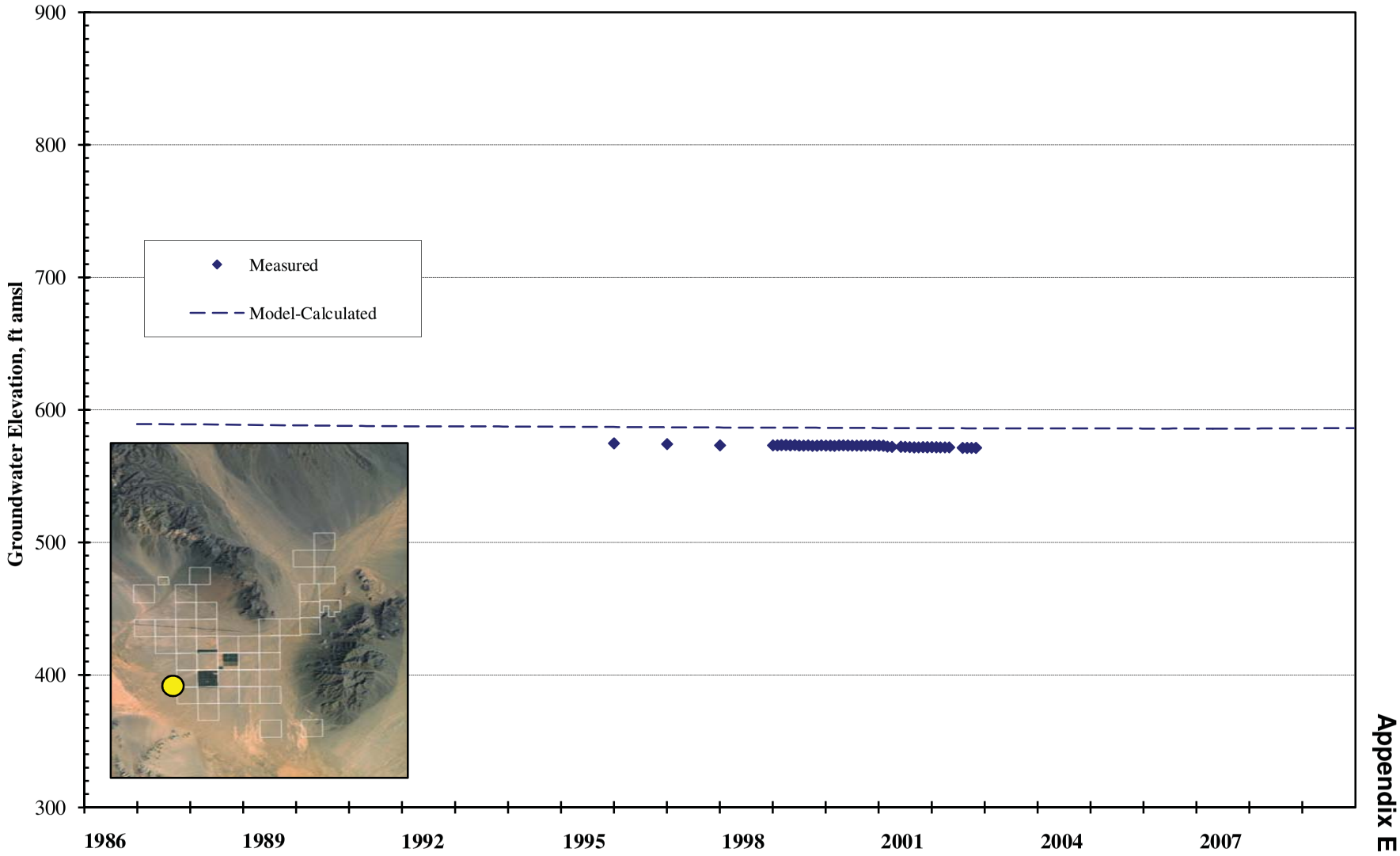
Appendix E

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



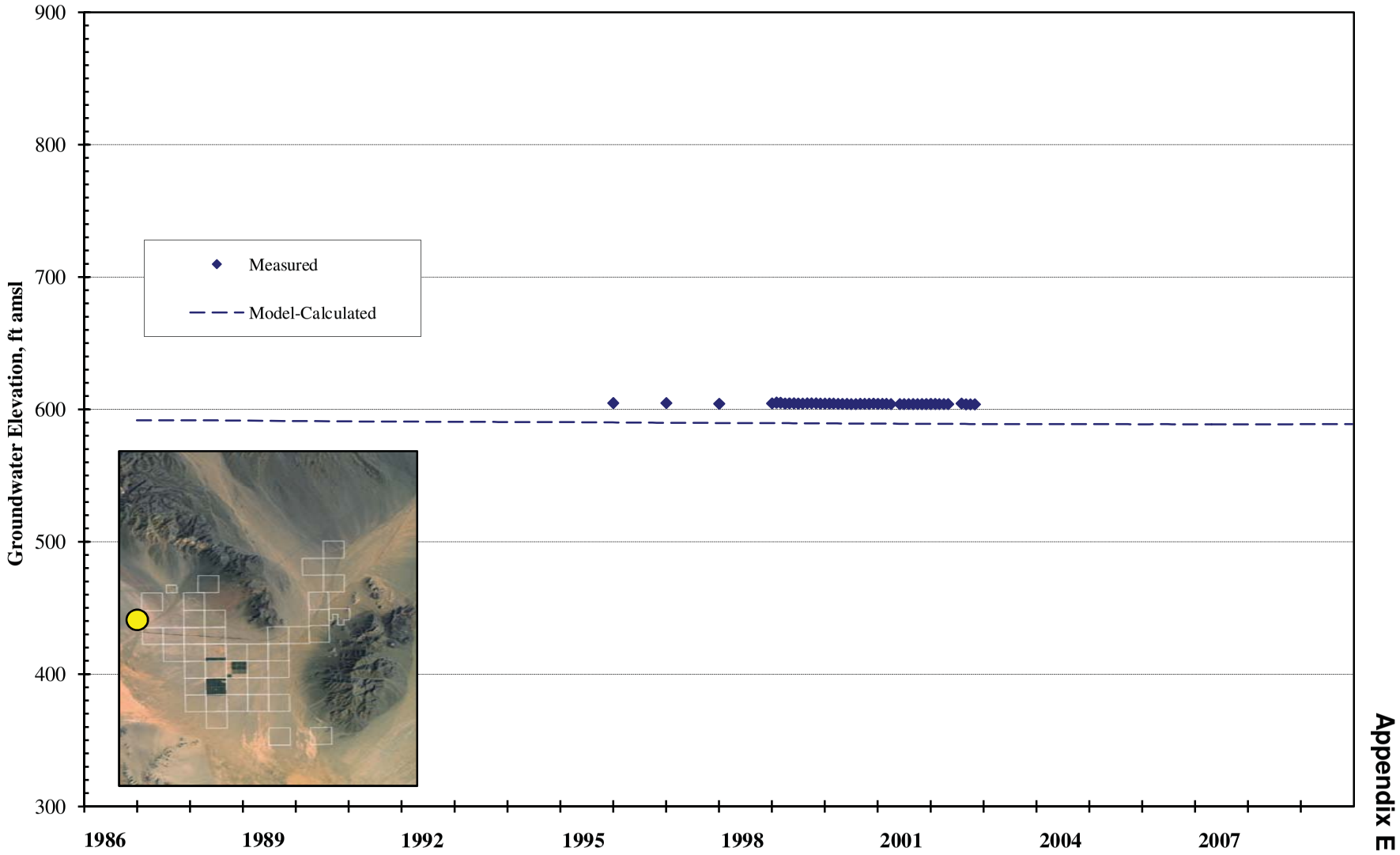
Appendix E

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



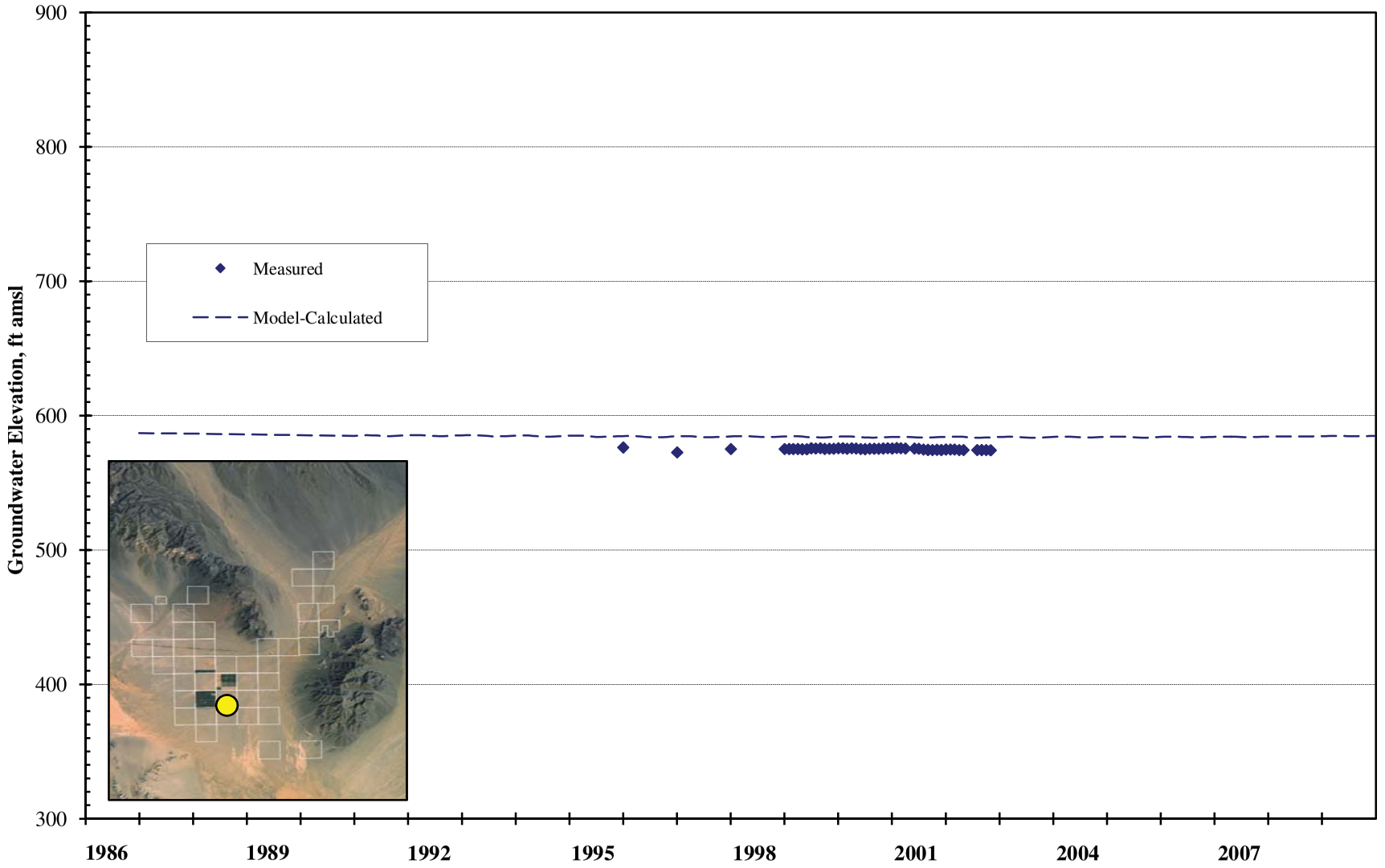
Appendix E

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



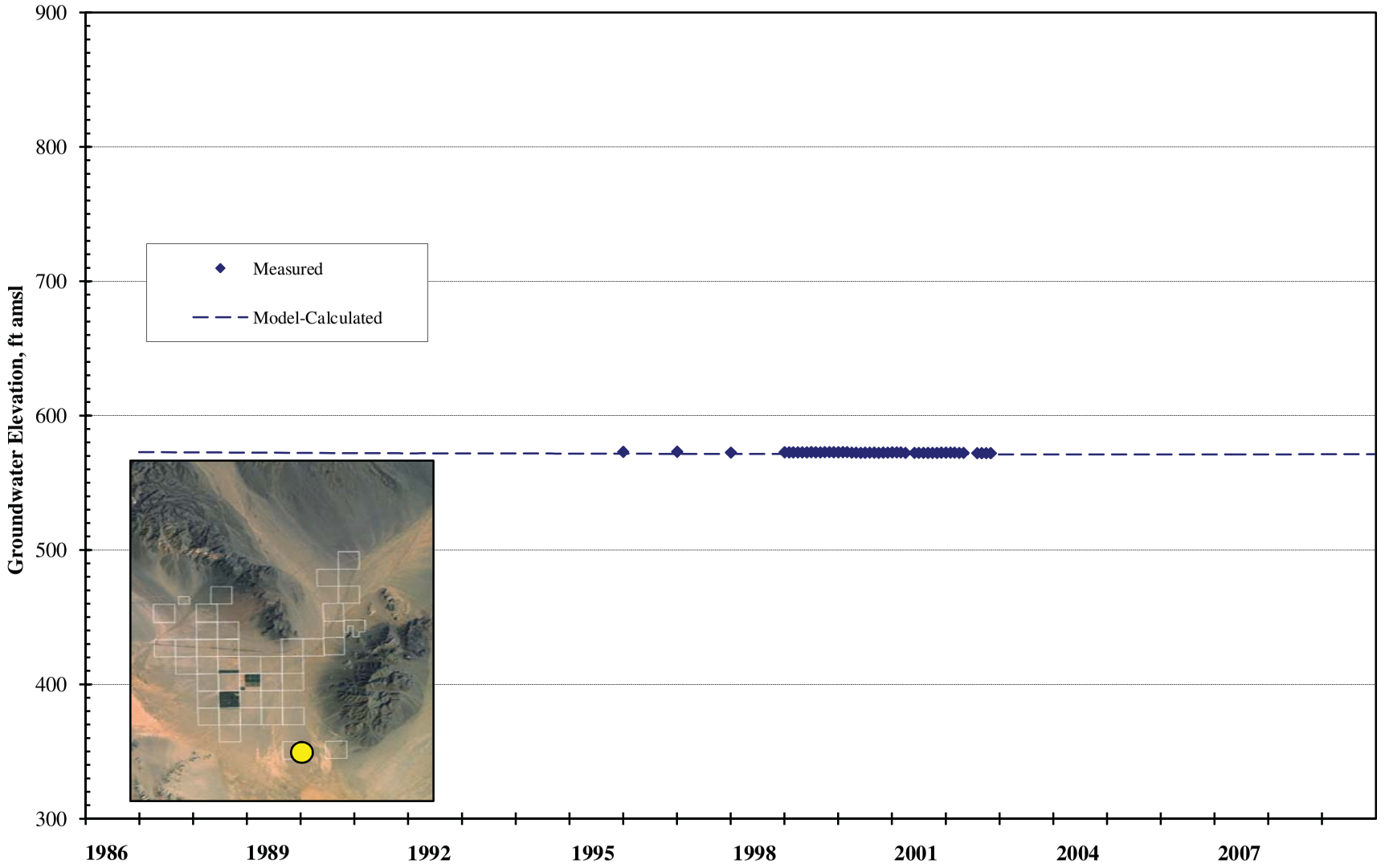
Appendix E

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



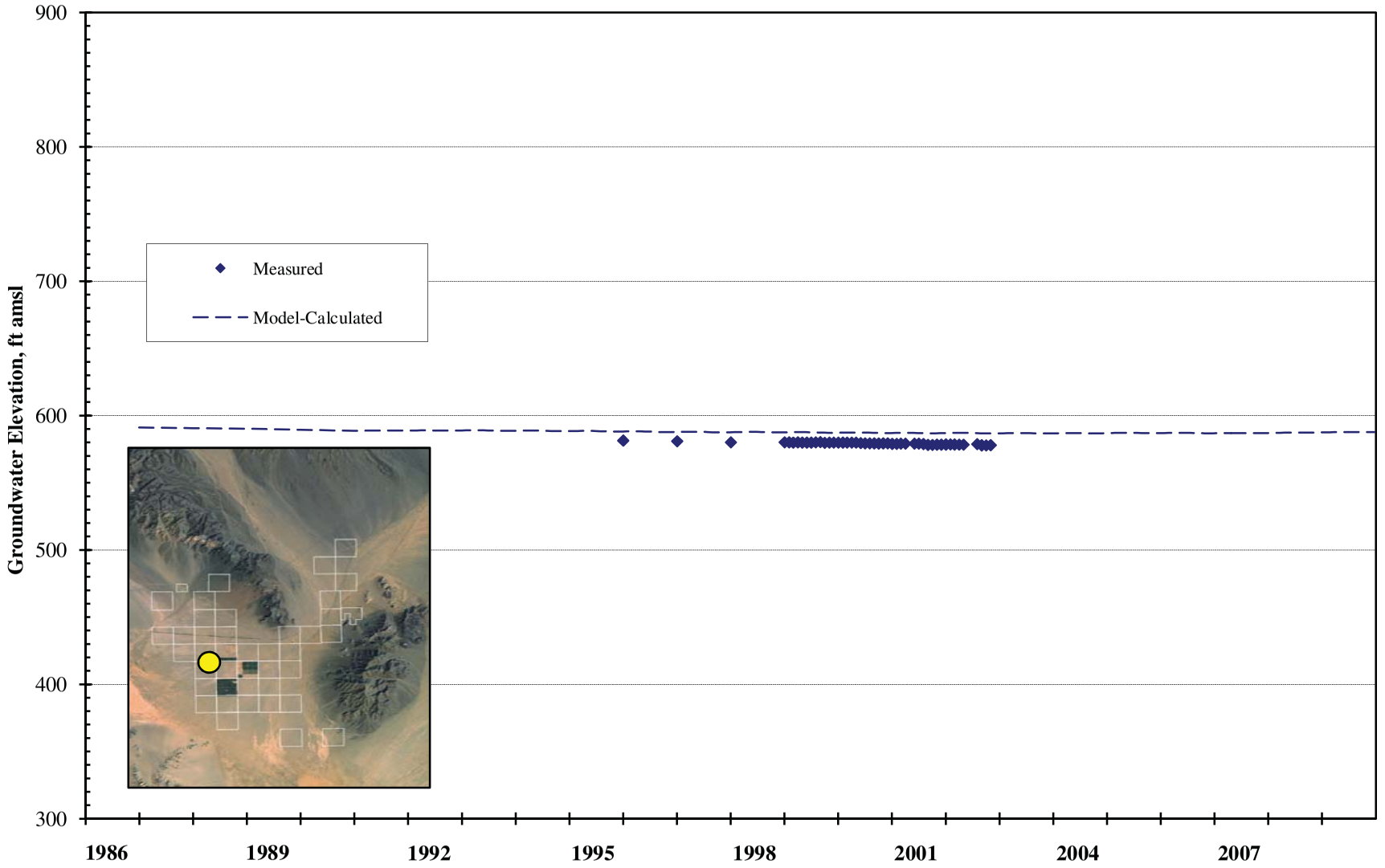
Appendix E

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



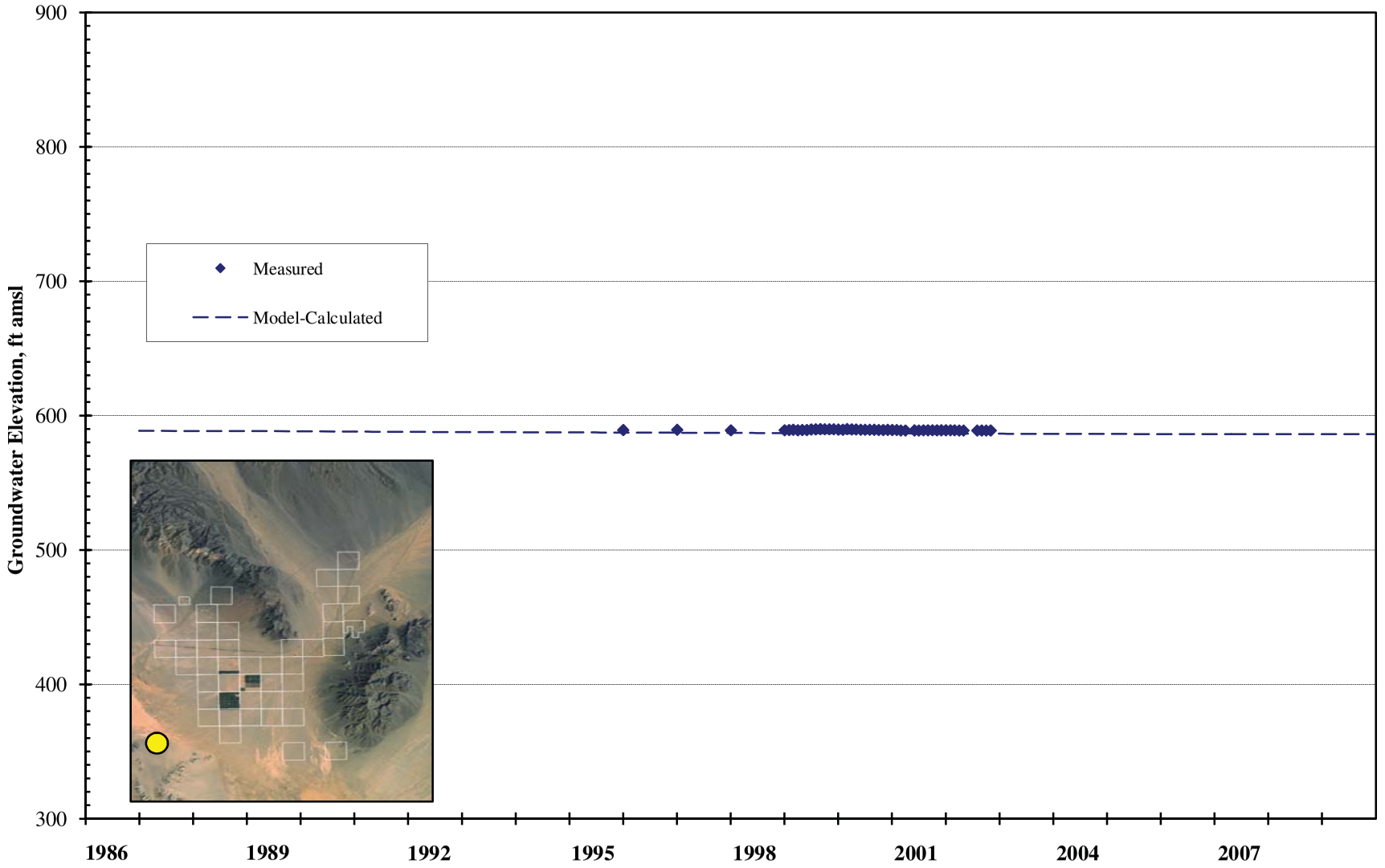
Appendix E

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



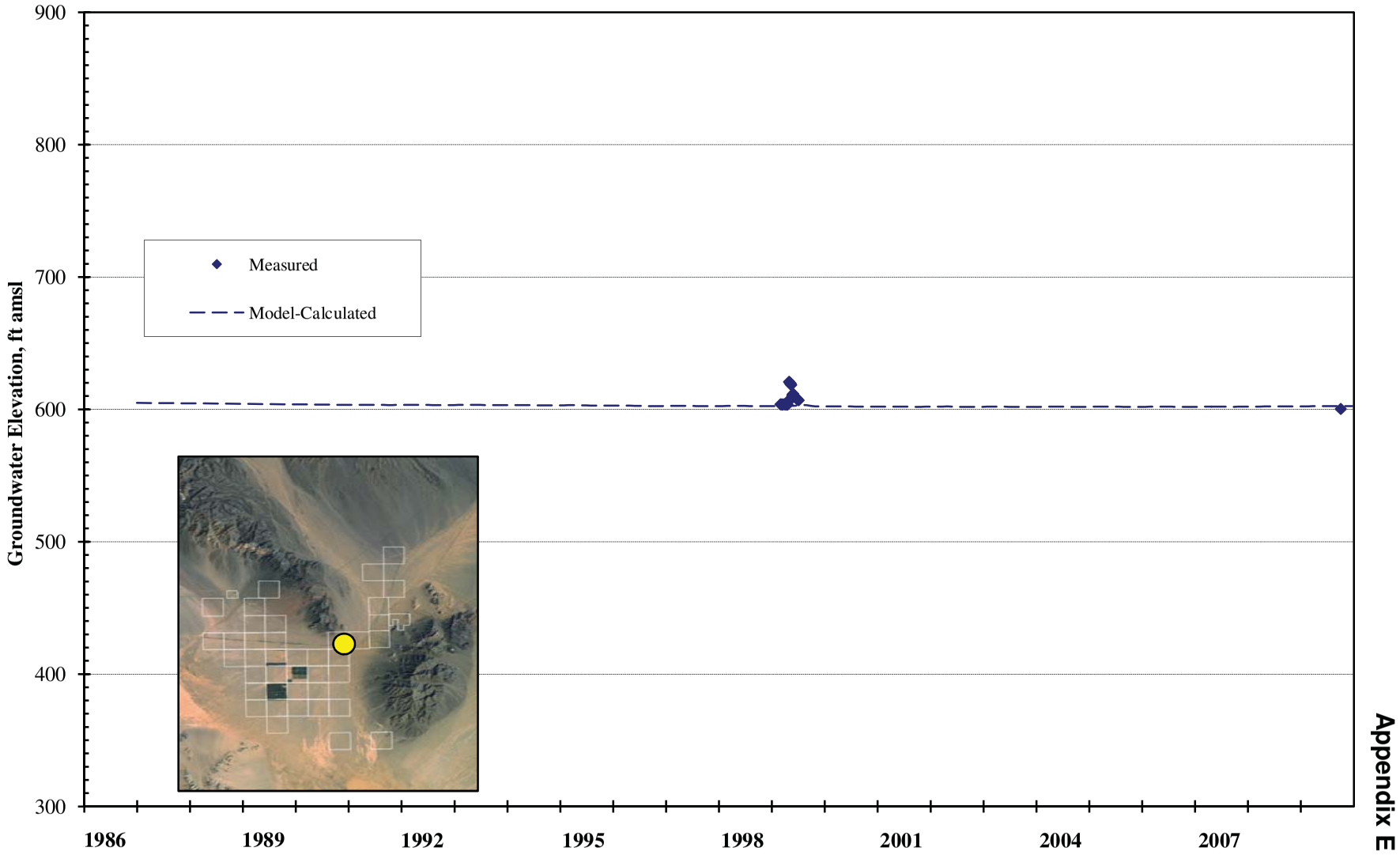
Appendix E

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



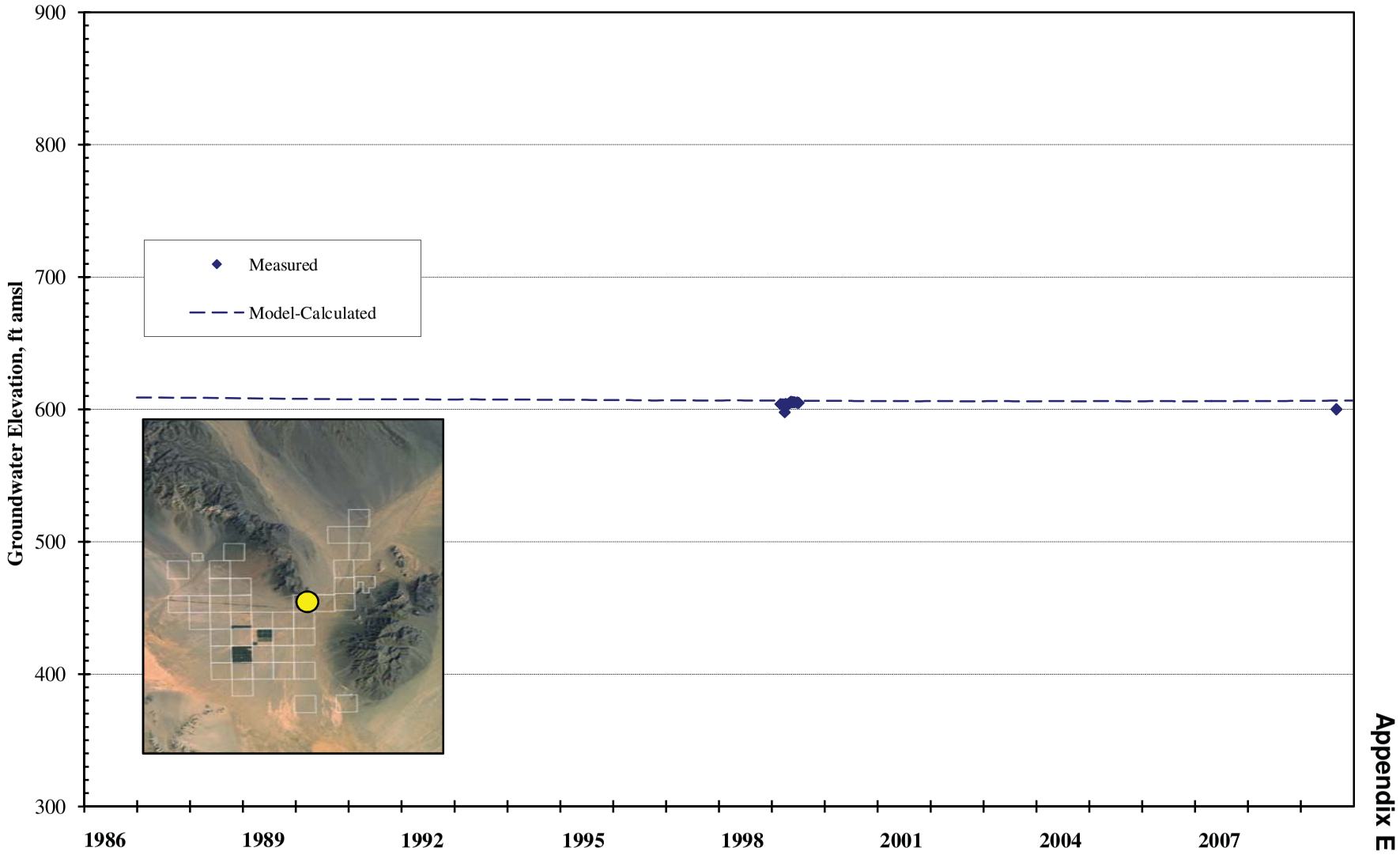
Appendix E

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



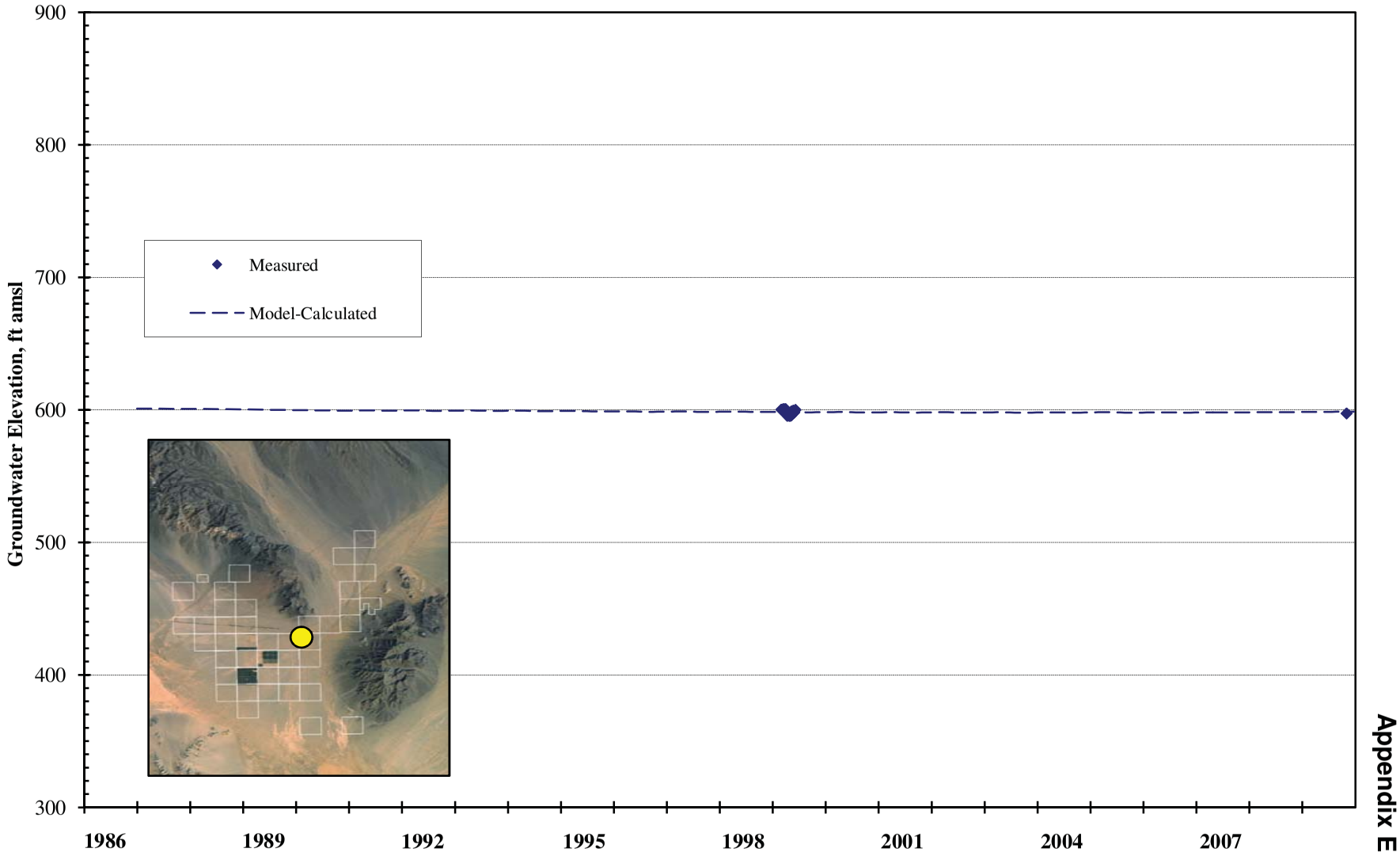
Appendix E

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



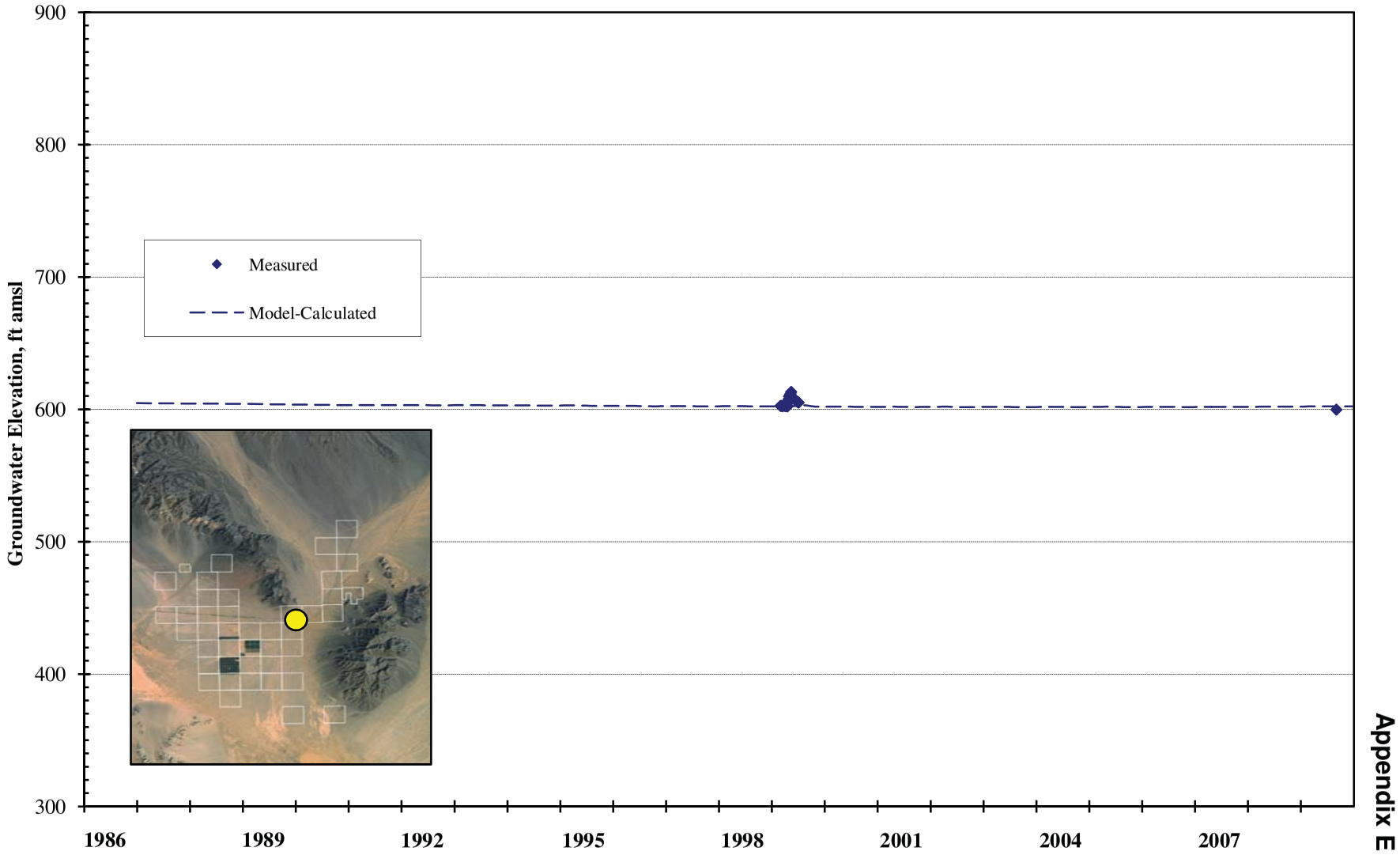
Appendix E

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



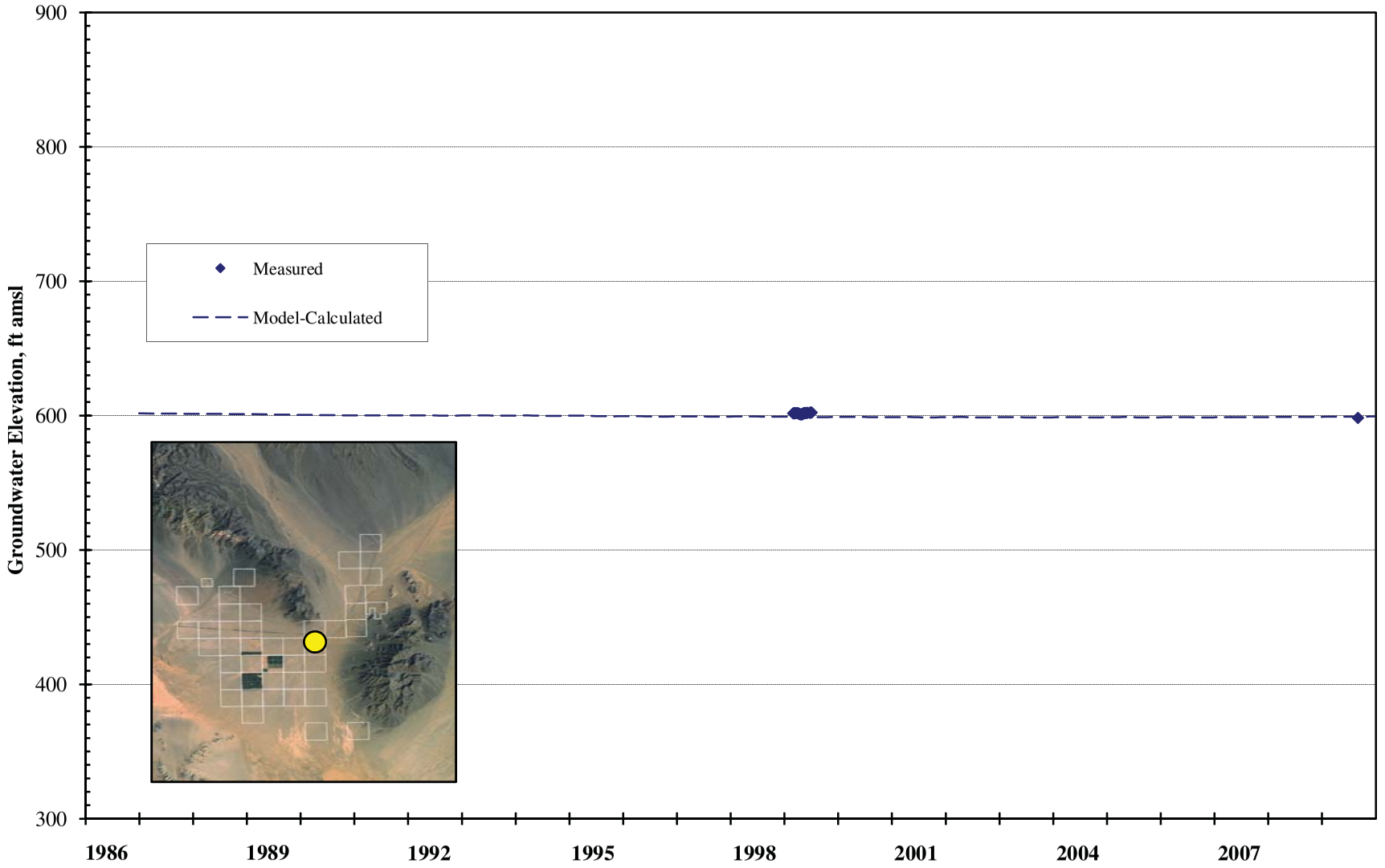
Appendix E

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



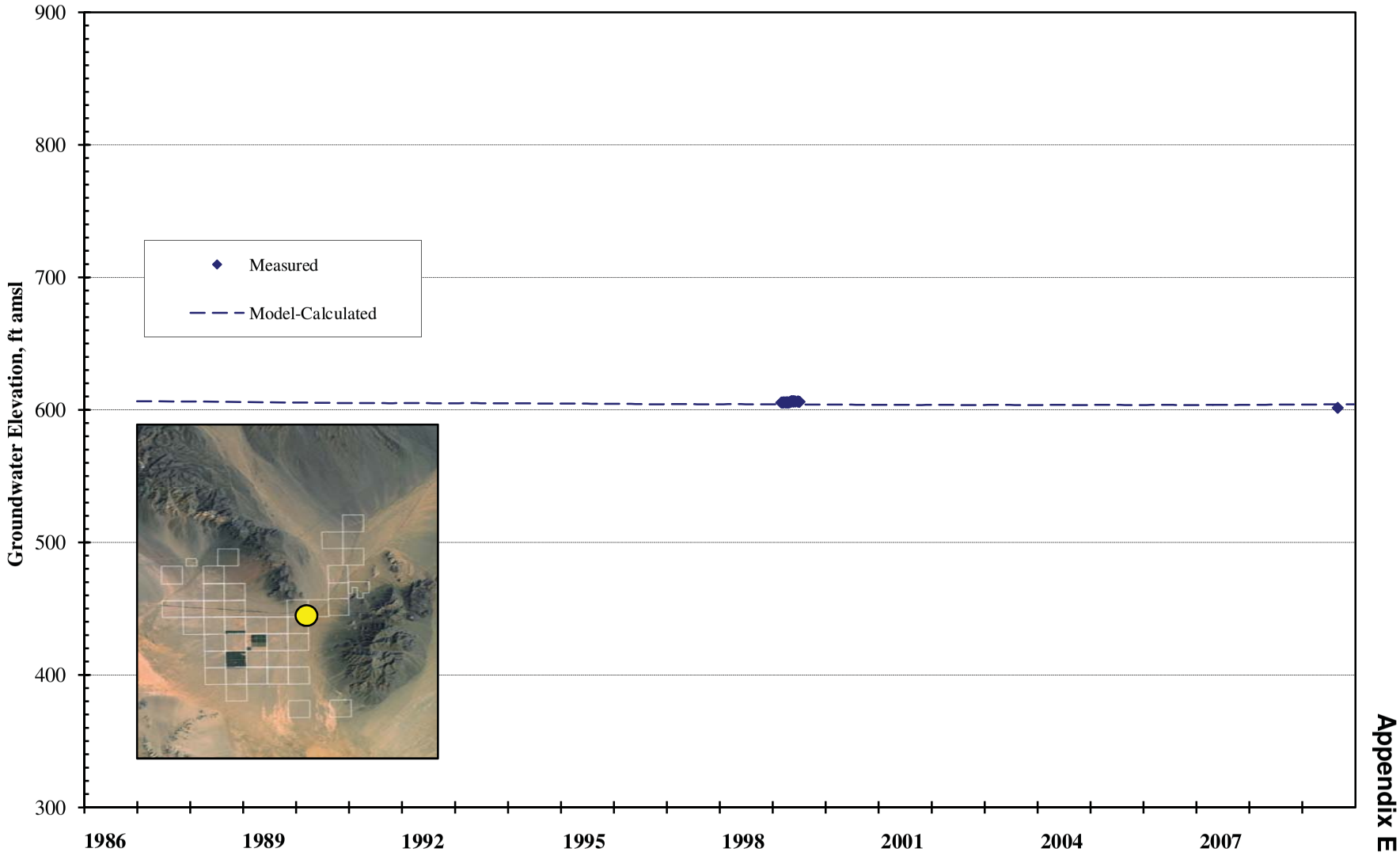
Appendix E

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



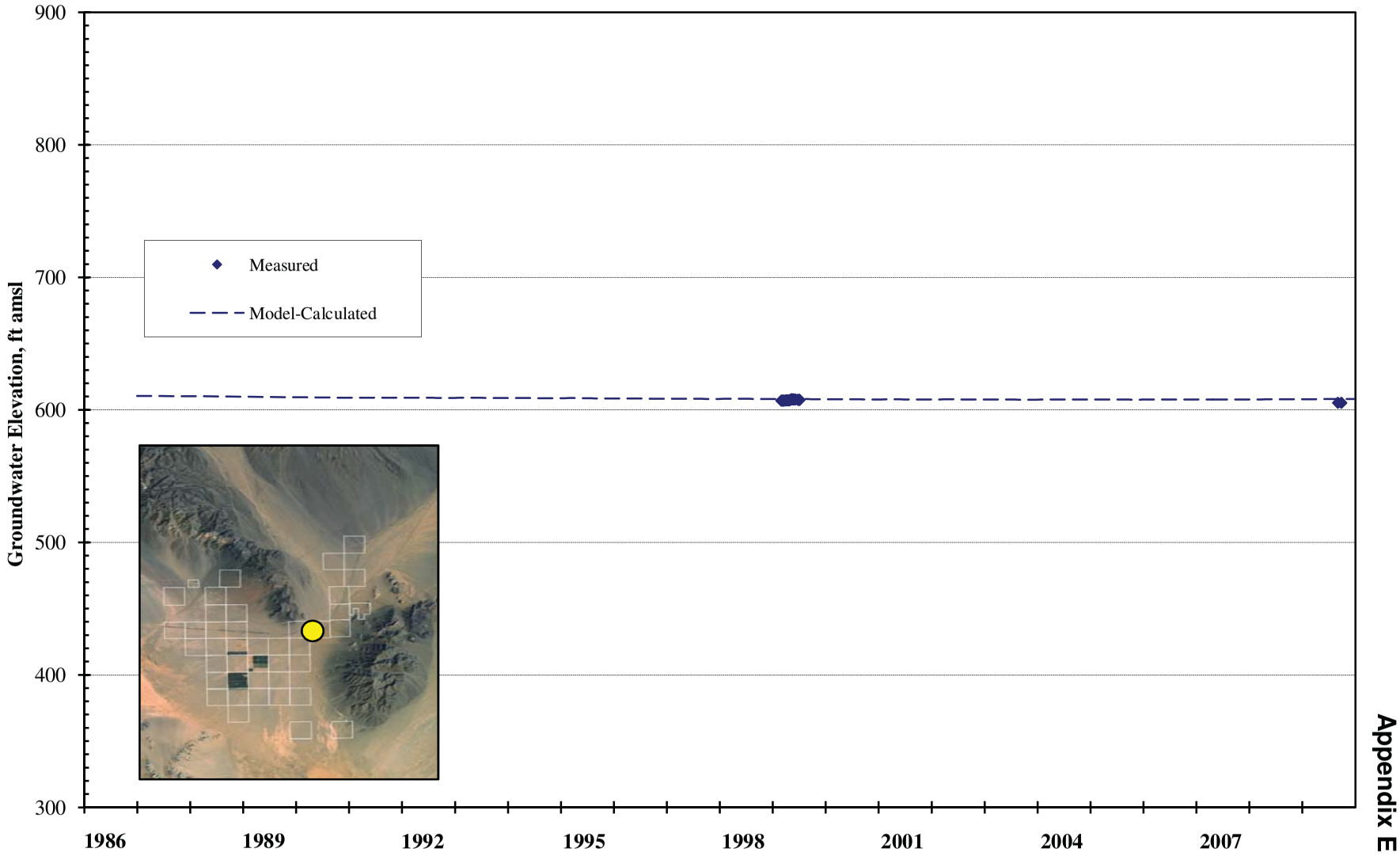
Appendix E

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



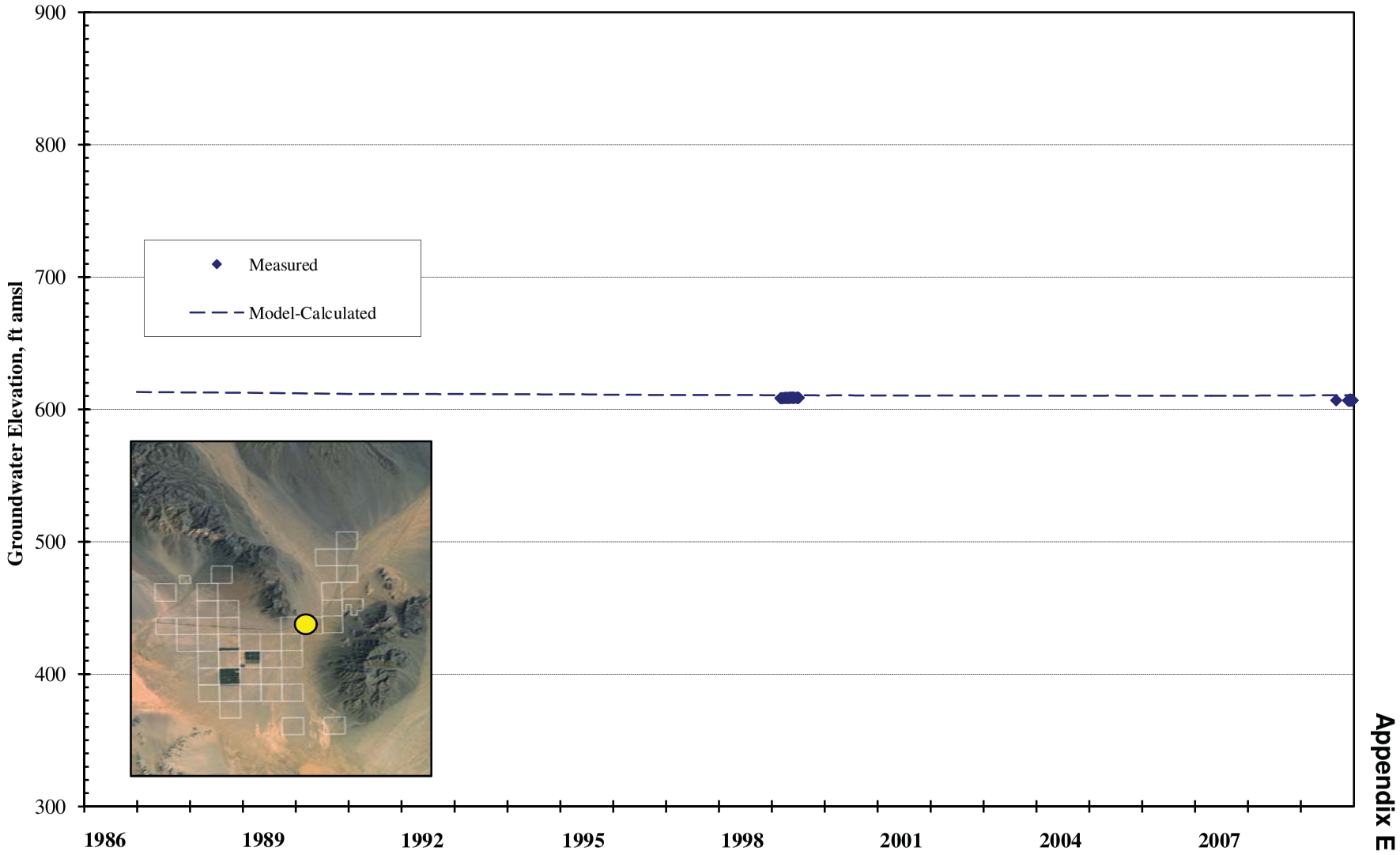
Appendix E

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



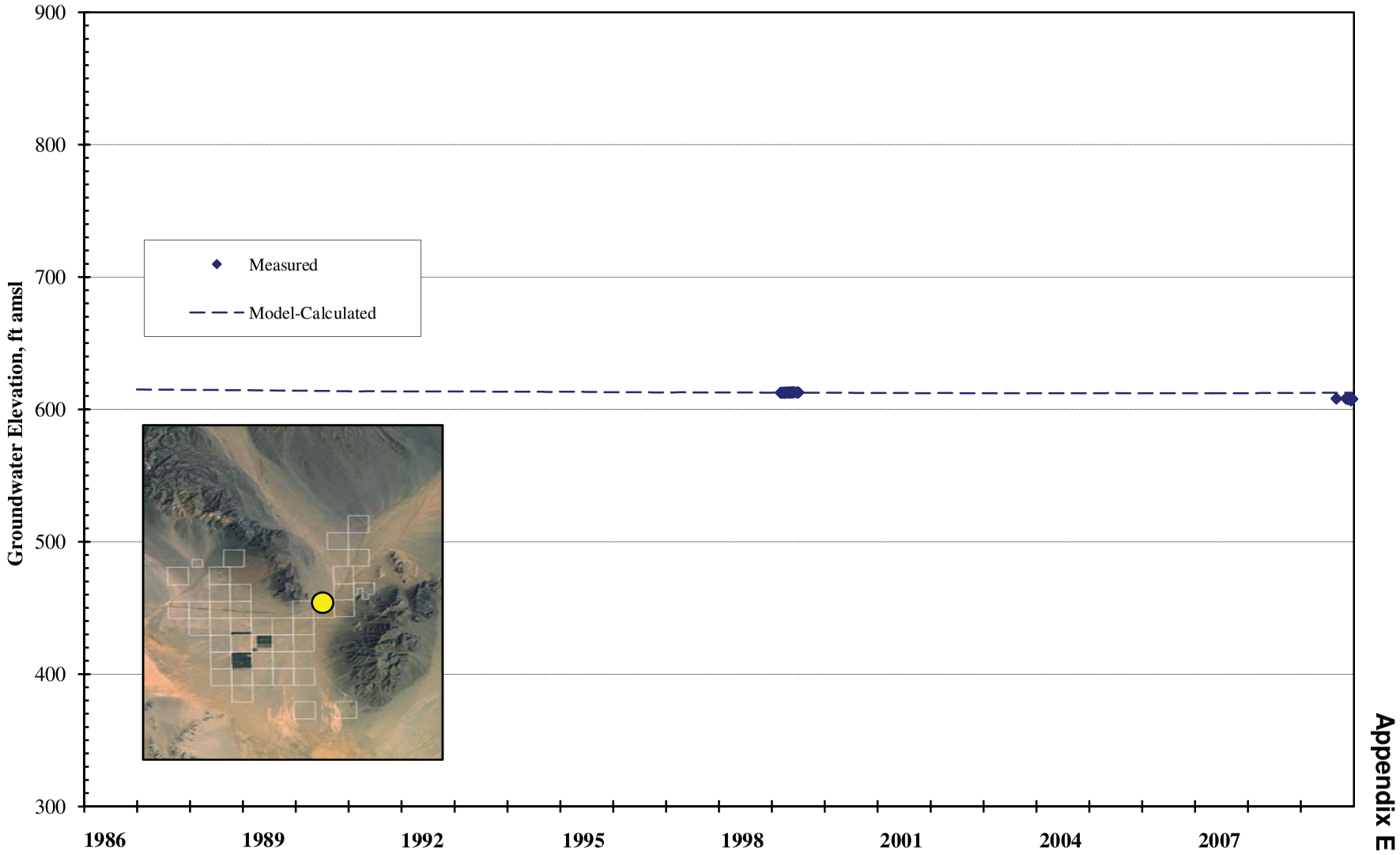
Appendix E

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



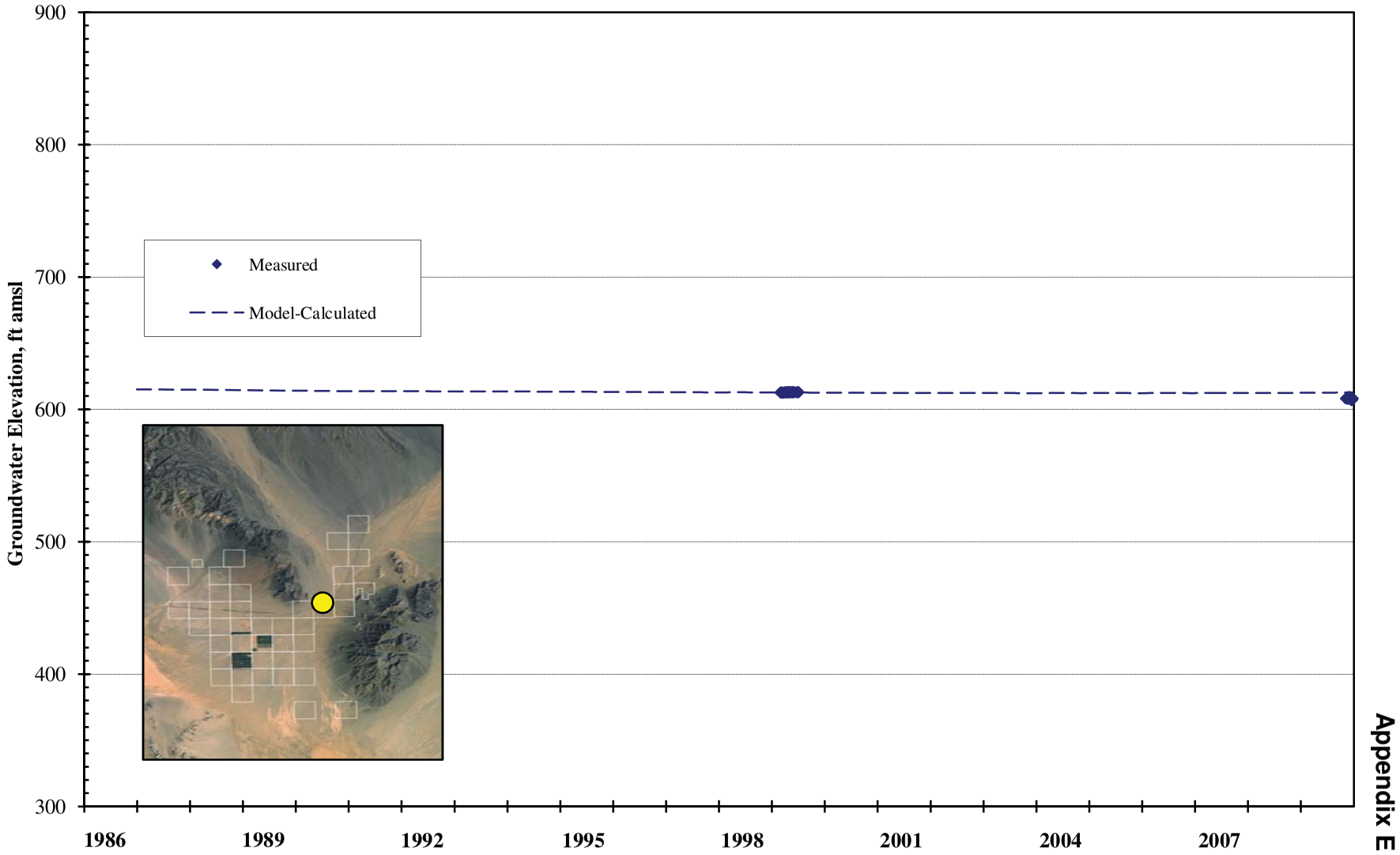
Appendix E

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



Appendix E

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



Appendix E

APPENDIX F

Hydrographs for Transient Model Calibration

With Natural Recharge of 16,000 acre-ft/yr

GEOSCIENCE

APPENDIX F

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

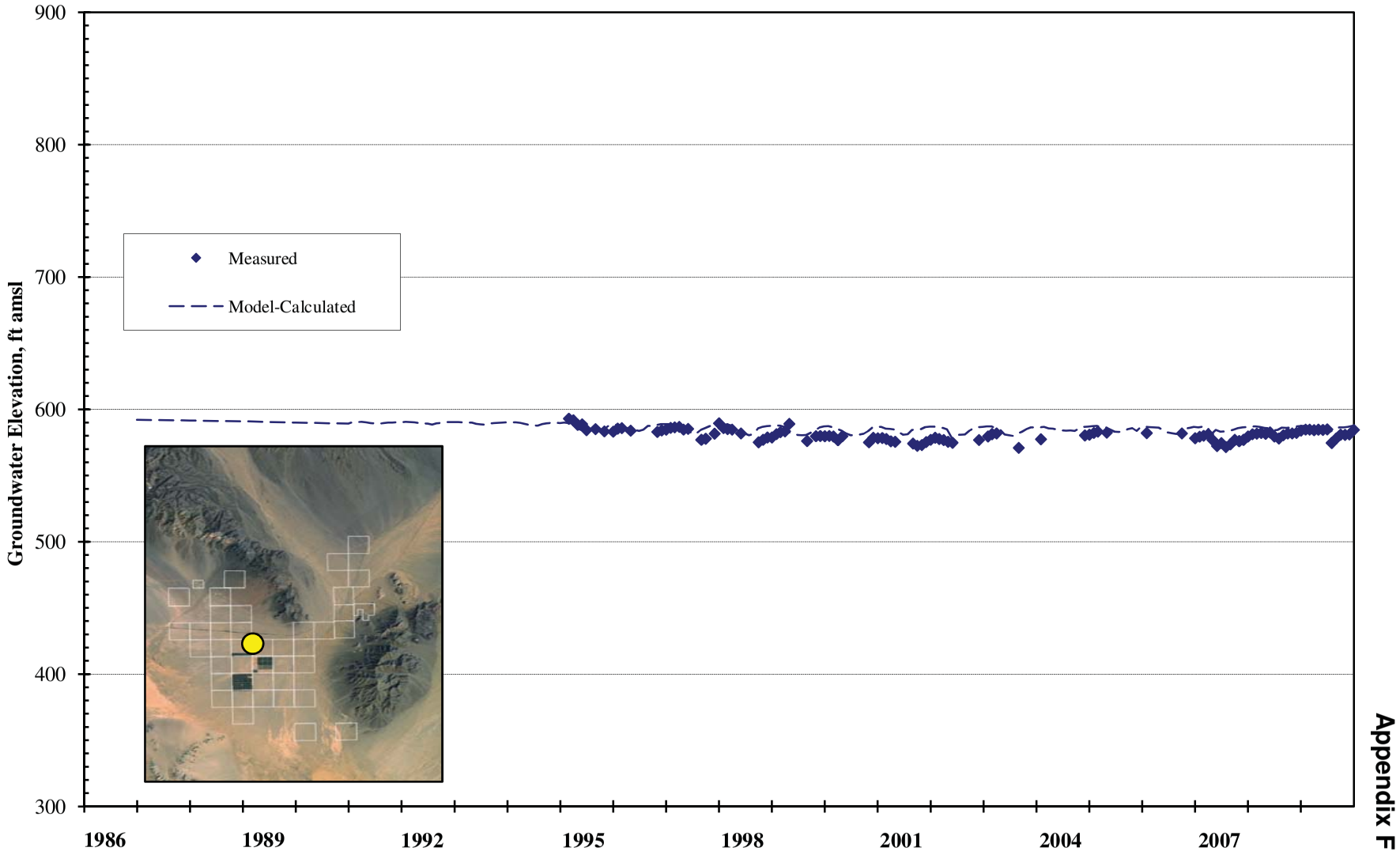
WITH NATURAL RECHARGE OF 16,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N F-1
Hydrograph for Cadiz Well 21S F-2
Hydrograph for Cadiz Well 22 ..... F-3
Hydrograph for Cadiz Well 27N F-4
Hydrograph for Cadiz Well 27S F-5
Hydrograph for Cadiz Well 28 ..... F-6
Hydrograph for Cadiz Well 33 ..... F-7
Hydrograph for Cadiz Dorm Well F-8
Hydrograph for Cadiz Labor Well F-9
Hydrograph for Cadiz Park Well F-10
Hydrograph for Cadiz Well 6N/15E-01 ..... F-11
Hydrograph for Cadiz Well 6N/15E-29 ..... F-12
Hydrograph for Cadiz Well 5N/14E-13 ..... F-13
Hydrograph for Well SCE 5 ..... F-14
Hydrograph for Well SCE 9 ..... F-15
Hydrograph for Well SCE 10 ..... F-16
Hydrograph for Well SCE 11 ..... F-17
Hydrograph for Well SCE 17 ..... F-18
Hydrograph for Well SCE 18 ..... F-19
Hydrograph for Well CI 1 ..... F-20
Hydrograph for Well CI 2 ..... F-21

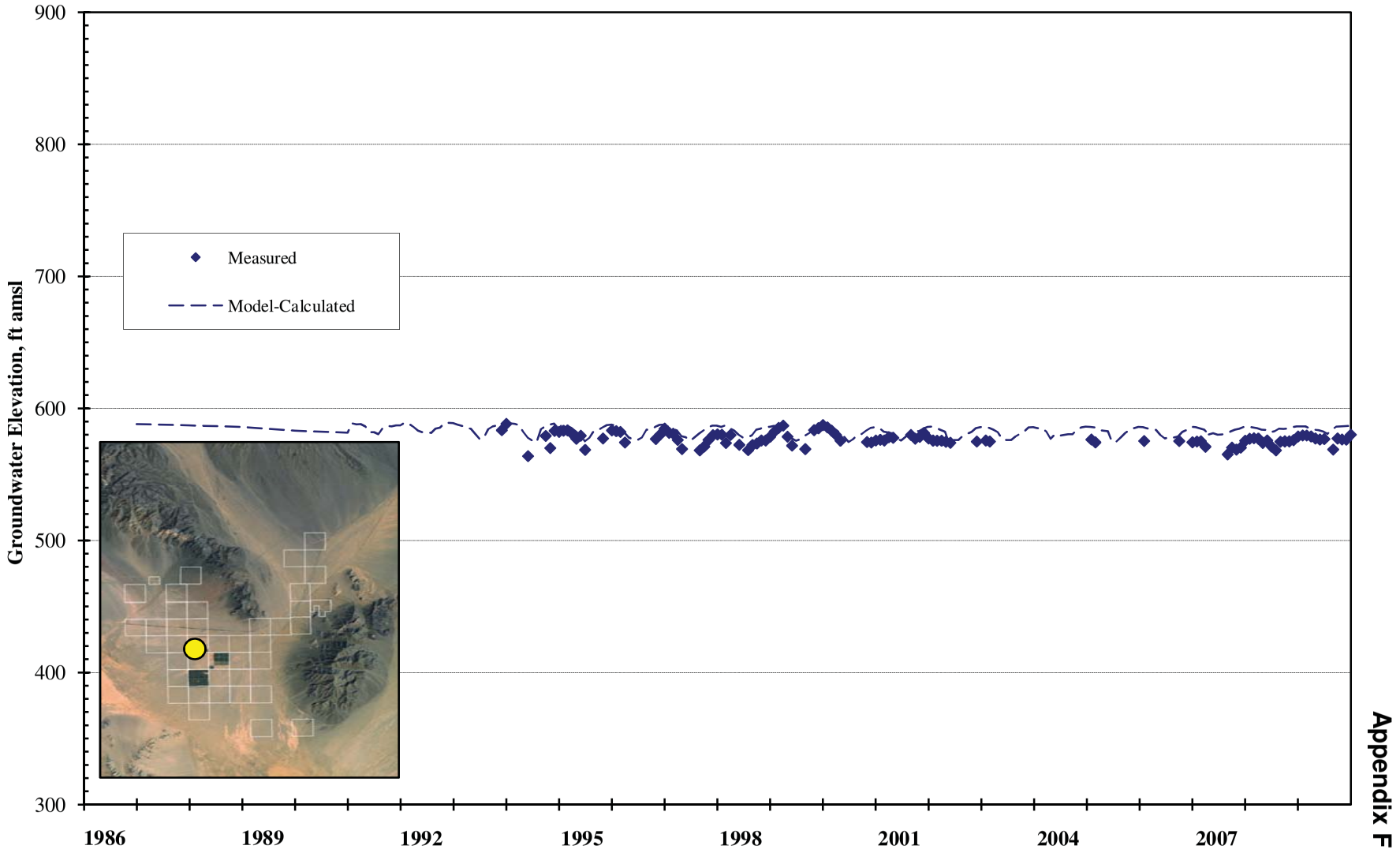
Hydrograph for Well CI 3 ..... F-22
Hydrograph for Well MW 1 ..... F-23
Hydrograph for Well MW 2 ..... F-24
Hydrograph for Well MW 3 ..... F-25
Hydrograph for Well MW 5 ..... F-26
Hydrograph for Well MW 6 ..... F-27
Hydrograph for Well MW 7 ..... F-28
Hydrograph for Well MW 7A F-29

Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



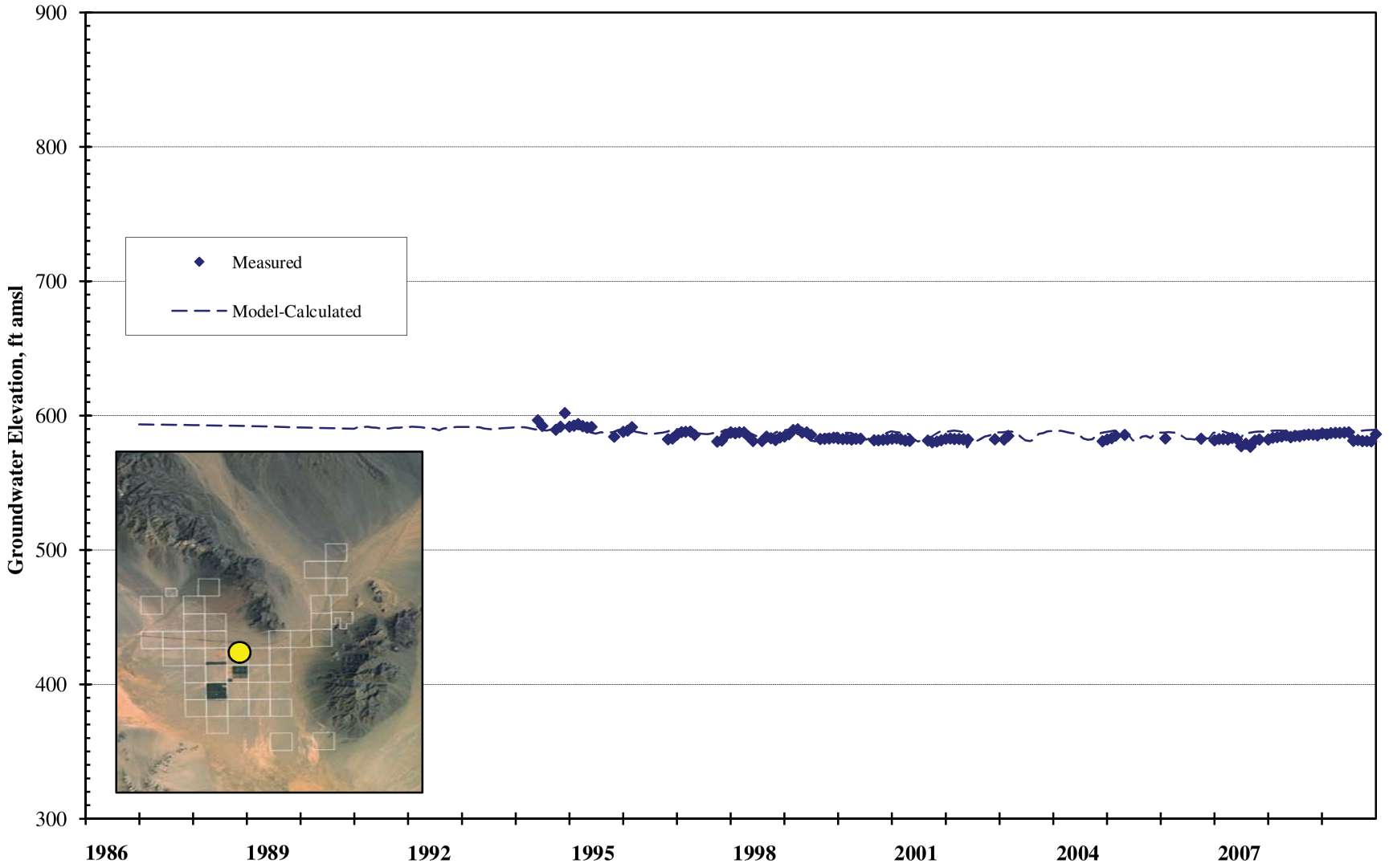
Appendix F

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



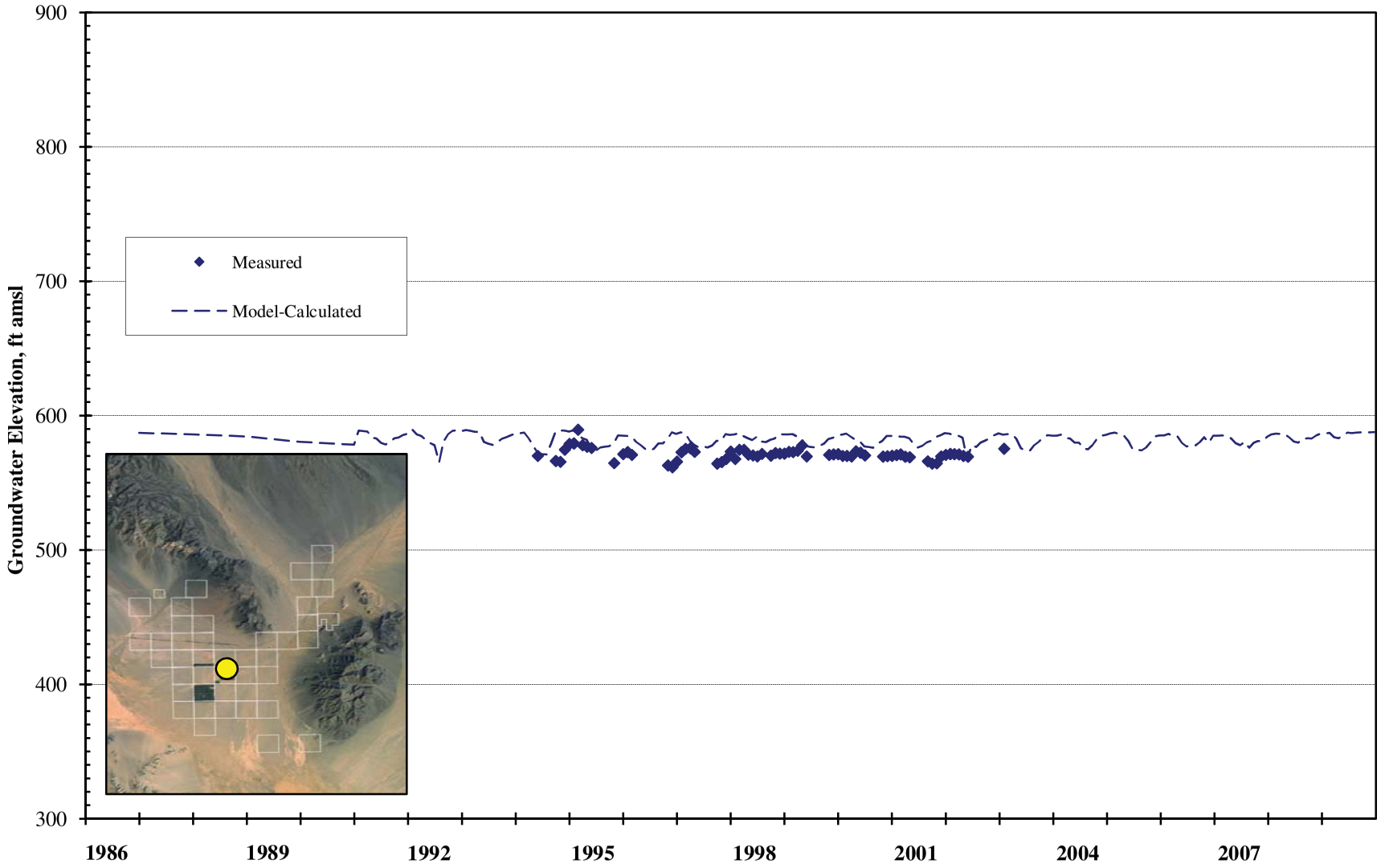
Appendix F

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



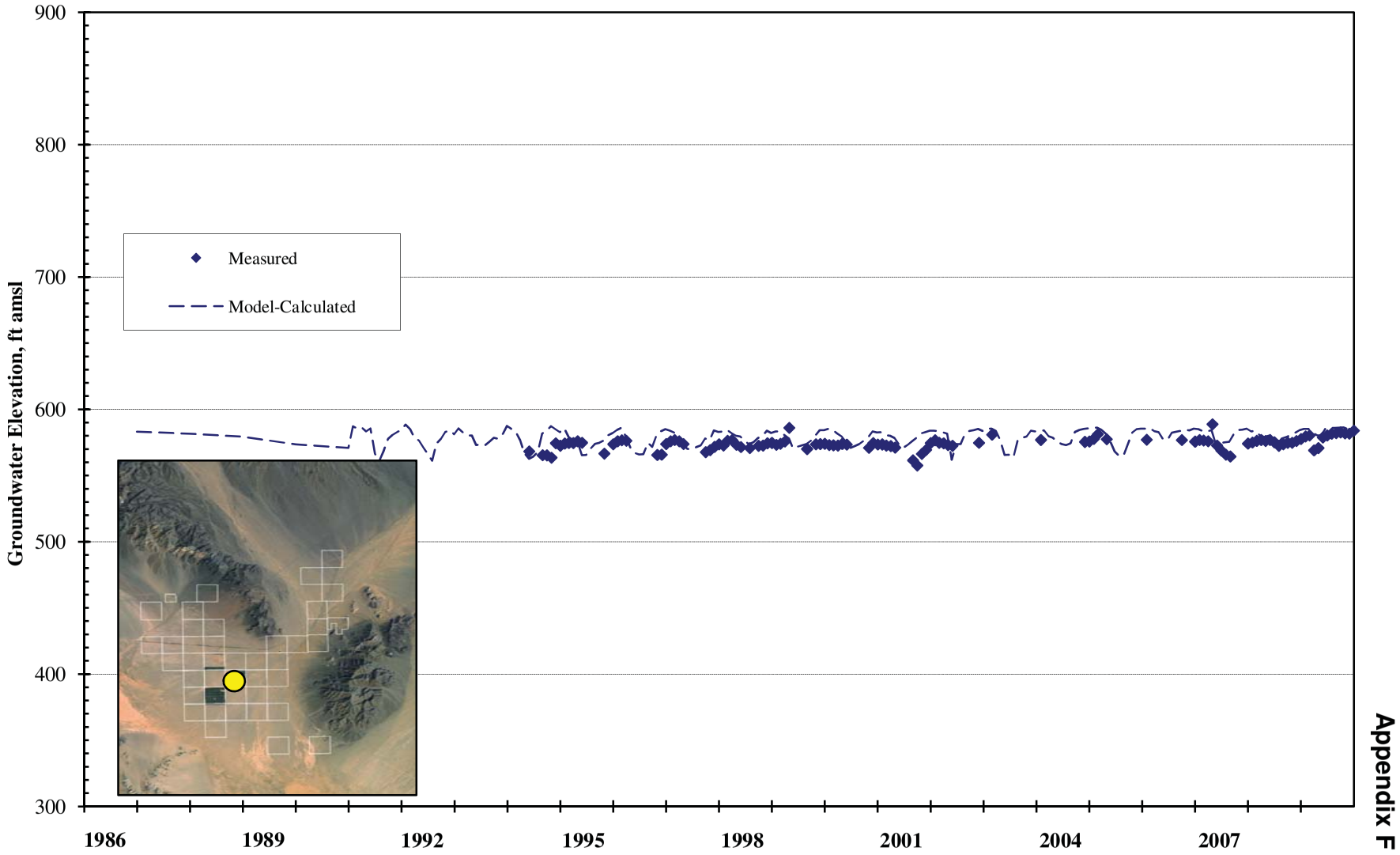
Appendix F

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



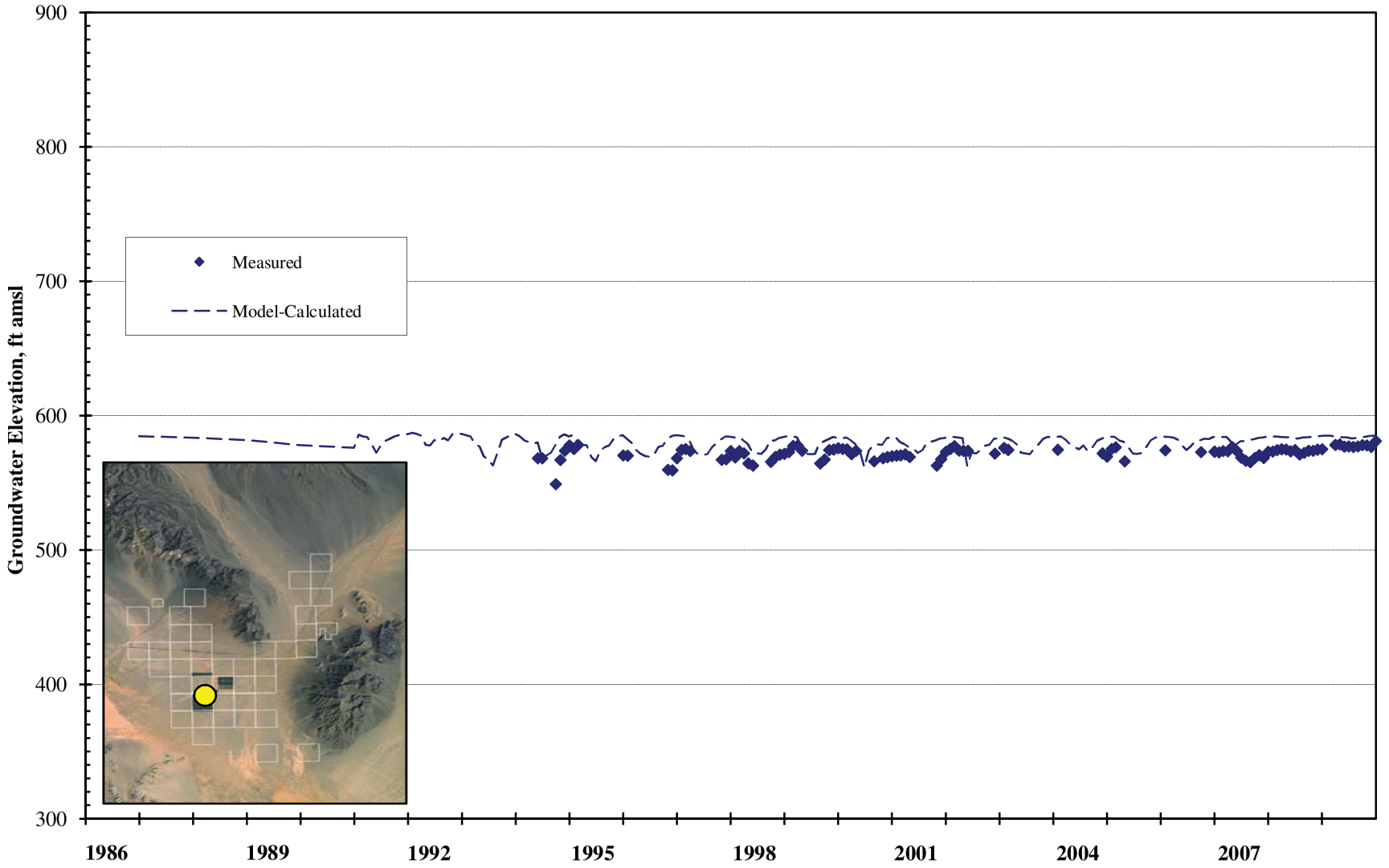
Appendix F

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



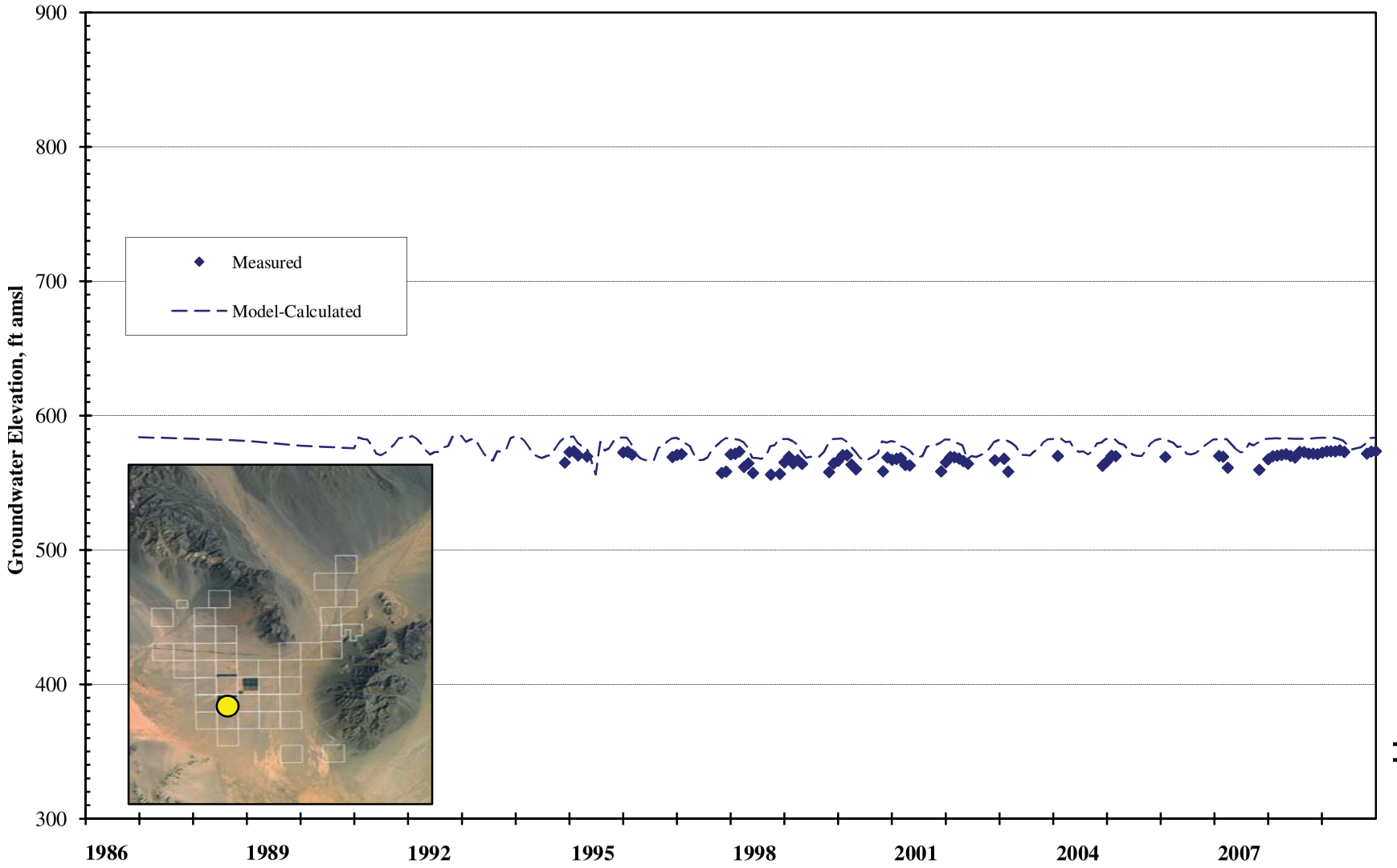
Appendix F

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



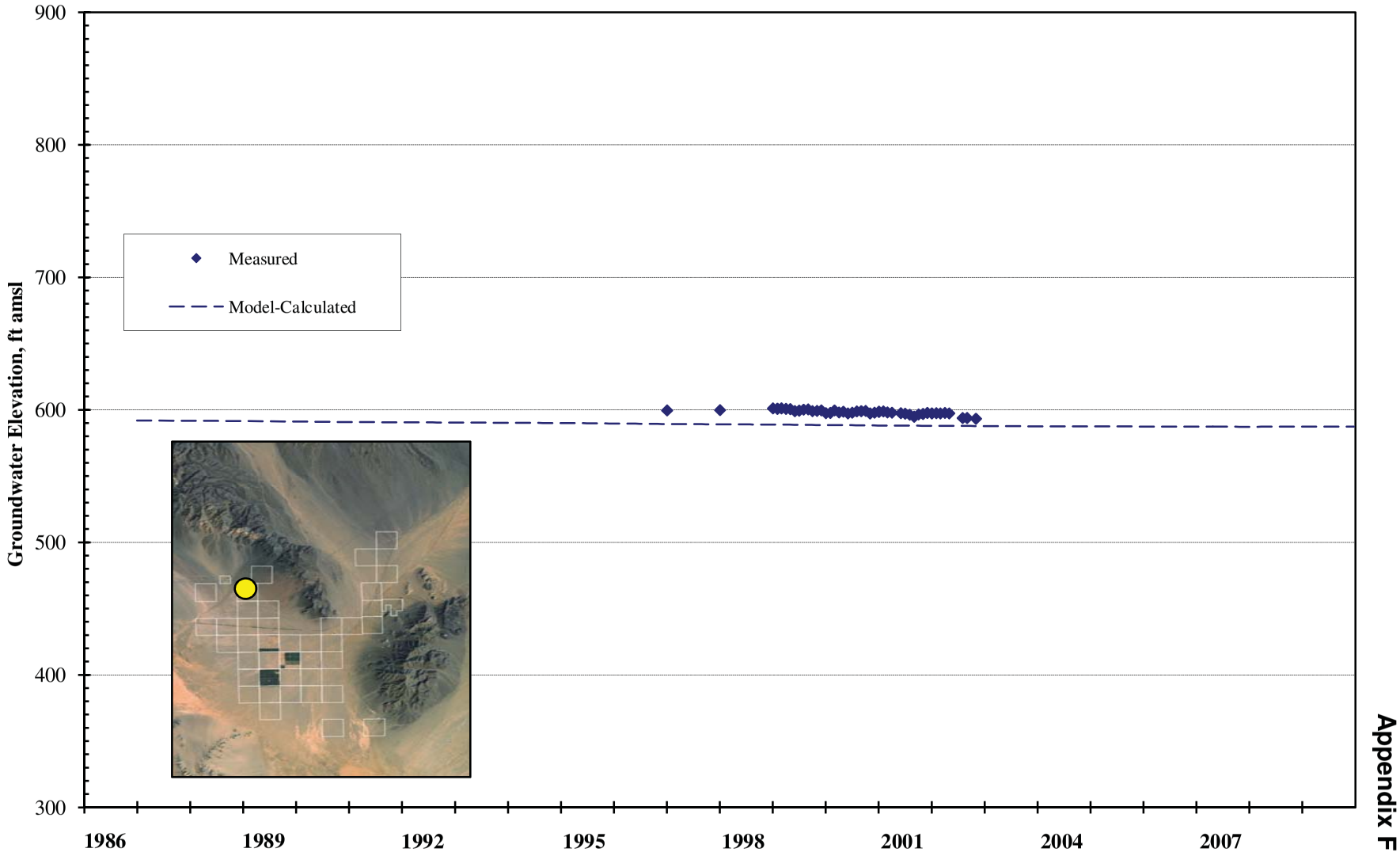
Appendix F

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



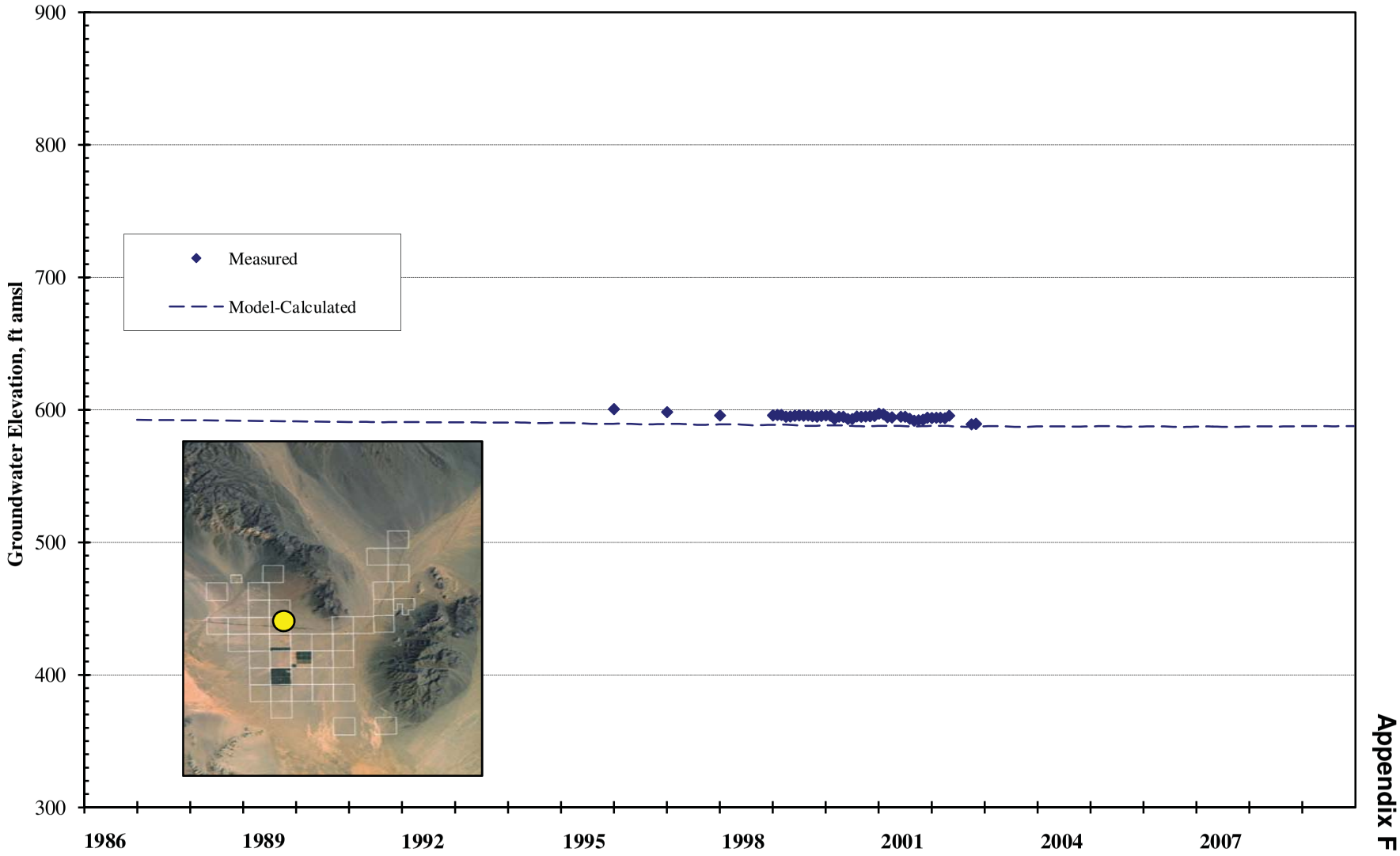
Appendix F

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



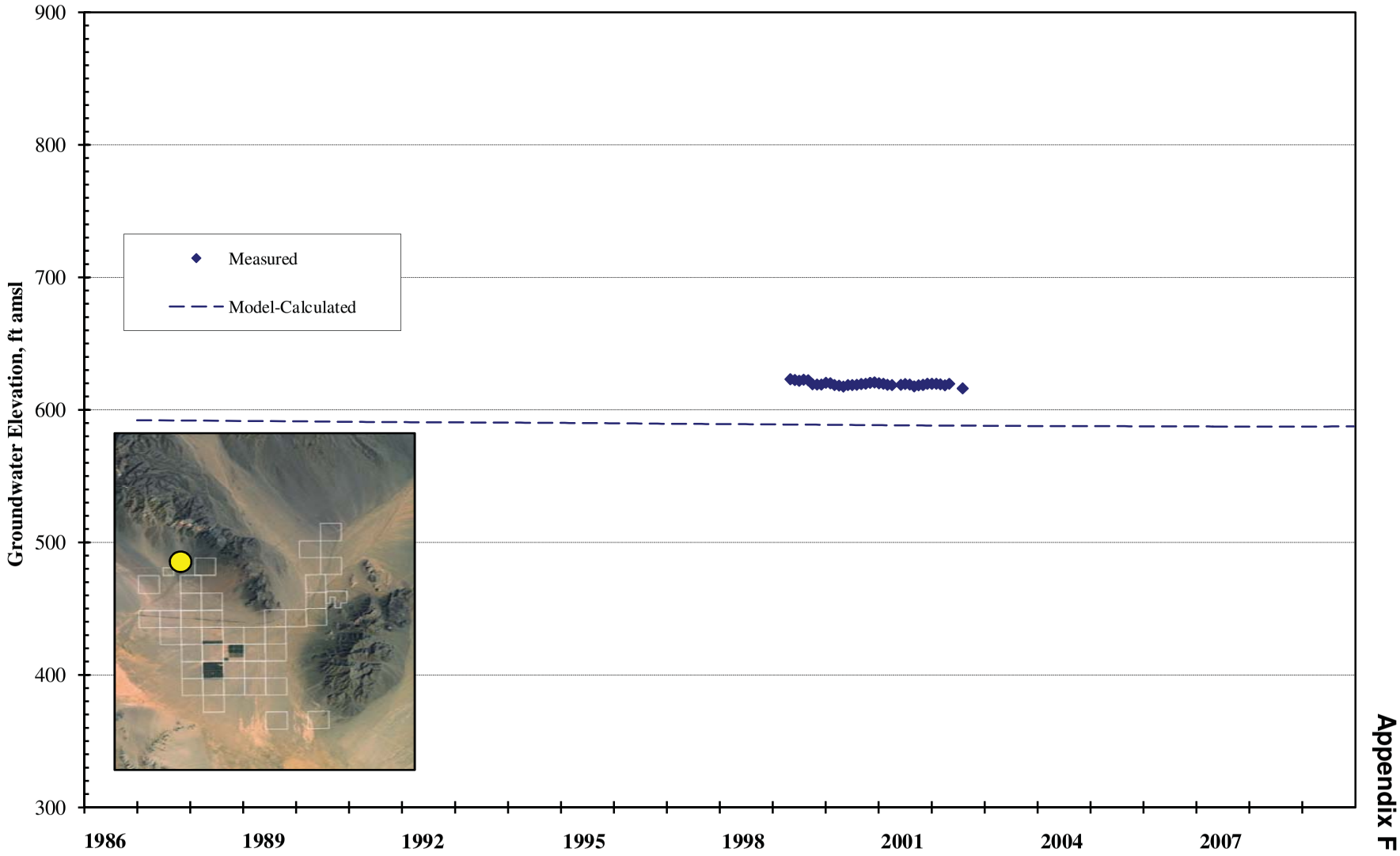
Appendix F

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



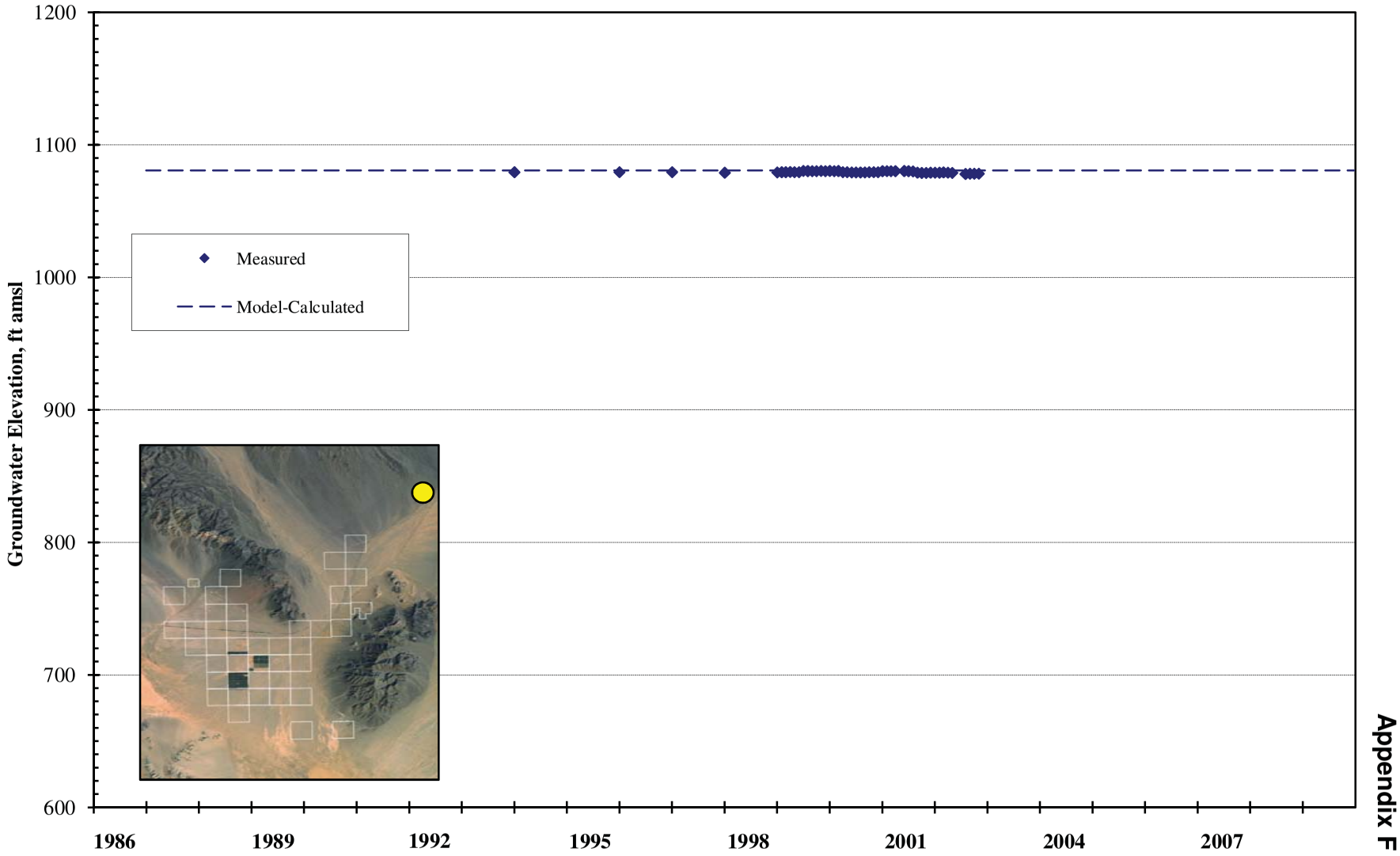
Appendix F

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



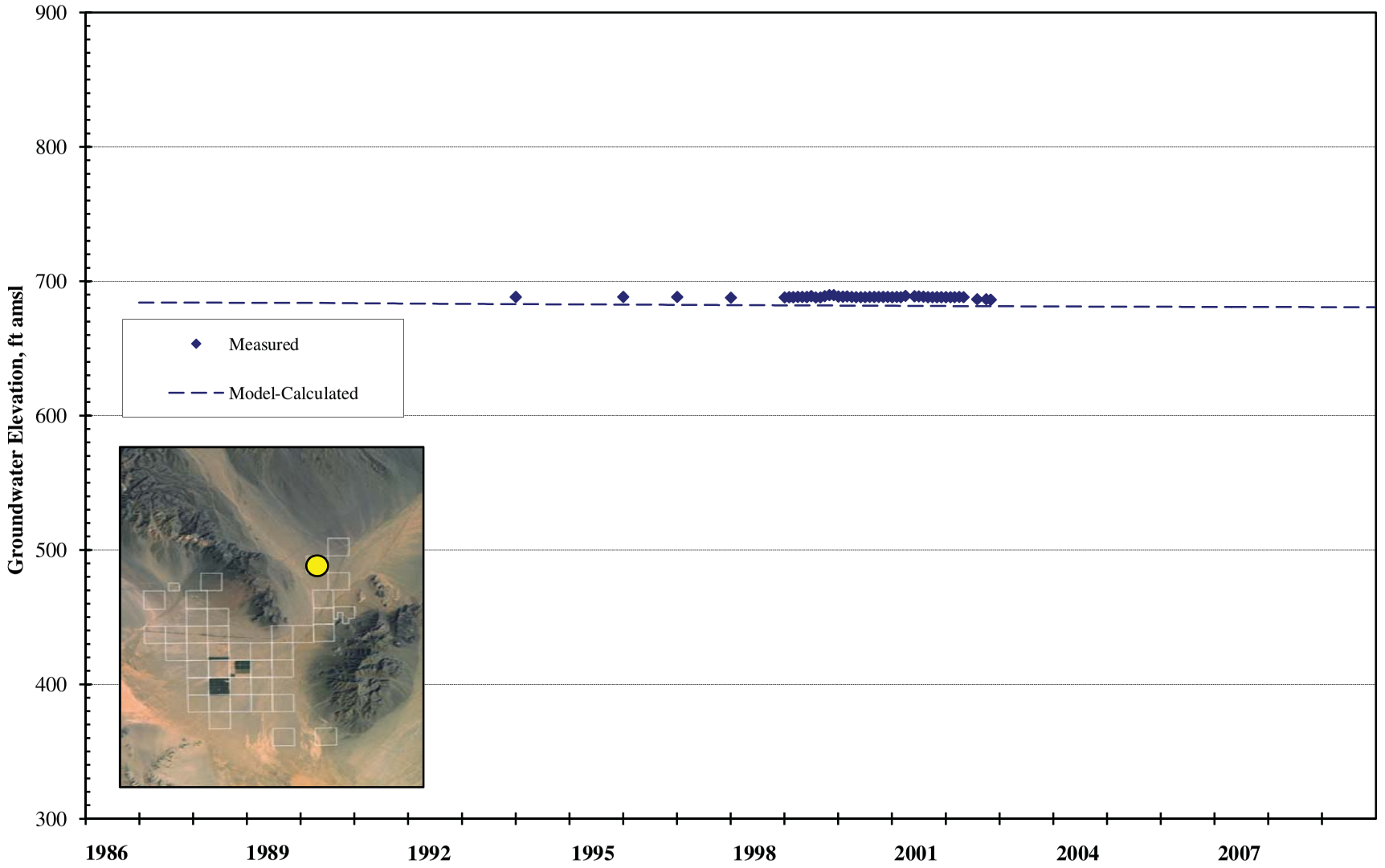
Appendix F

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



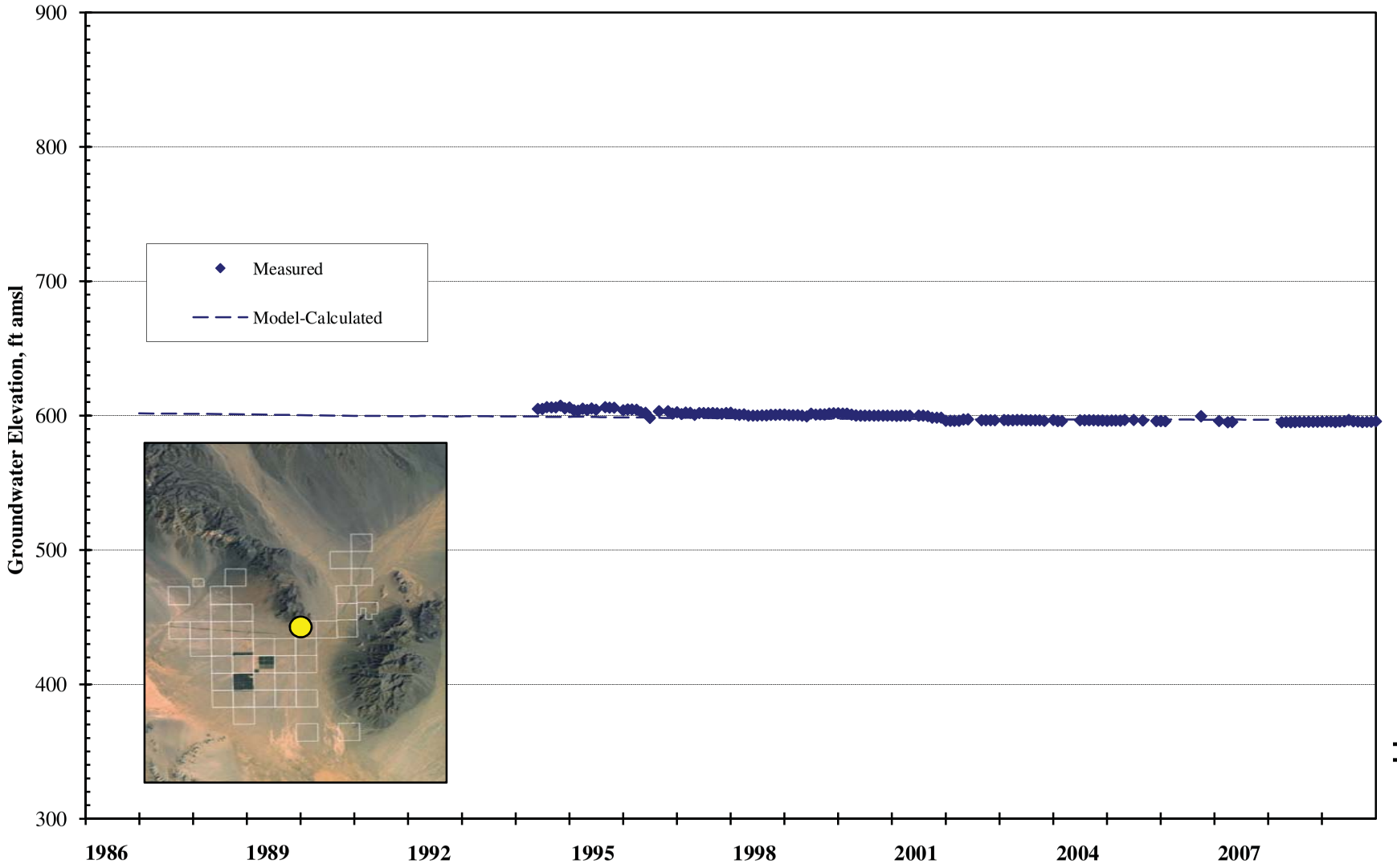
Appendix F

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



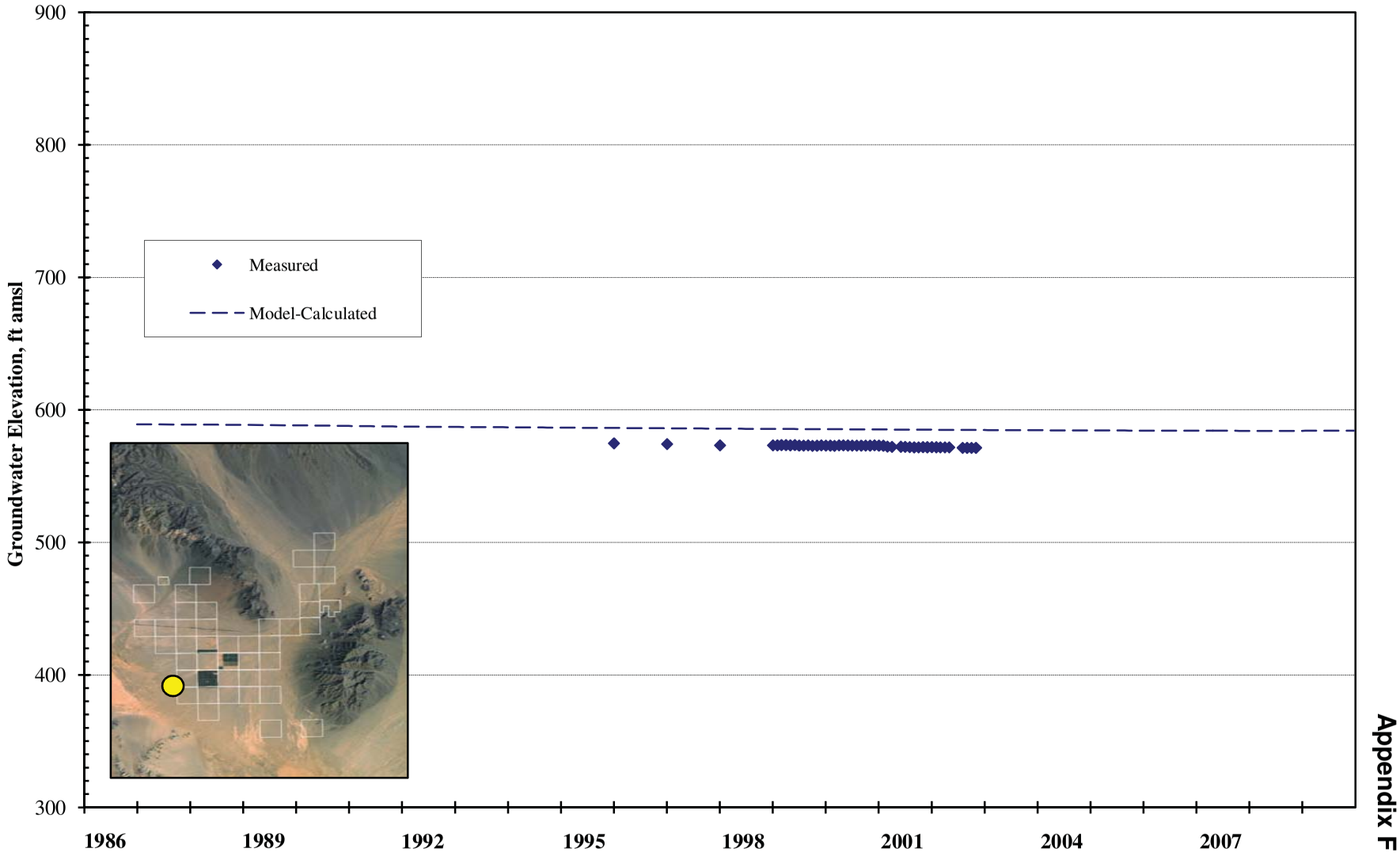
Appendix F

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



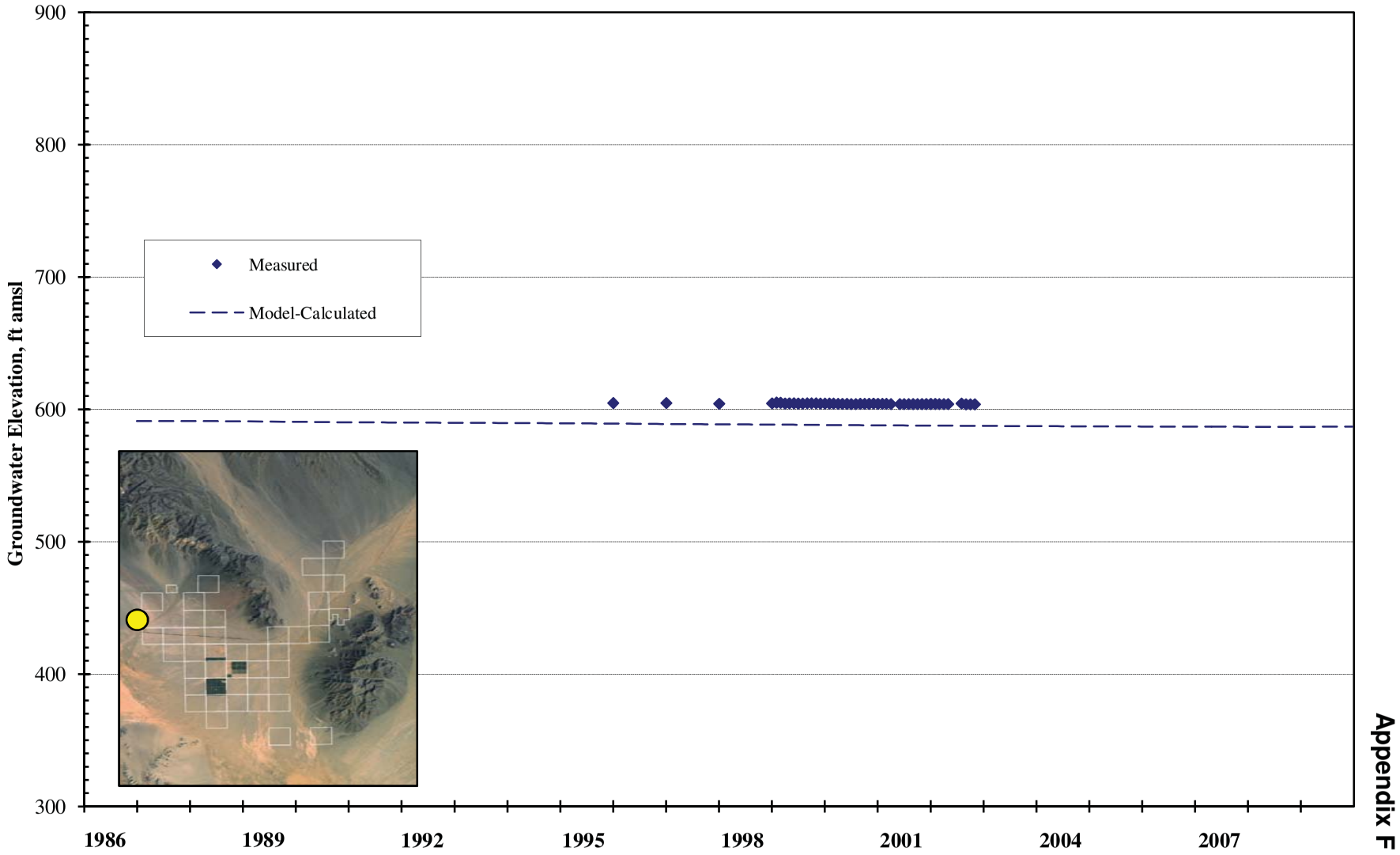
Appendix F

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



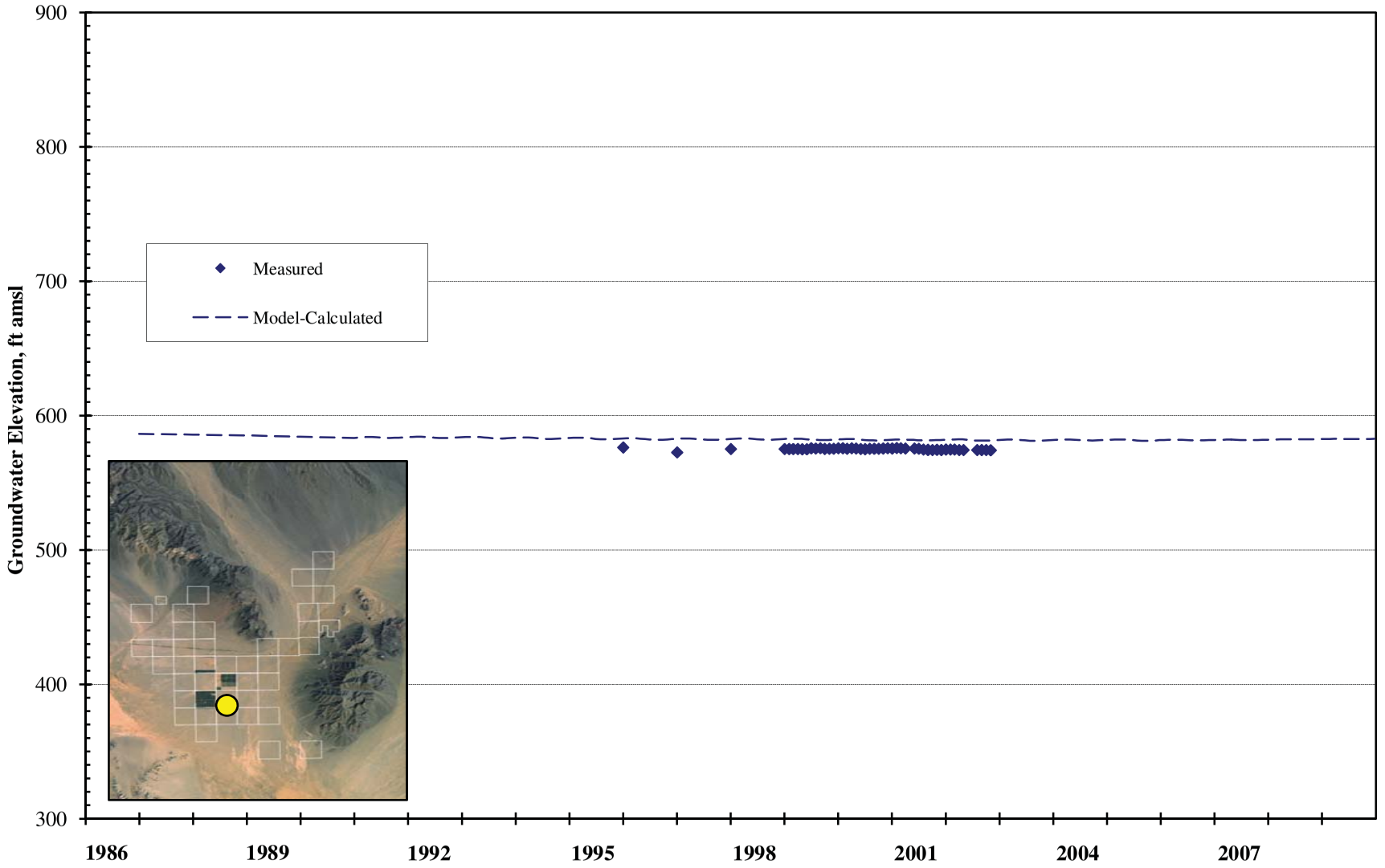
Appendix F

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



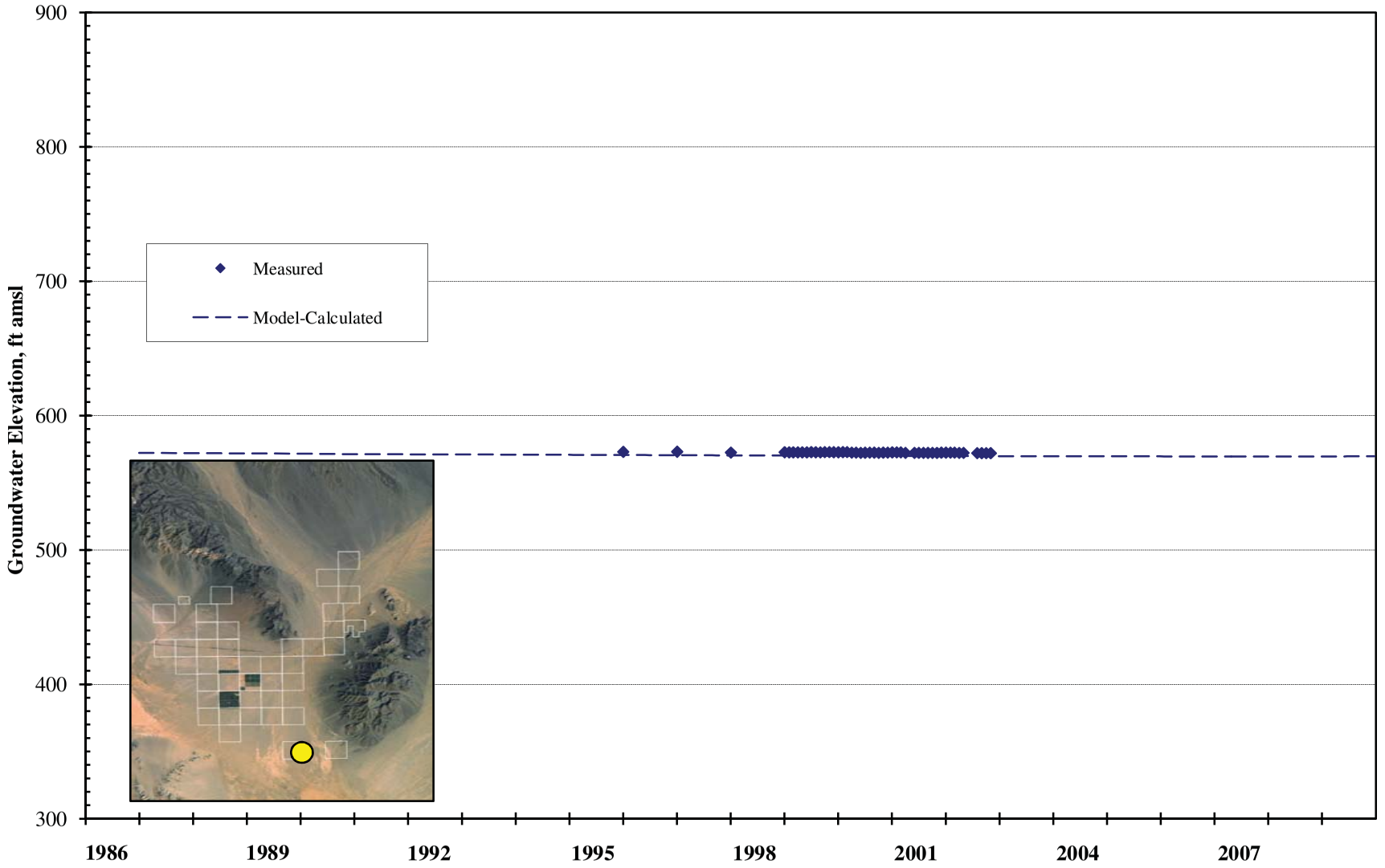
Appendix F

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



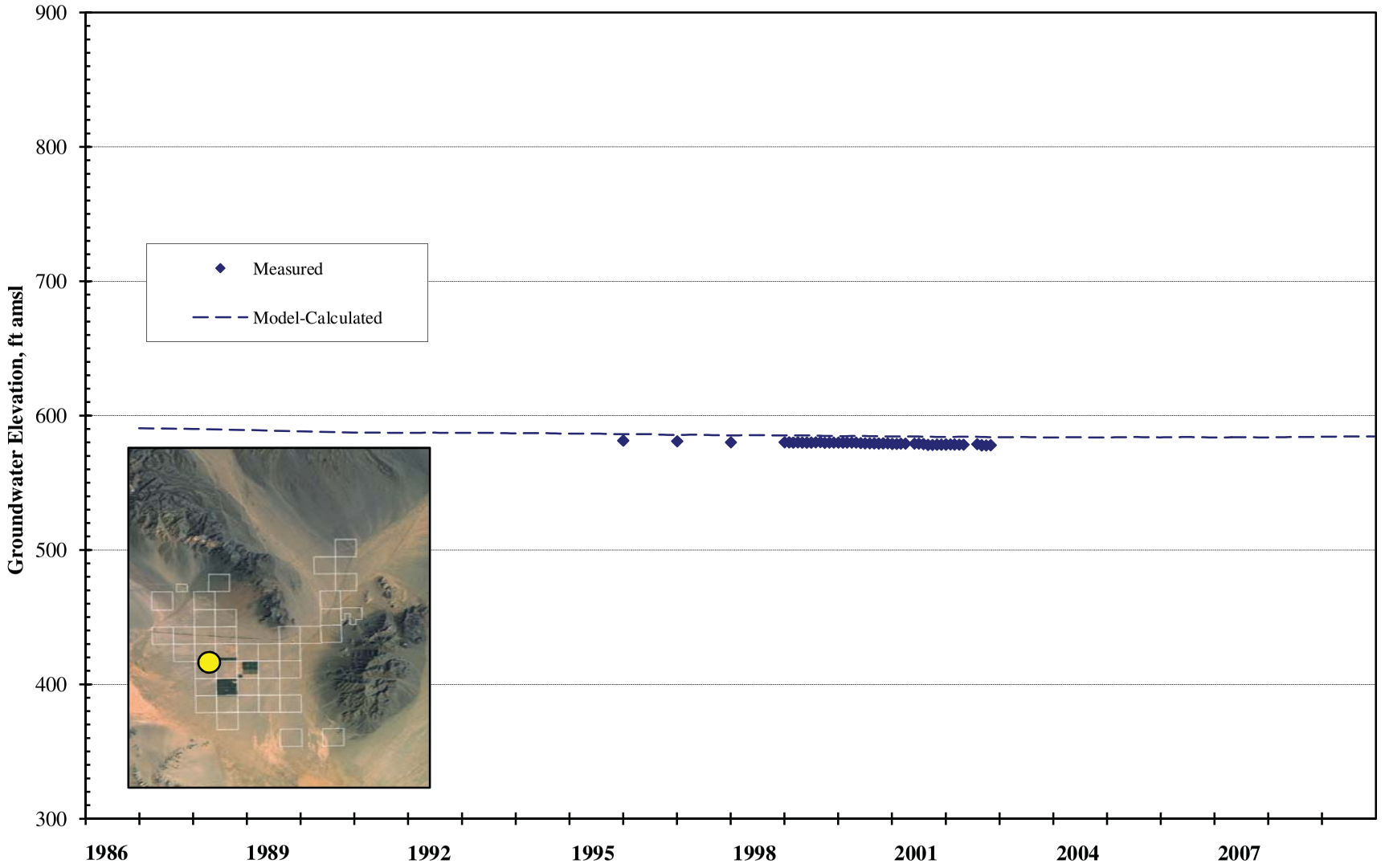
Appendix F

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



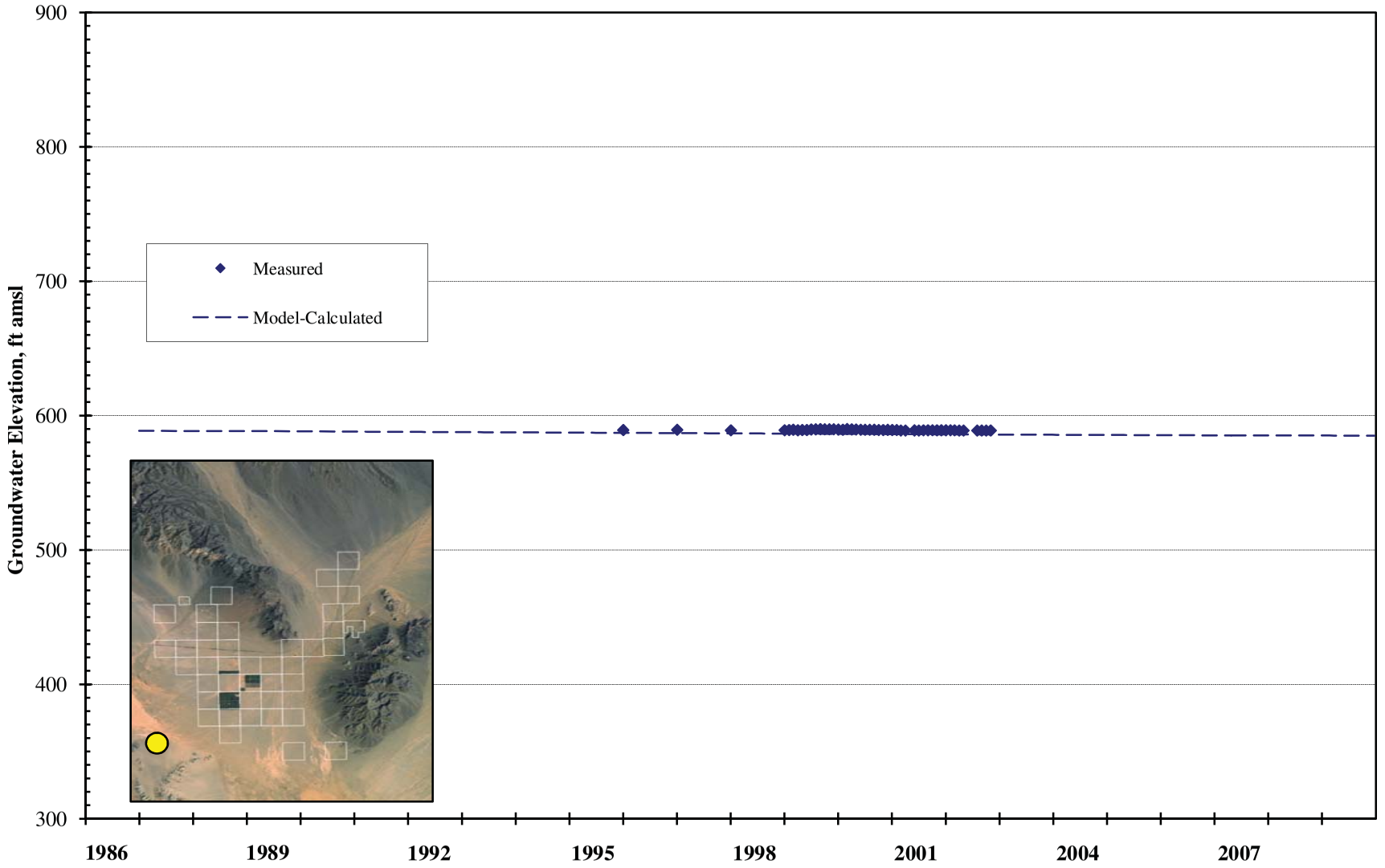
Appendix F

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



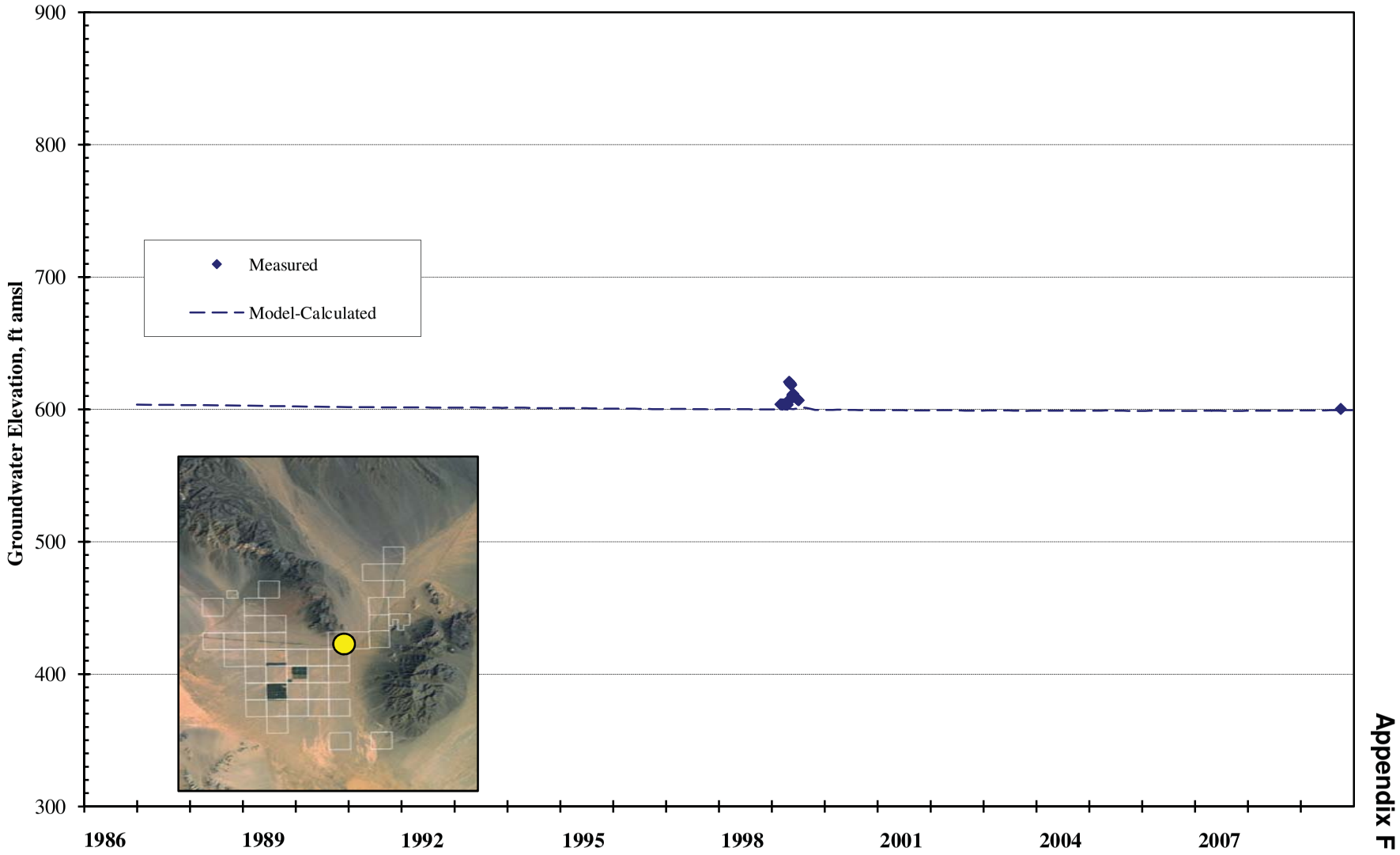
Appendix F

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



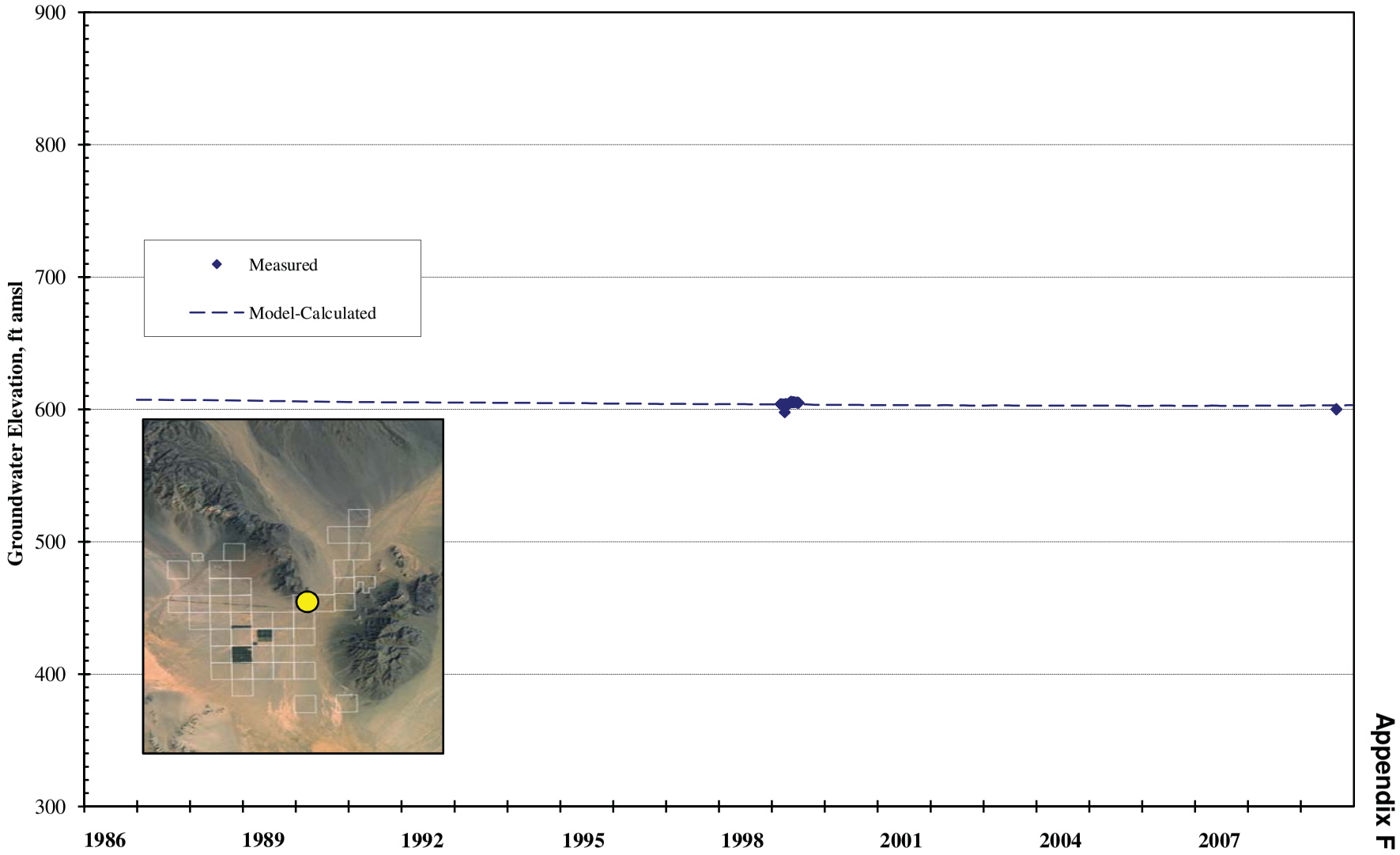
Appendix F

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



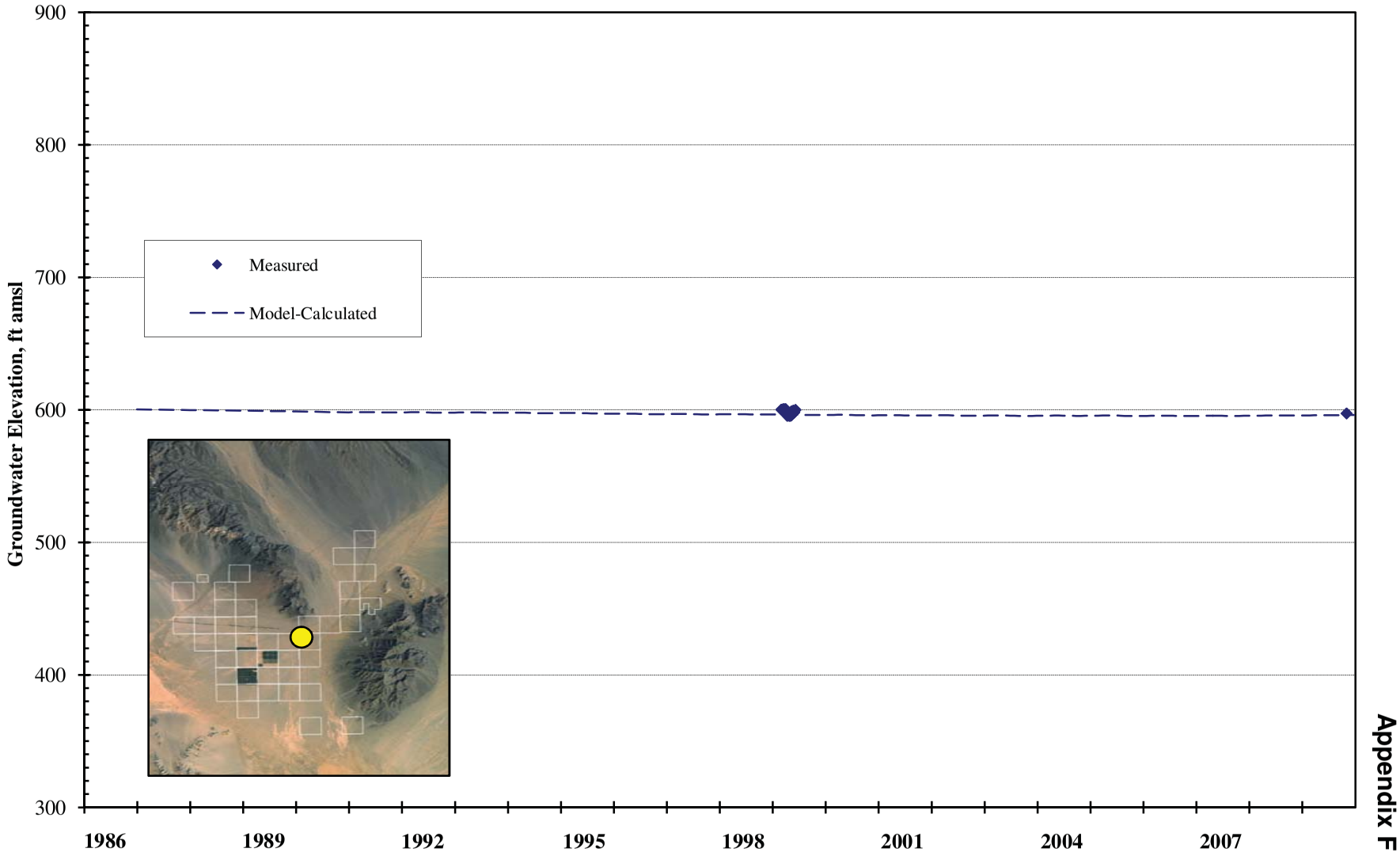
Appendix F

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



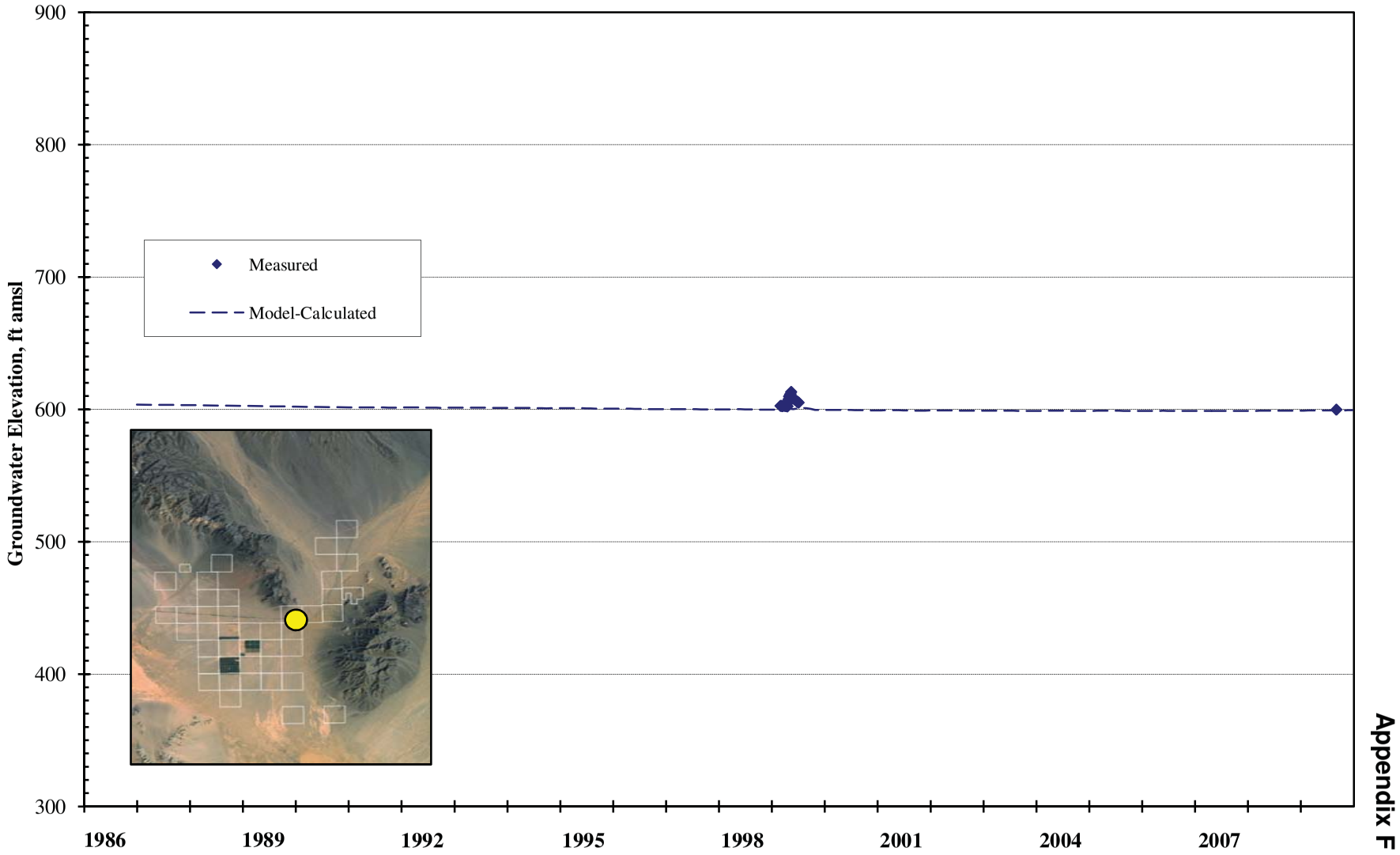
Appendix F

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



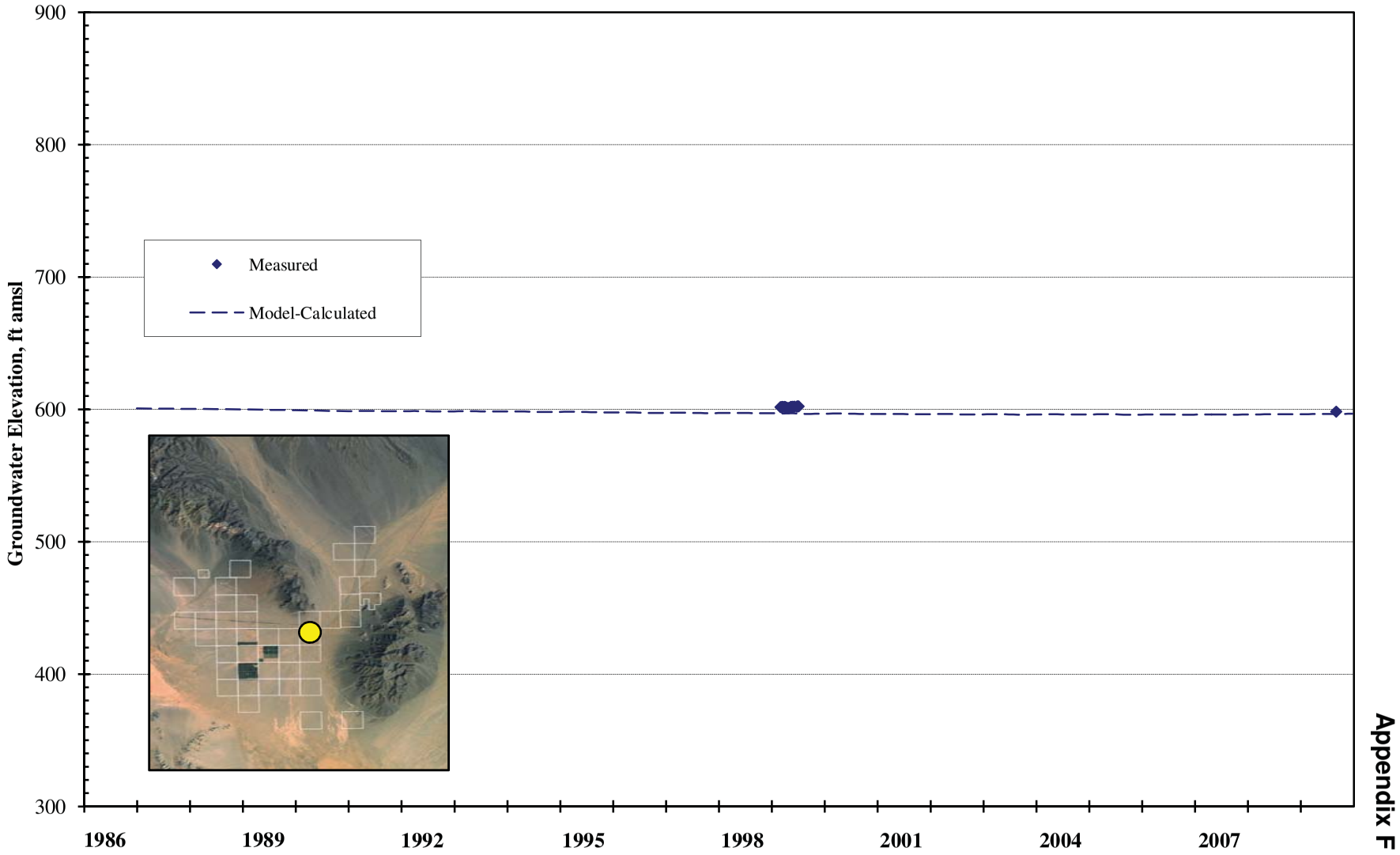
Appendix F

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



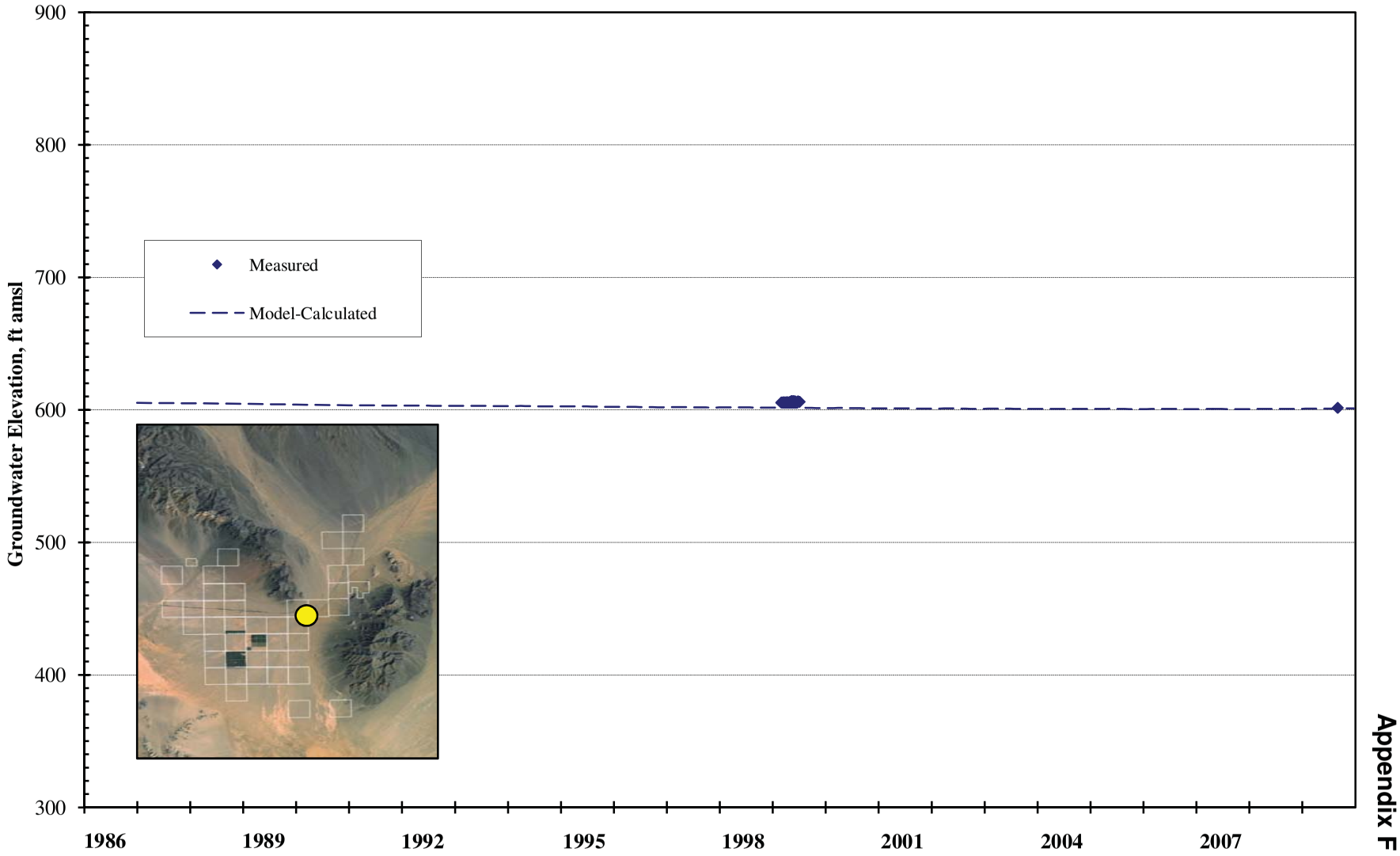
Appendix F

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



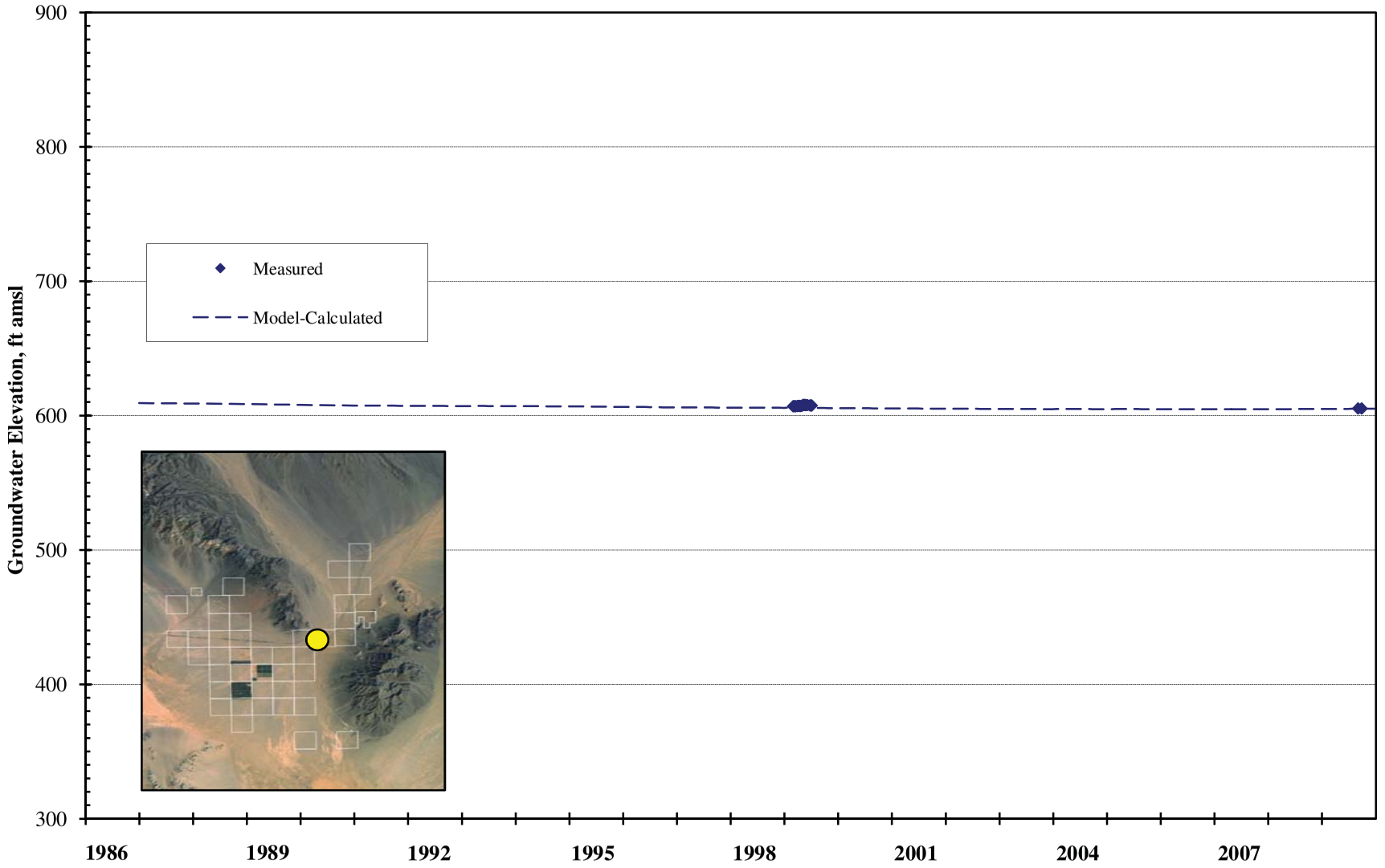
Appendix F

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



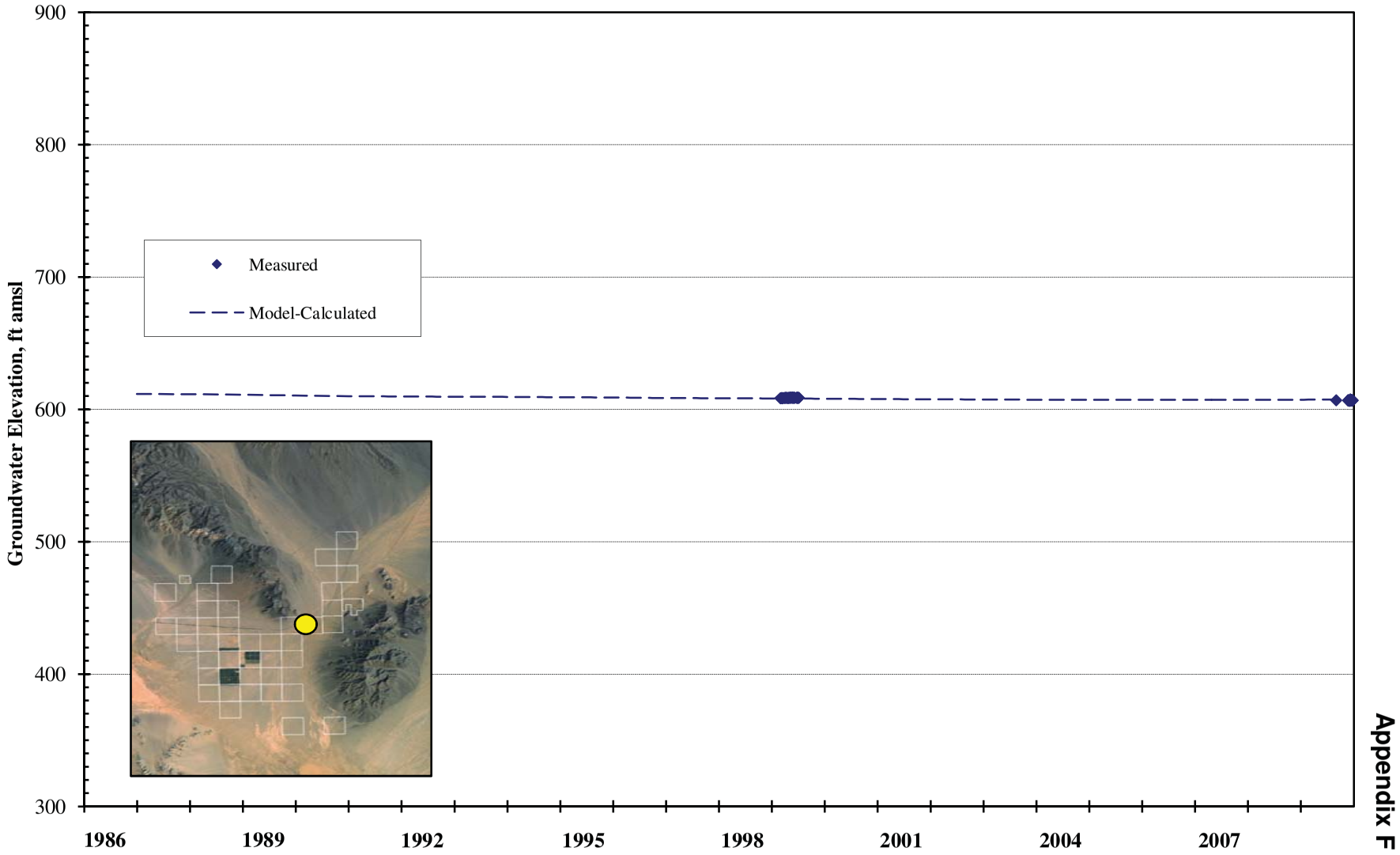
Appendix F

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



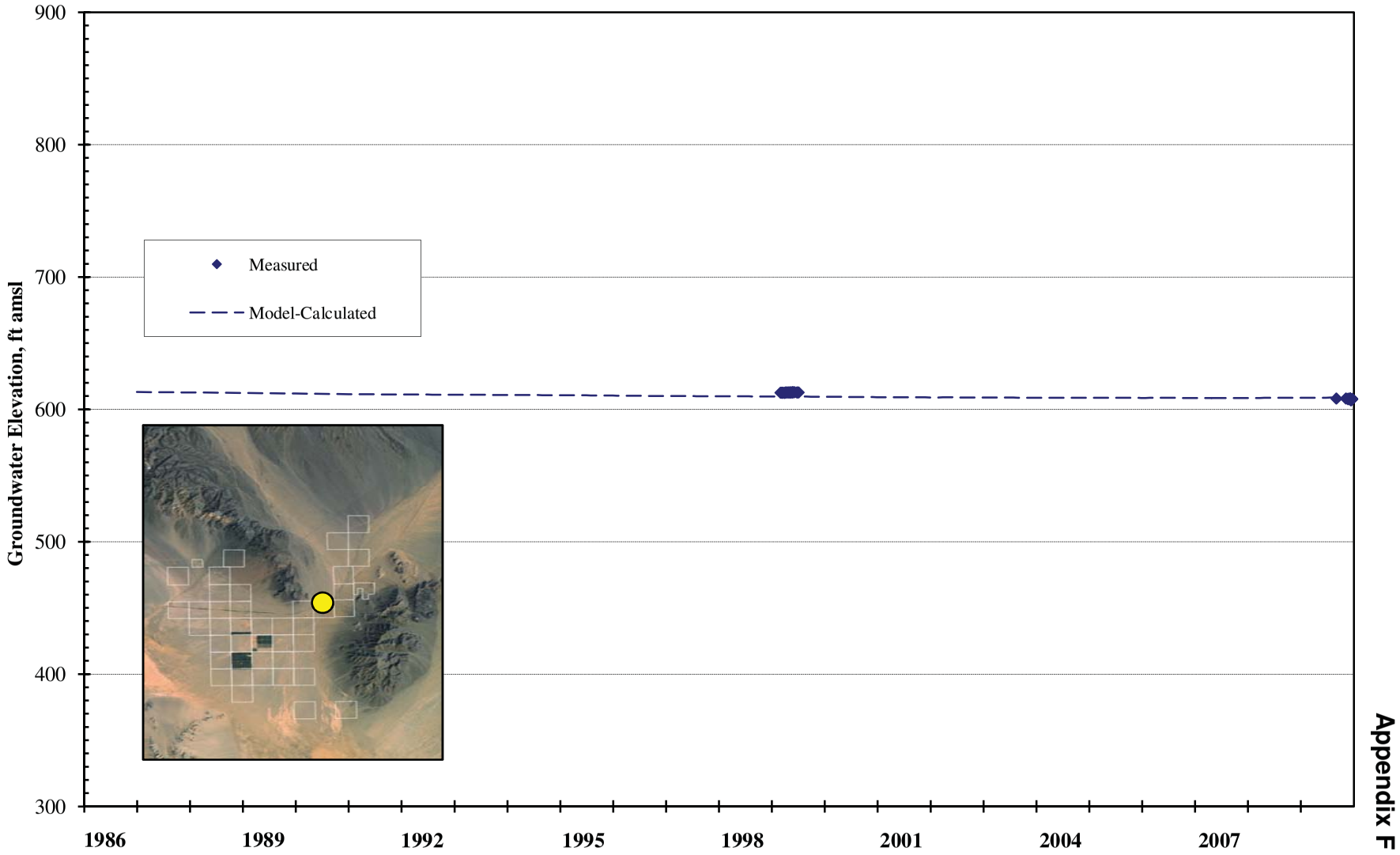
Appendix F

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



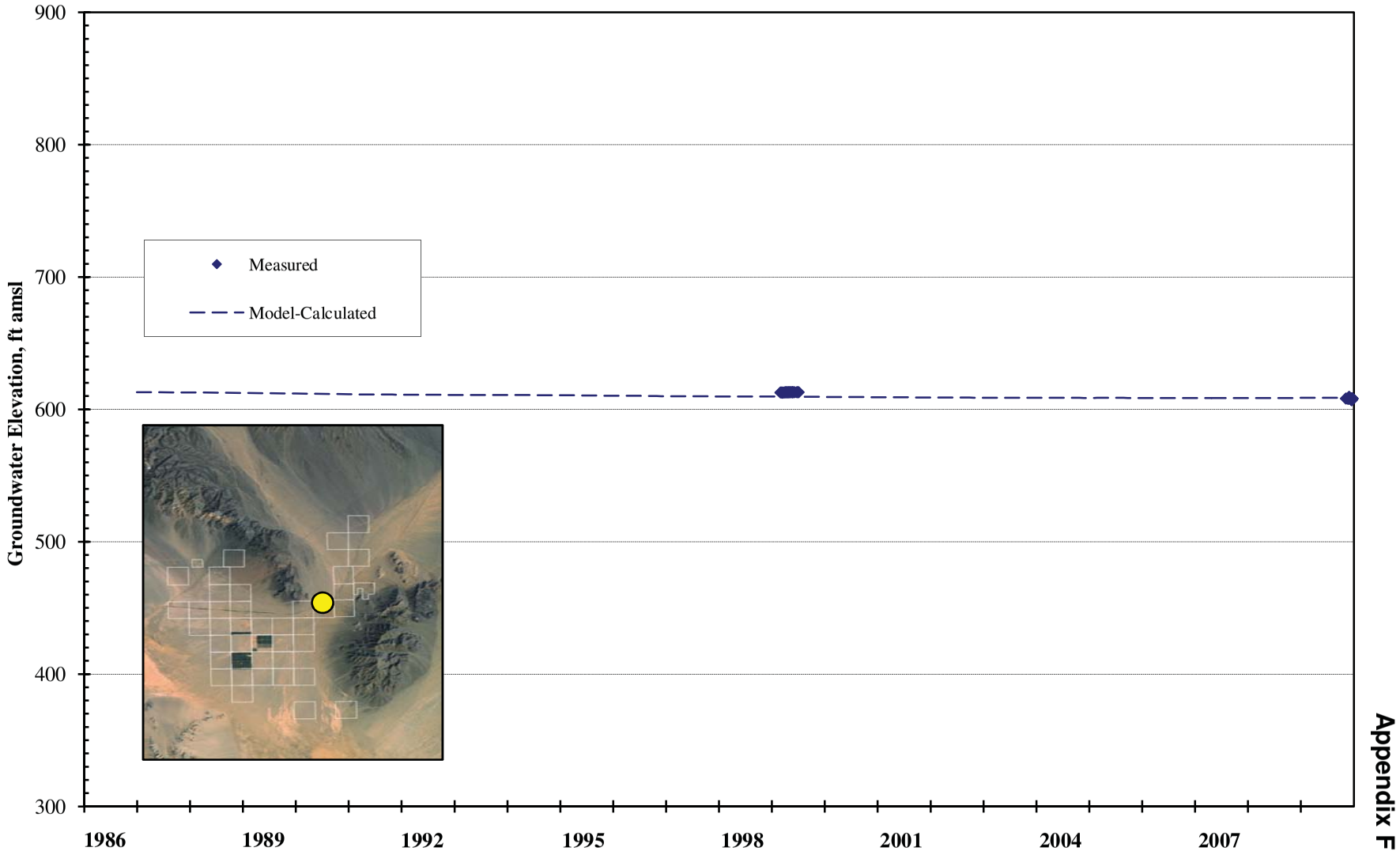
Appendix F

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



Appendix F

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



Appendix F

APPENDIX G

Hydrographs for Transient Model Calibration

With Natural Recharge of 5,000 acre-ft/yr

GEOSCIENCE

APPENDIX G

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

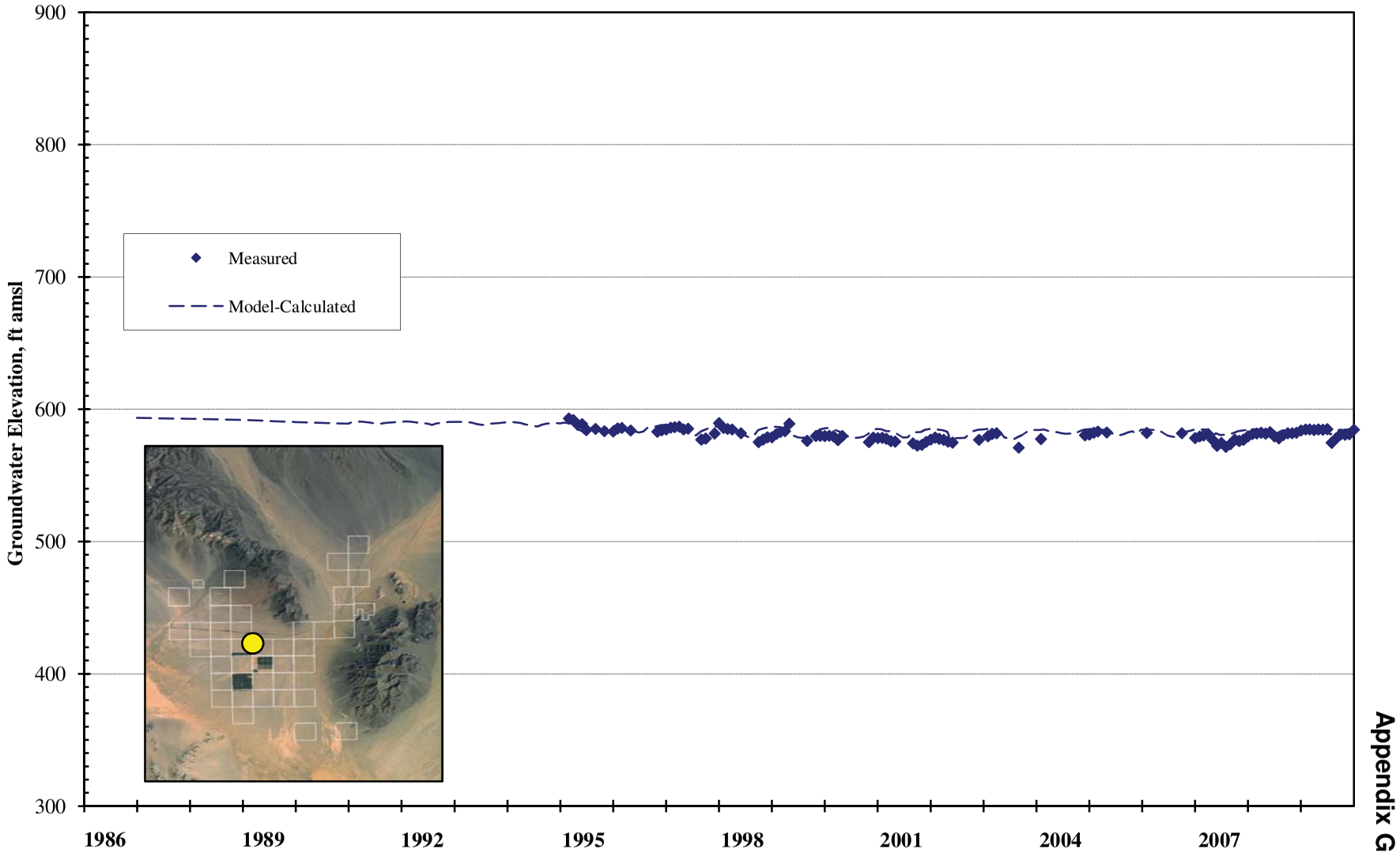
WITH NATURAL RECHARGE OF 5,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N G-1
Hydrograph for Cadiz Well 21S G-2
Hydrograph for Cadiz Well 22 ..... G-3
Hydrograph for Cadiz Well 27N G-4
Hydrograph for Cadiz Well 27S G-5
Hydrograph for Cadiz Well 28 ..... G-6
Hydrograph for Cadiz Well 33 ..... G-7
Hydrograph for Cadiz Dorm Well G-8
Hydrograph for Cadiz Labor Well G-9
Hydrograph for Cadiz Park Well G-10
Hydrograph for Cadiz Well 6N/15E-01 ..... G-11
Hydrograph for Cadiz Well 6N/15E-29 ..... G-12
Hydrograph for Cadiz Well 5N/14E-13 ..... G-13
Hydrograph for Well SCE 5 ..... G-14
Hydrograph for Well SCE 9 ..... G-15
Hydrograph for Well SCE 10 ..... G-16
Hydrograph for Well SCE 11 ..... G-17
Hydrograph for Well SCE 17 ..... G-18
Hydrograph for Well SCE 18 ..... G-19
Hydrograph for Well CI 1 ..... G-20
Hydrograph for Well CI 2 ..... G-21

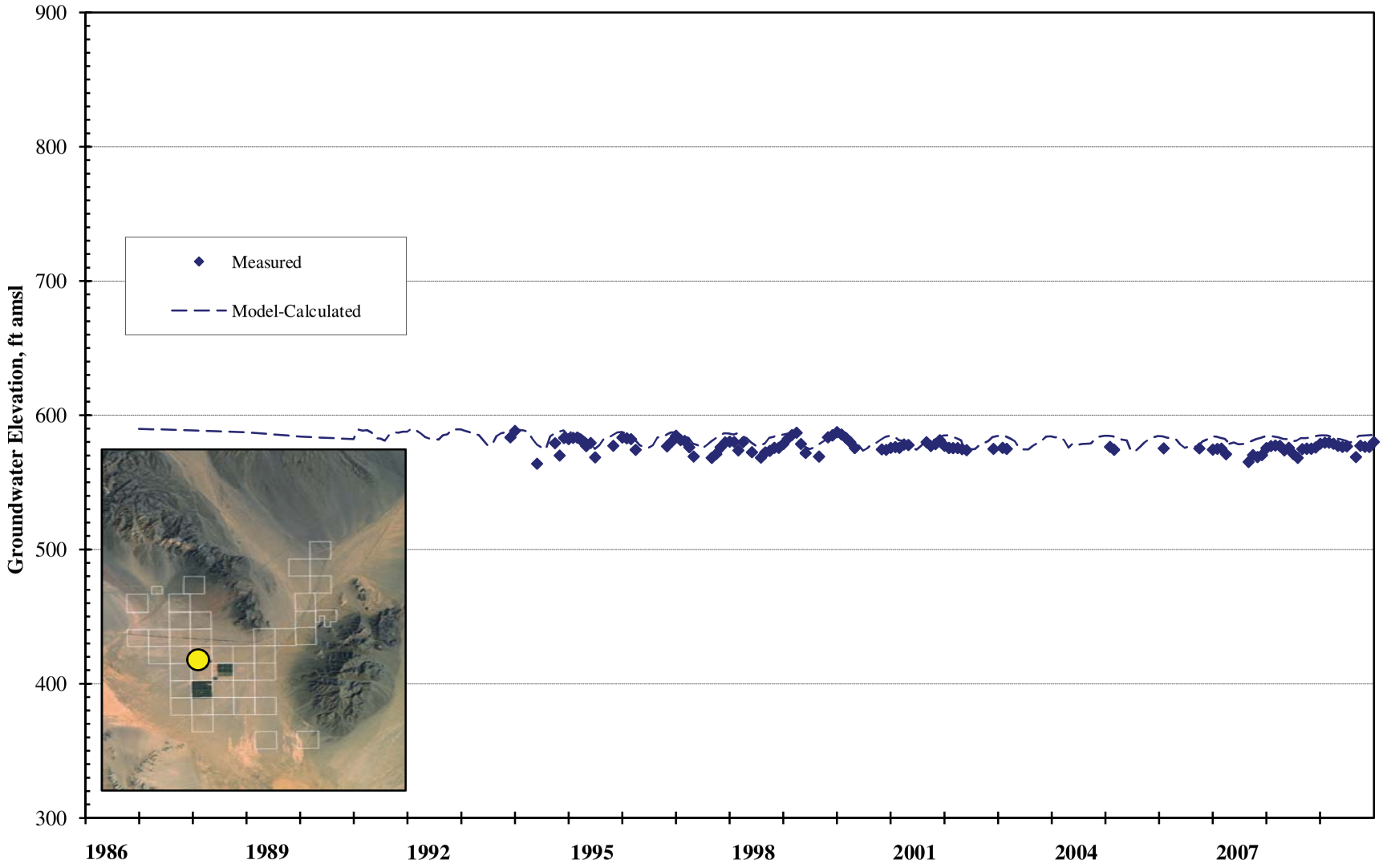
Hydrograph for Well CI 3 .....G-22
Hydrograph for Well MW 1 .....G-23
Hydrograph for Well MW 2 .....G-24
Hydrograph for Well MW 3 .....G-25
Hydrograph for Well MW 5 .....G-26
Hydrograph for Well MW 6 .....G-27
Hydrograph for Well MW 7 .....G-28
Hydrograph for Well MW 7A G-29

Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



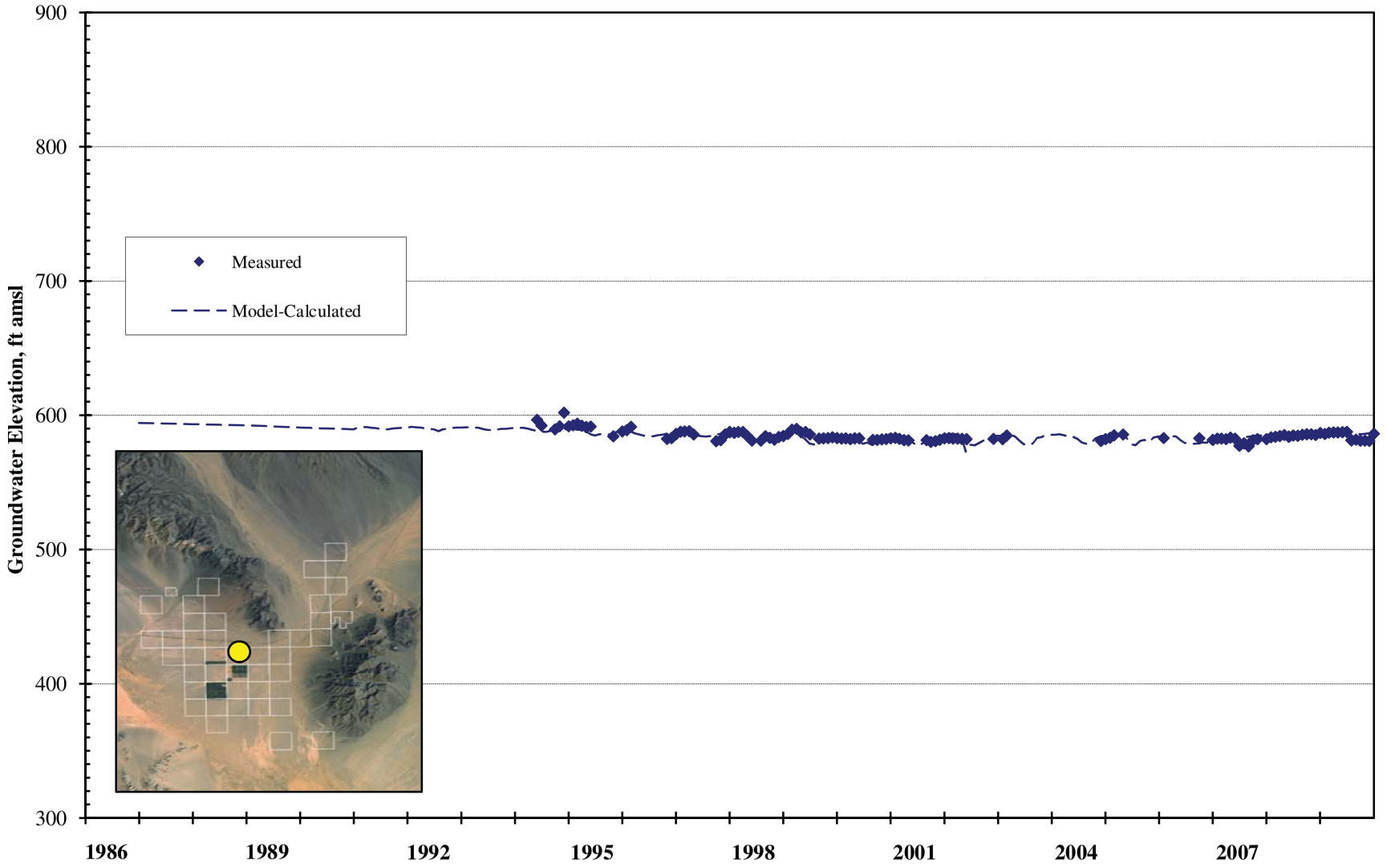
Appendix G

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



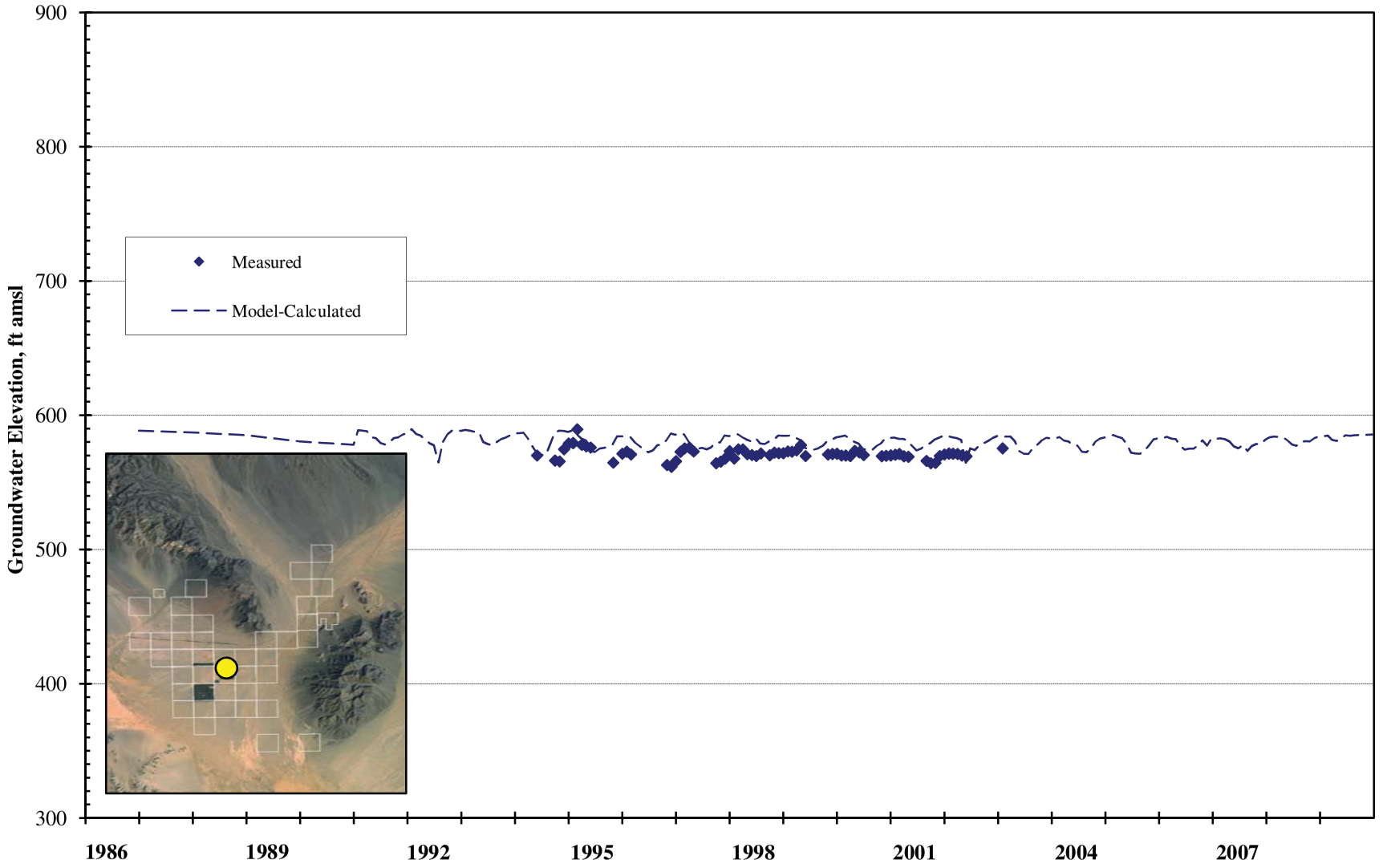
Appendix G

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



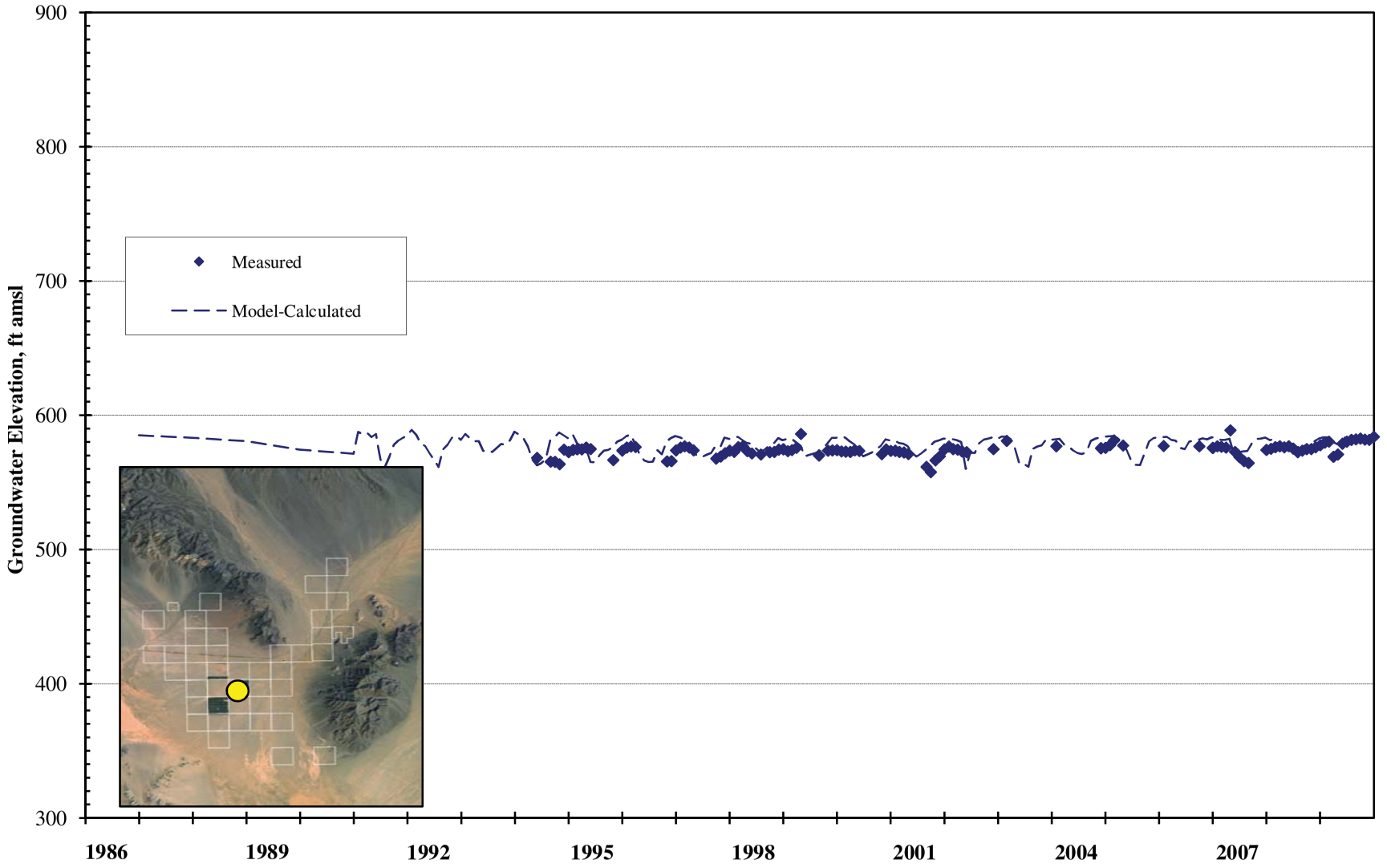
Appendix G

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



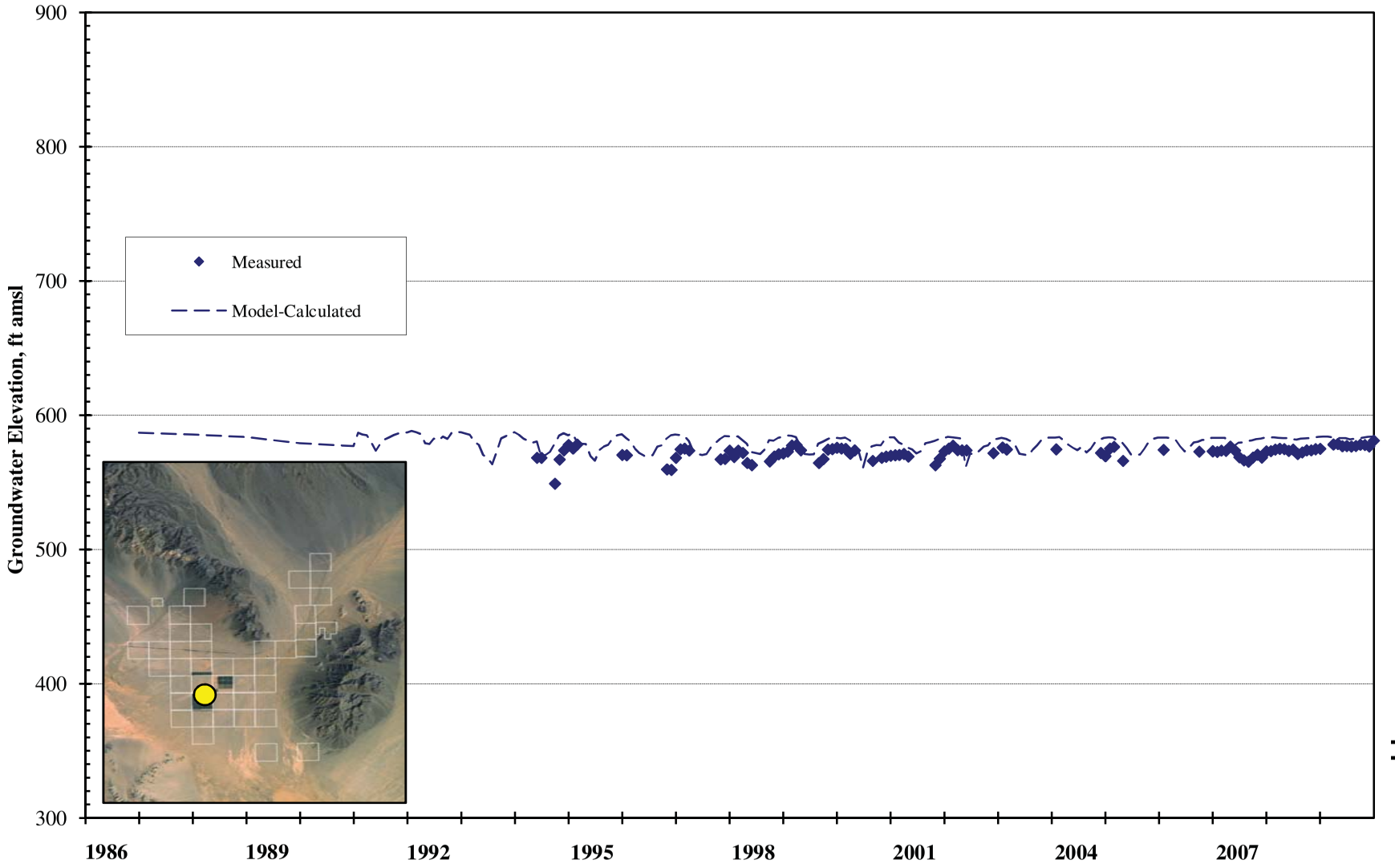
Appendix G

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



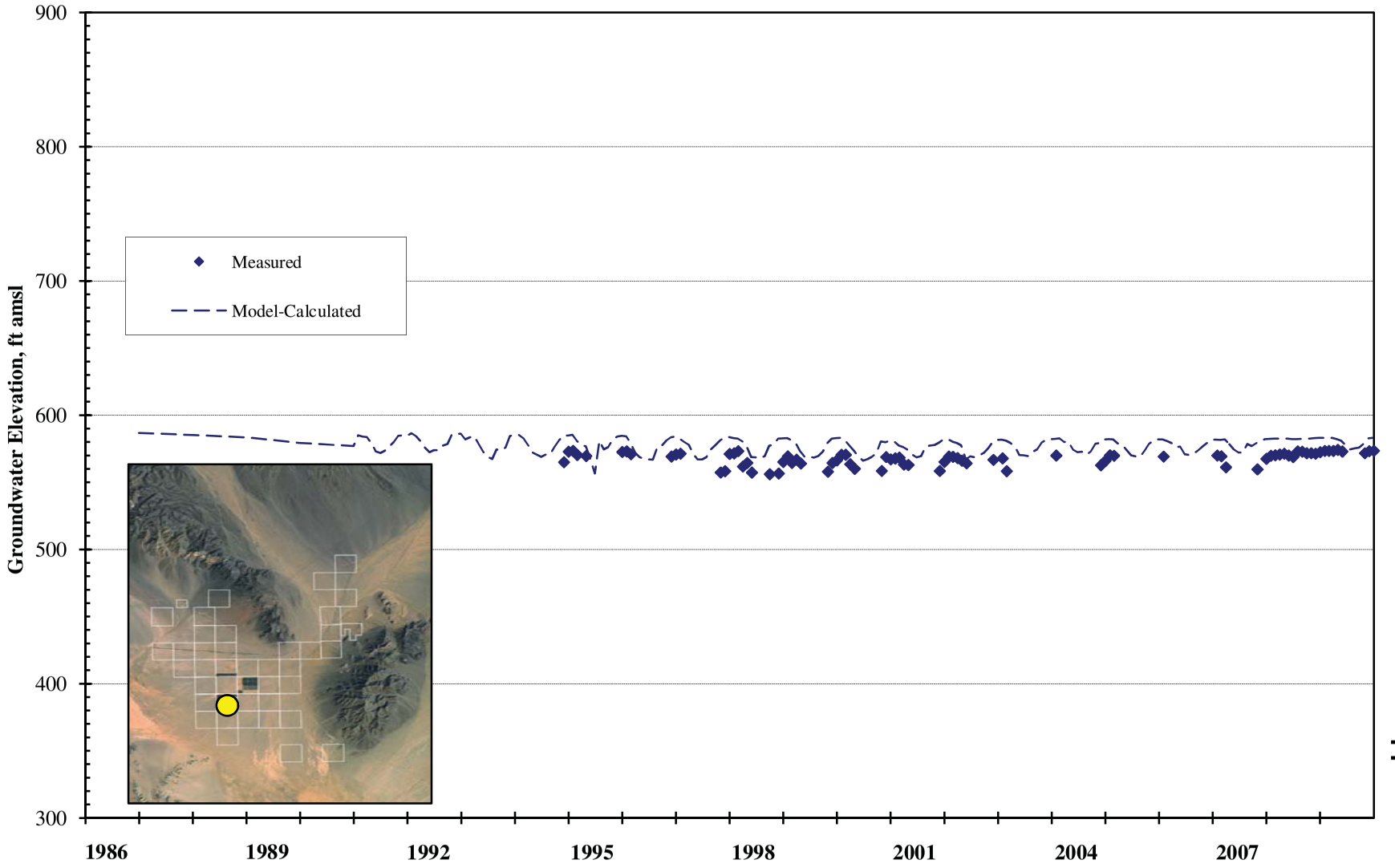
Appendix G

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



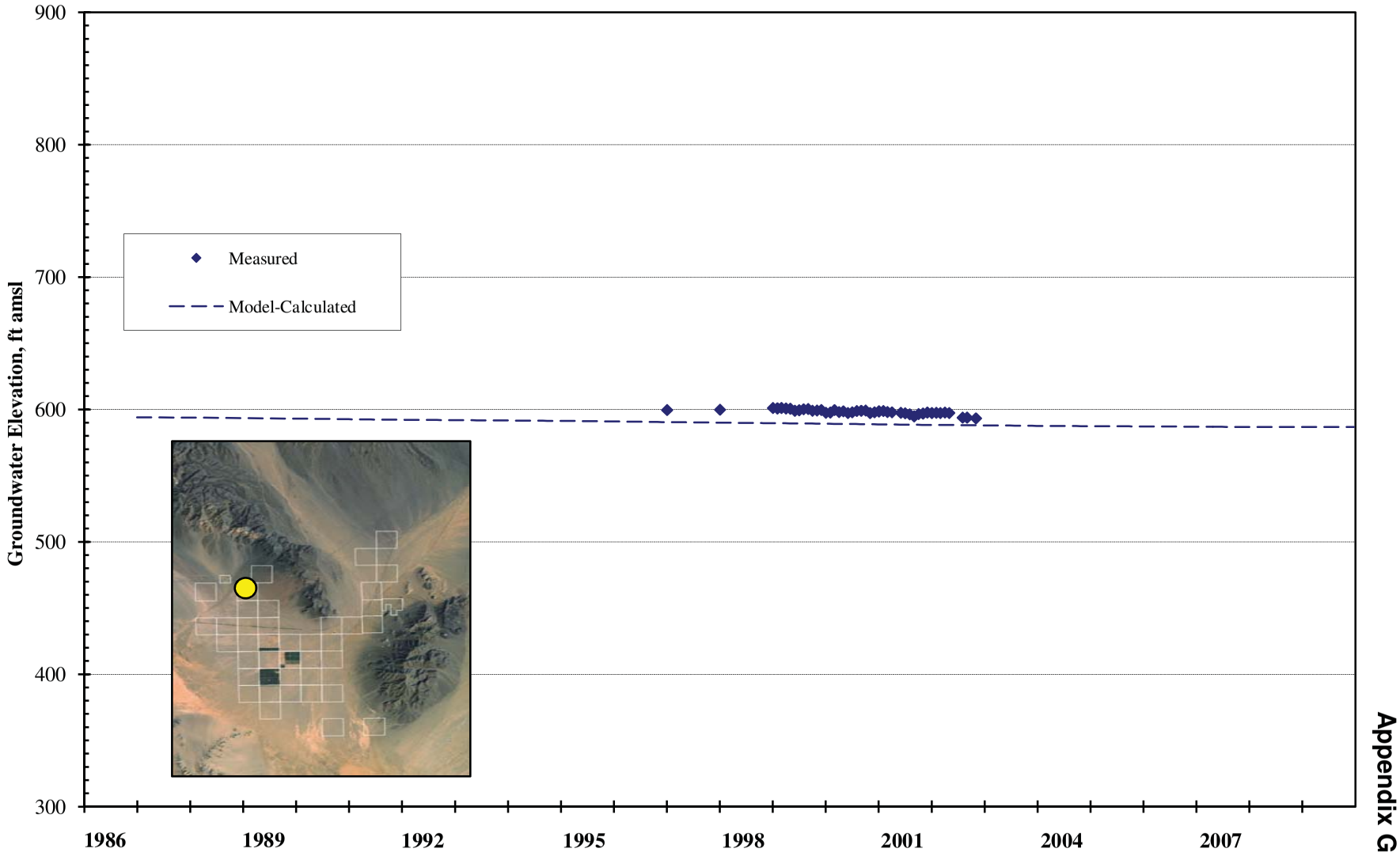
Appendix G

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



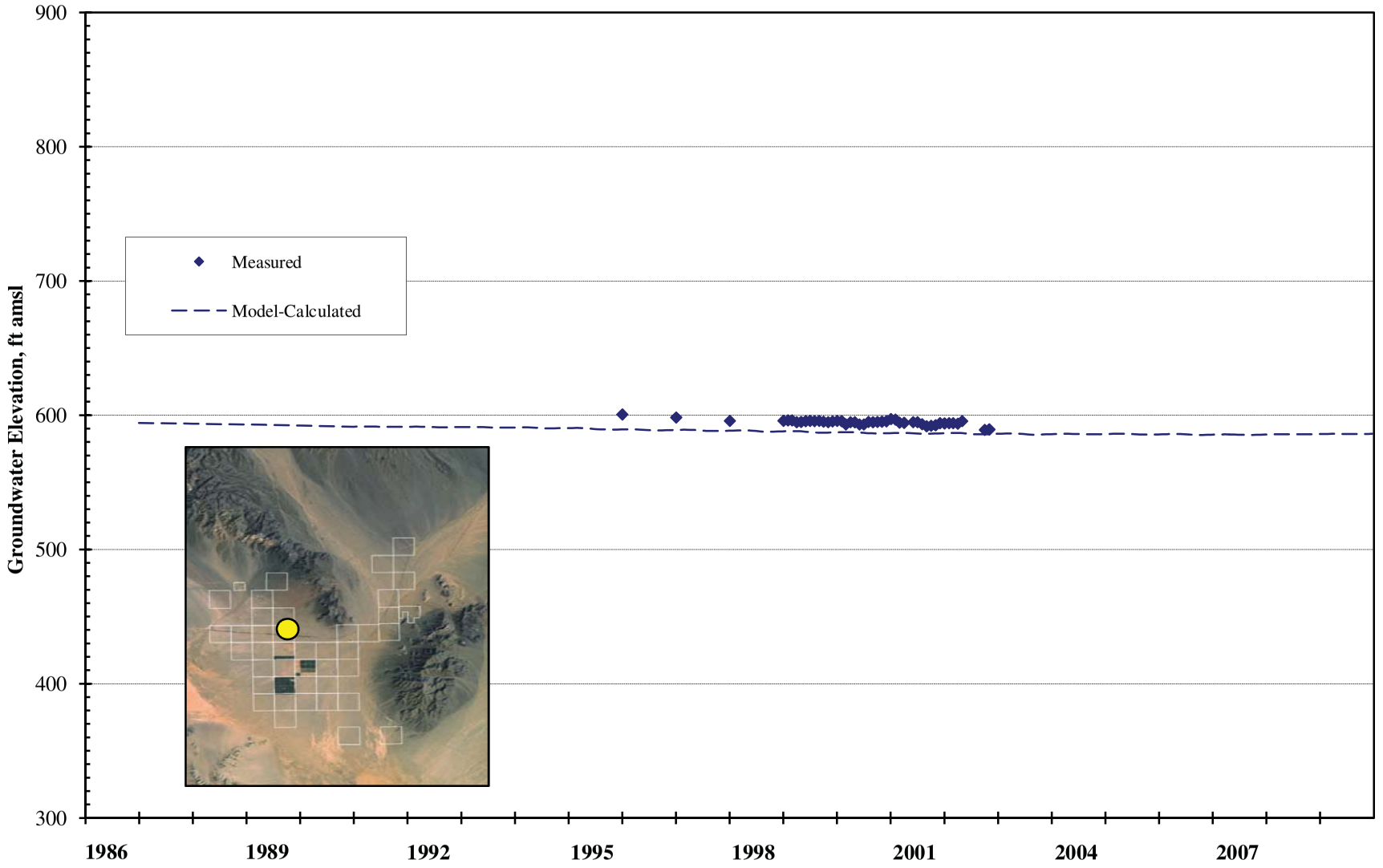
Appendix G

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



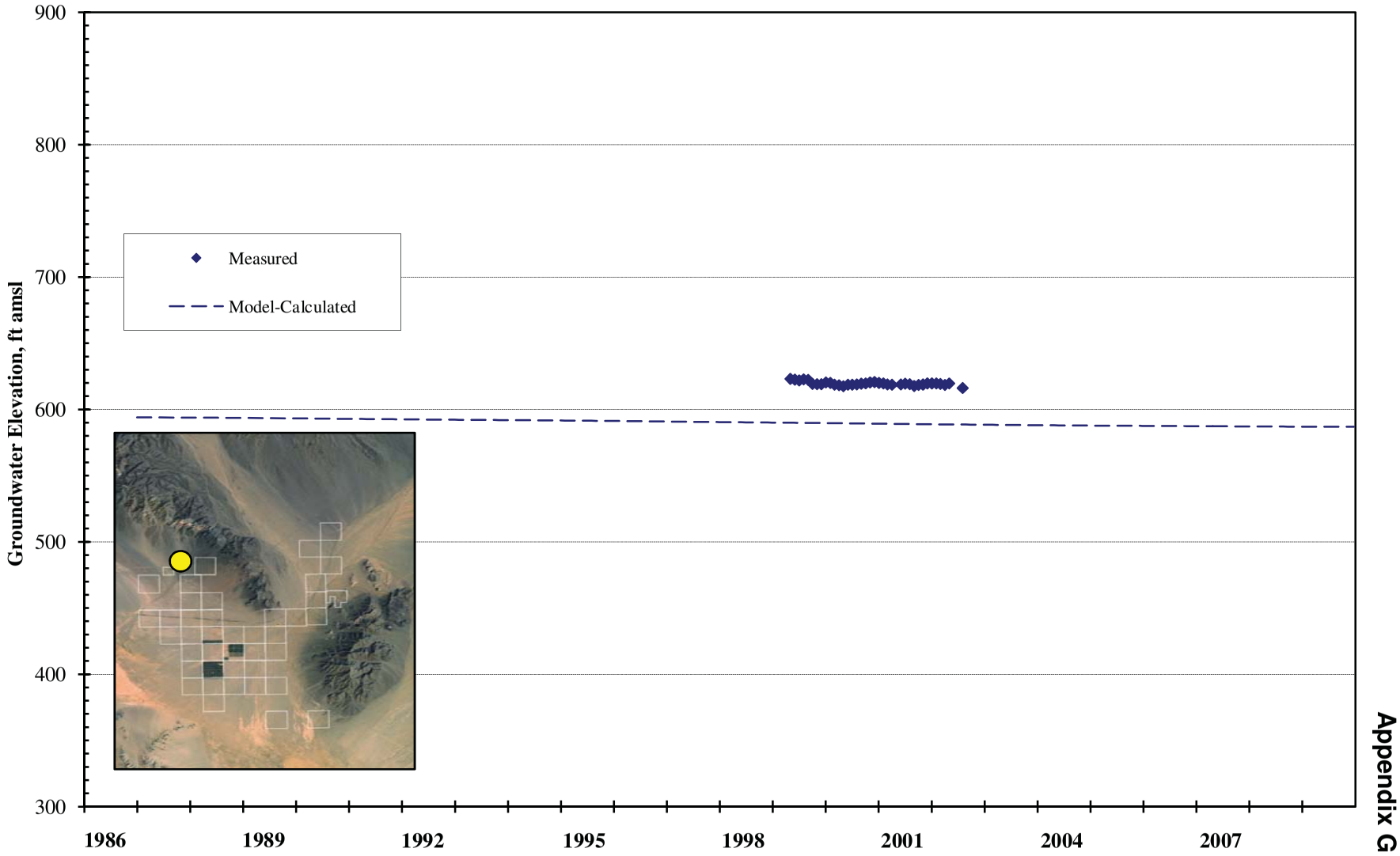
Appendix G

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



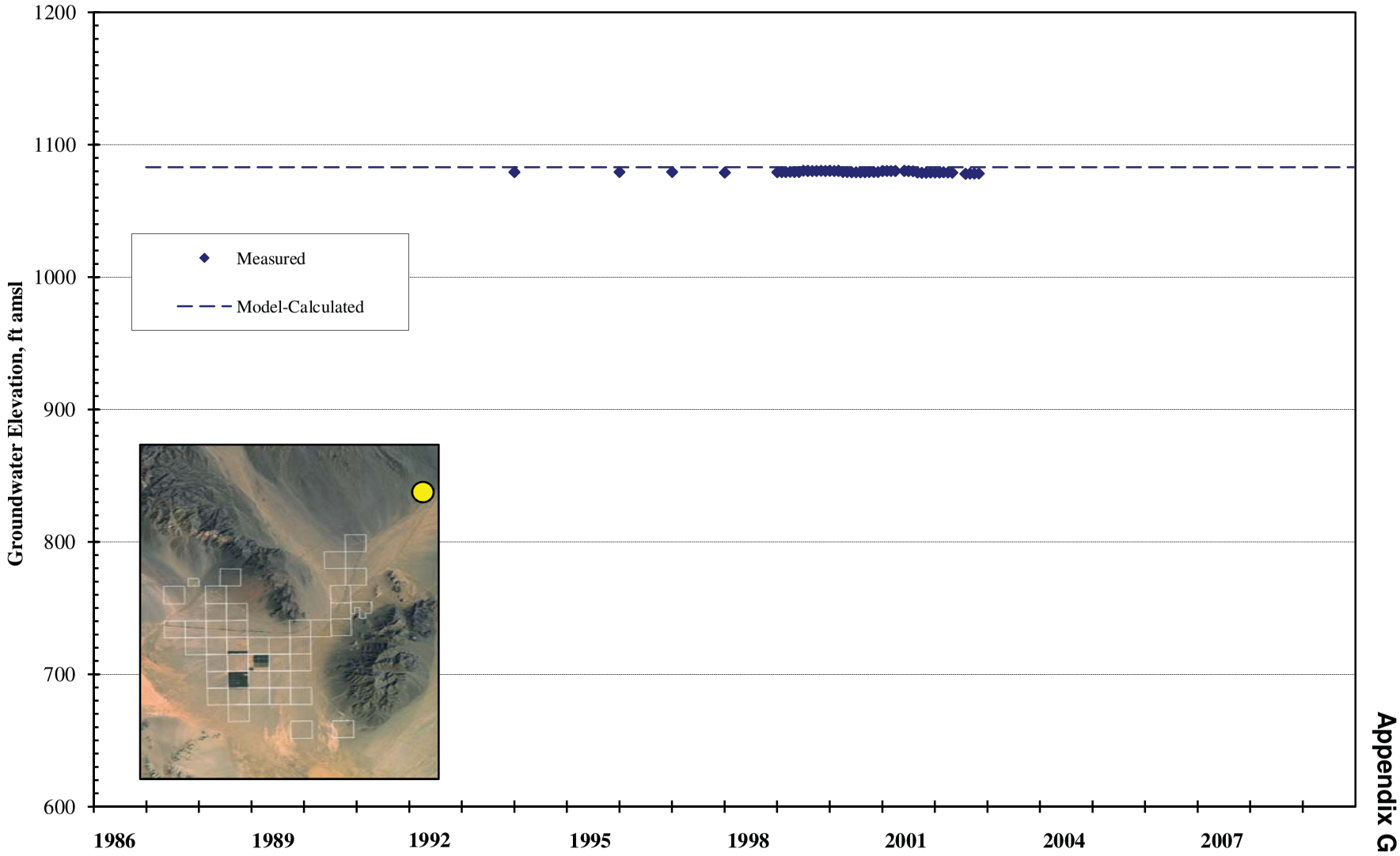
Appendix G

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



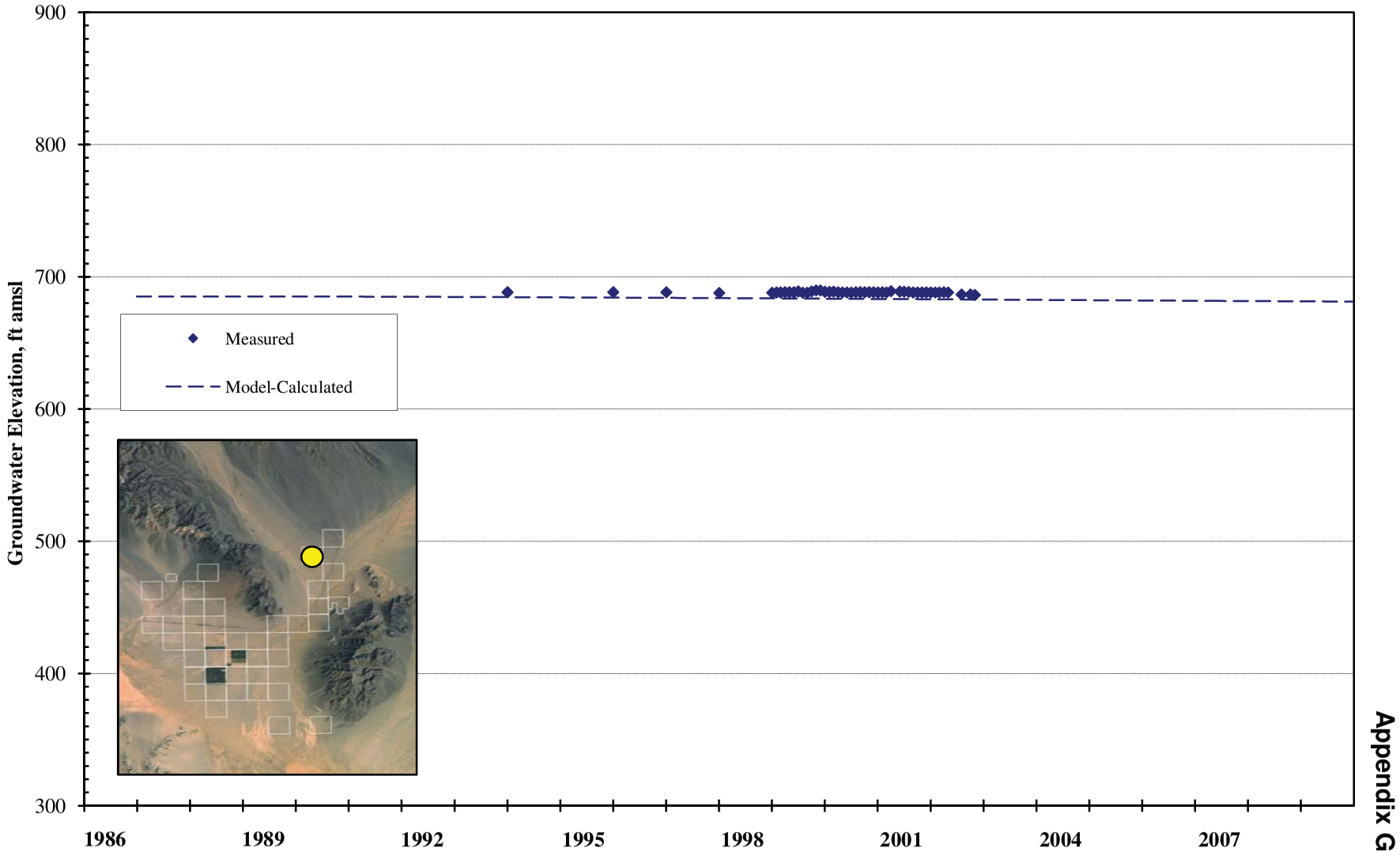
Appendix G

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



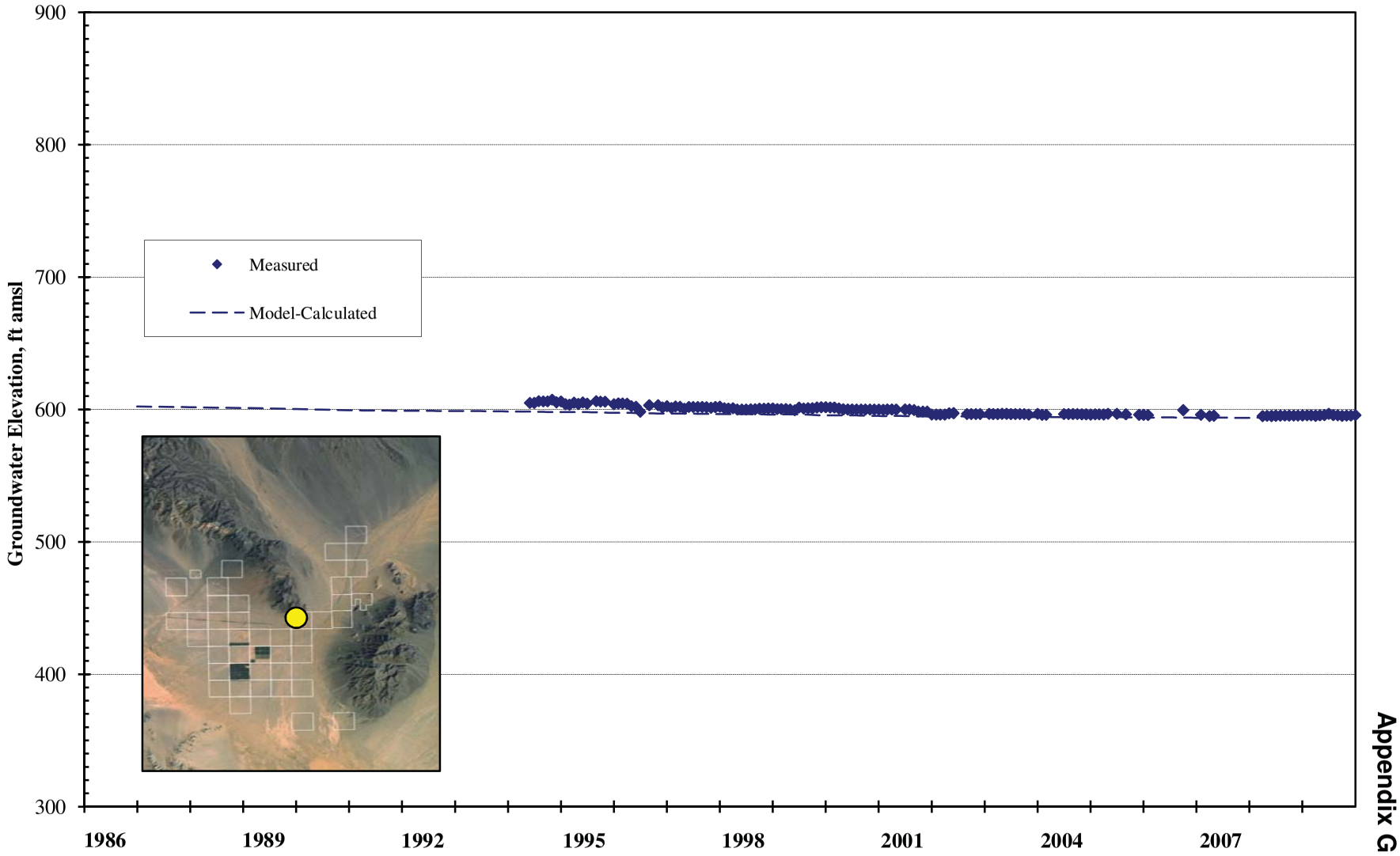
Appendix G

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



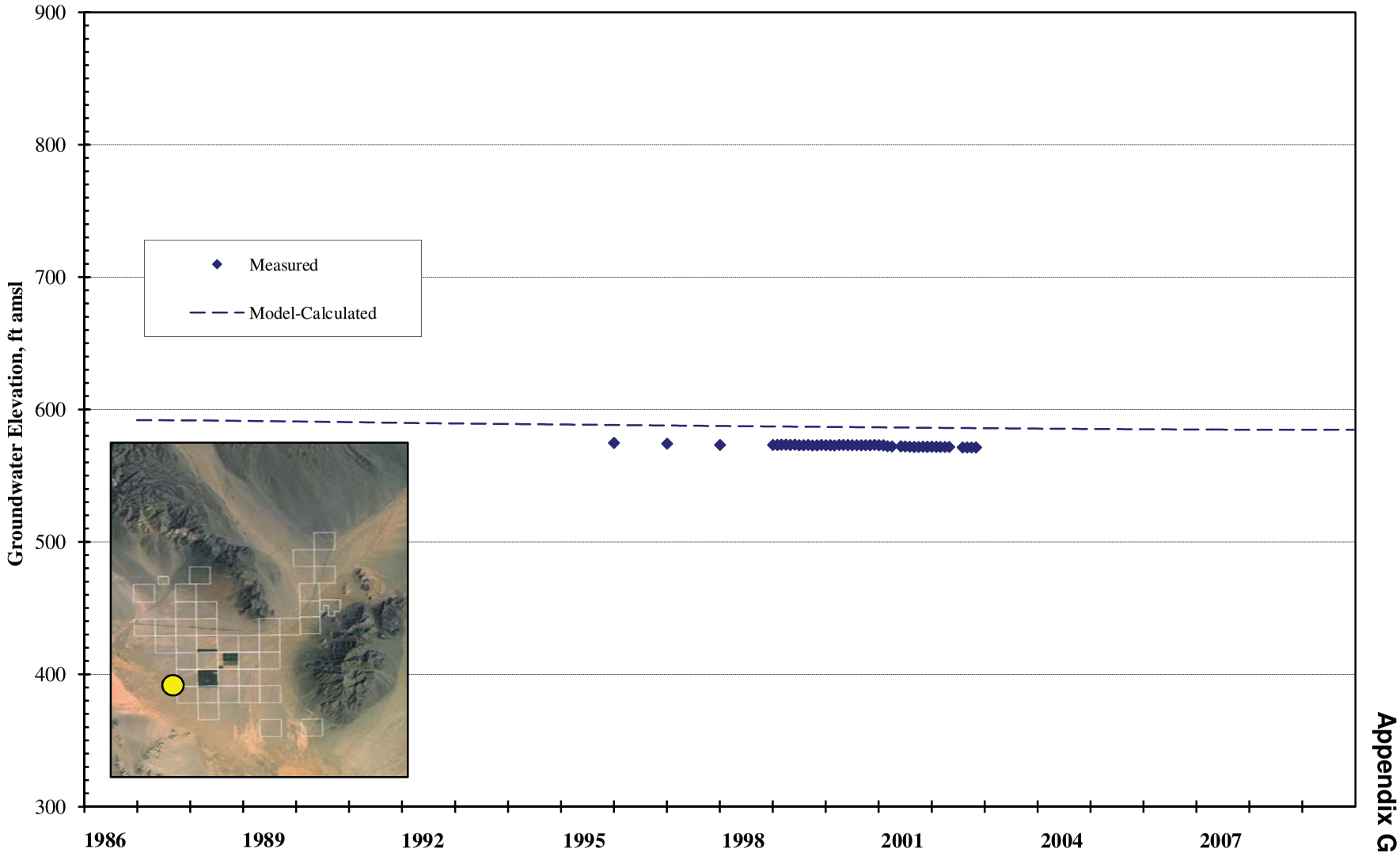
Appendix G

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



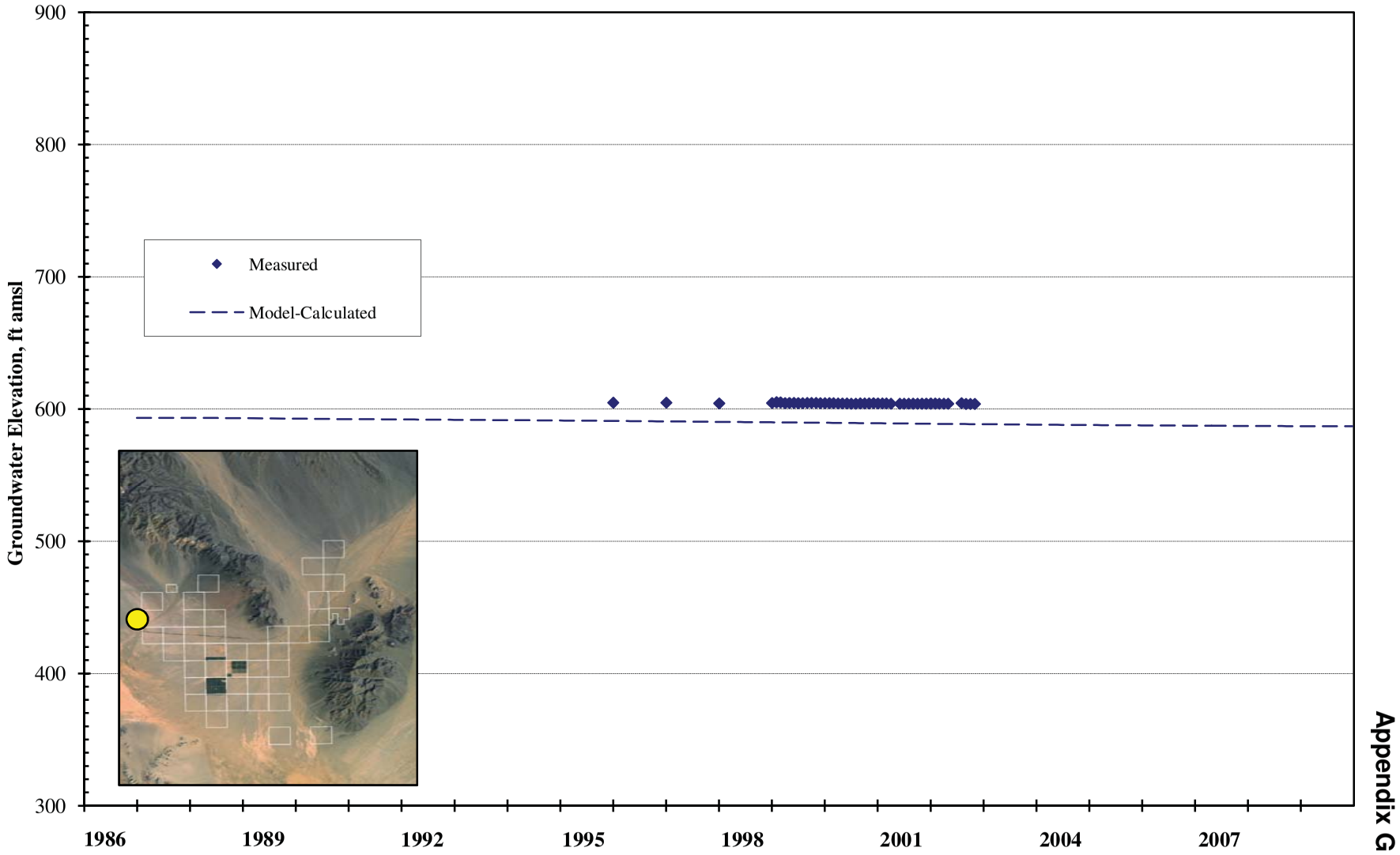
Appendix G

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



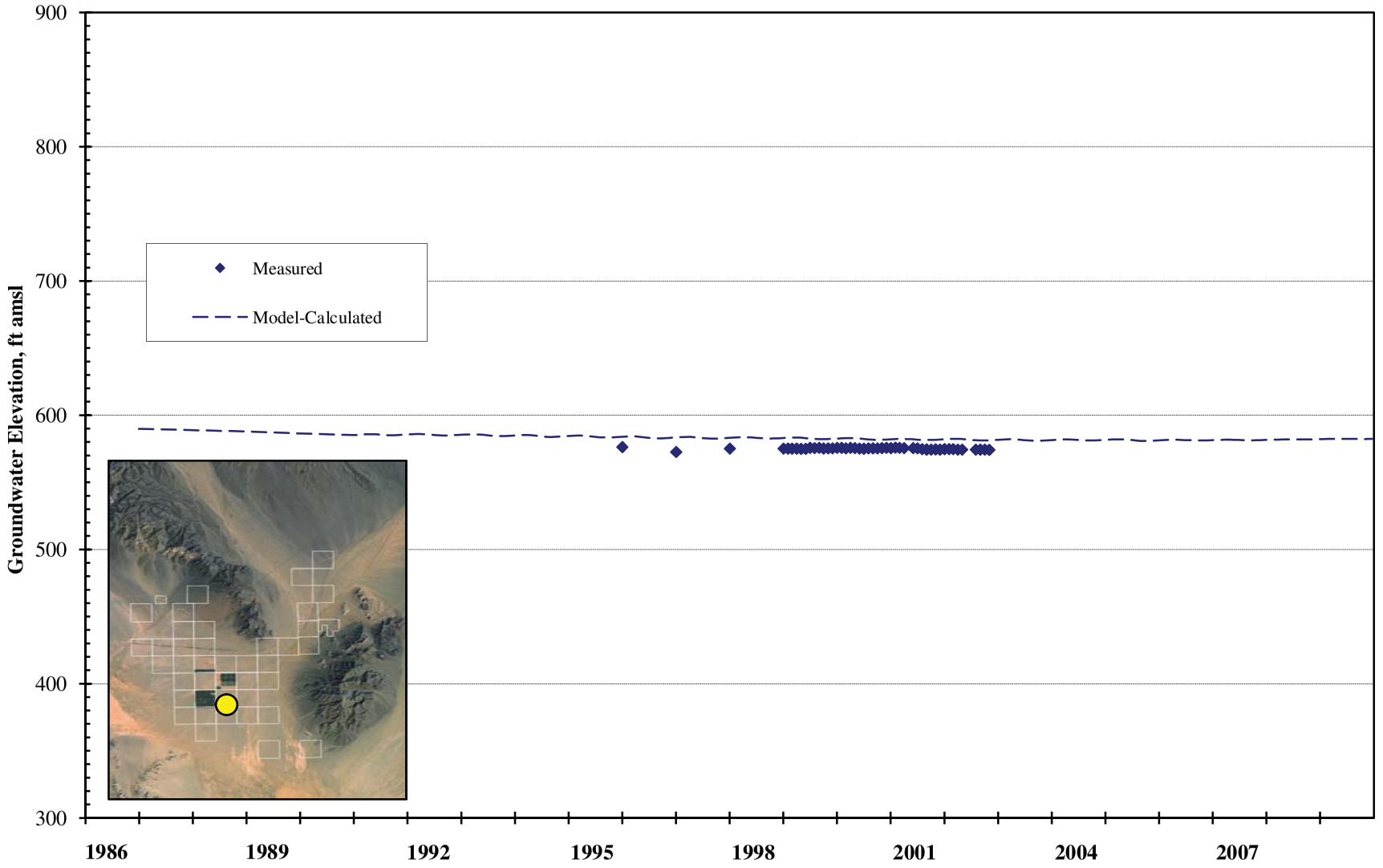
Appendix G

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



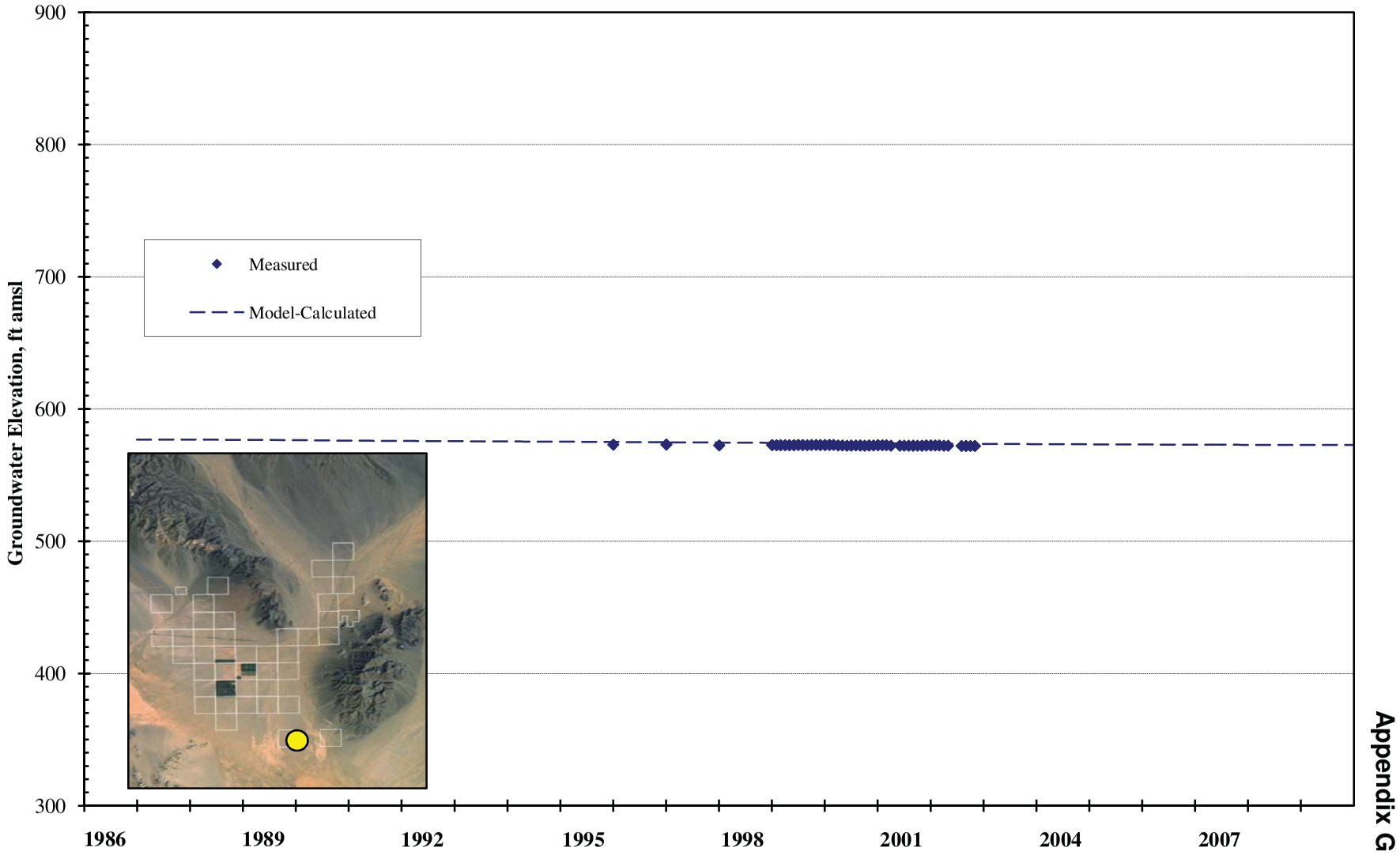
Appendix G

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



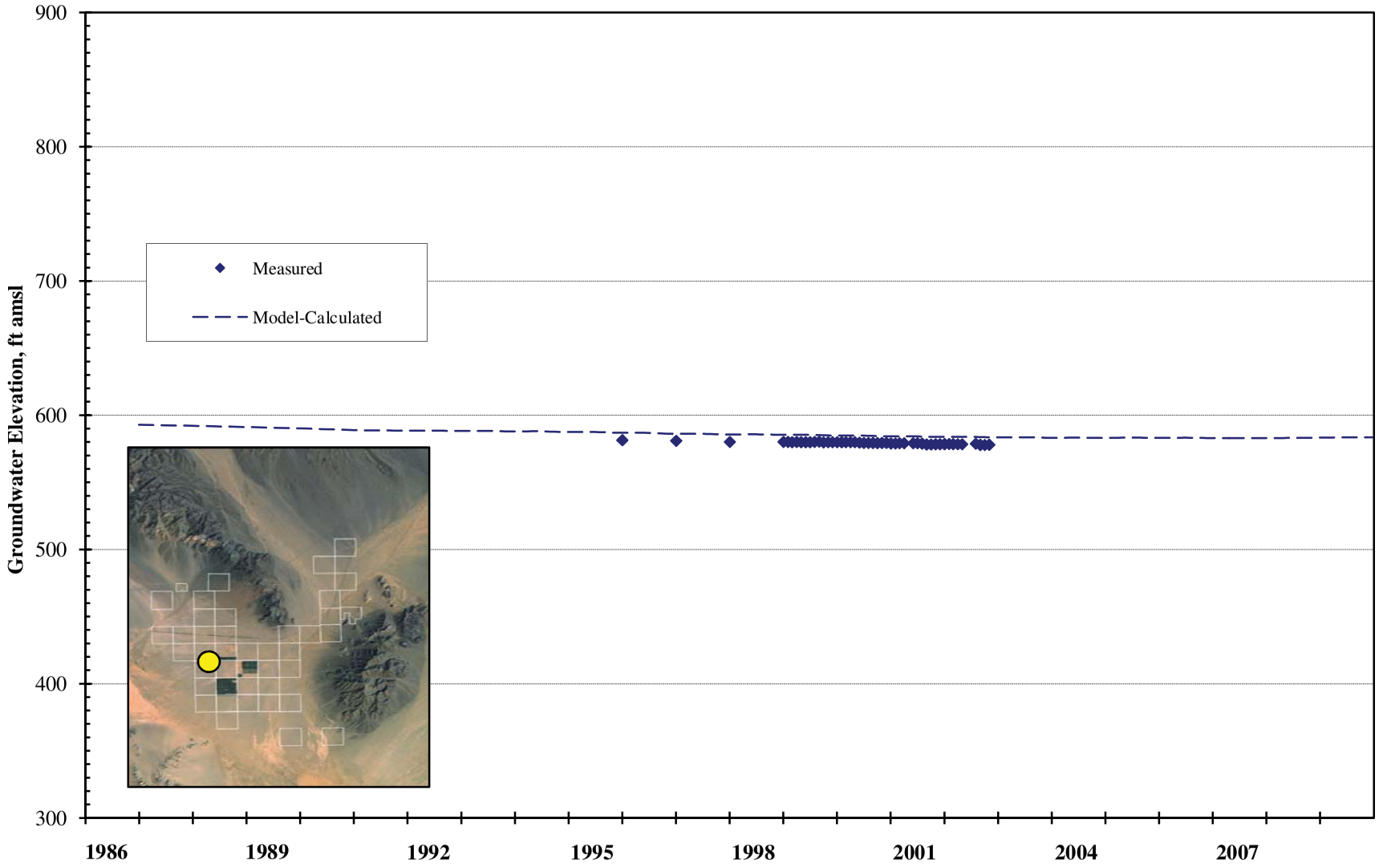
Appendix G

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



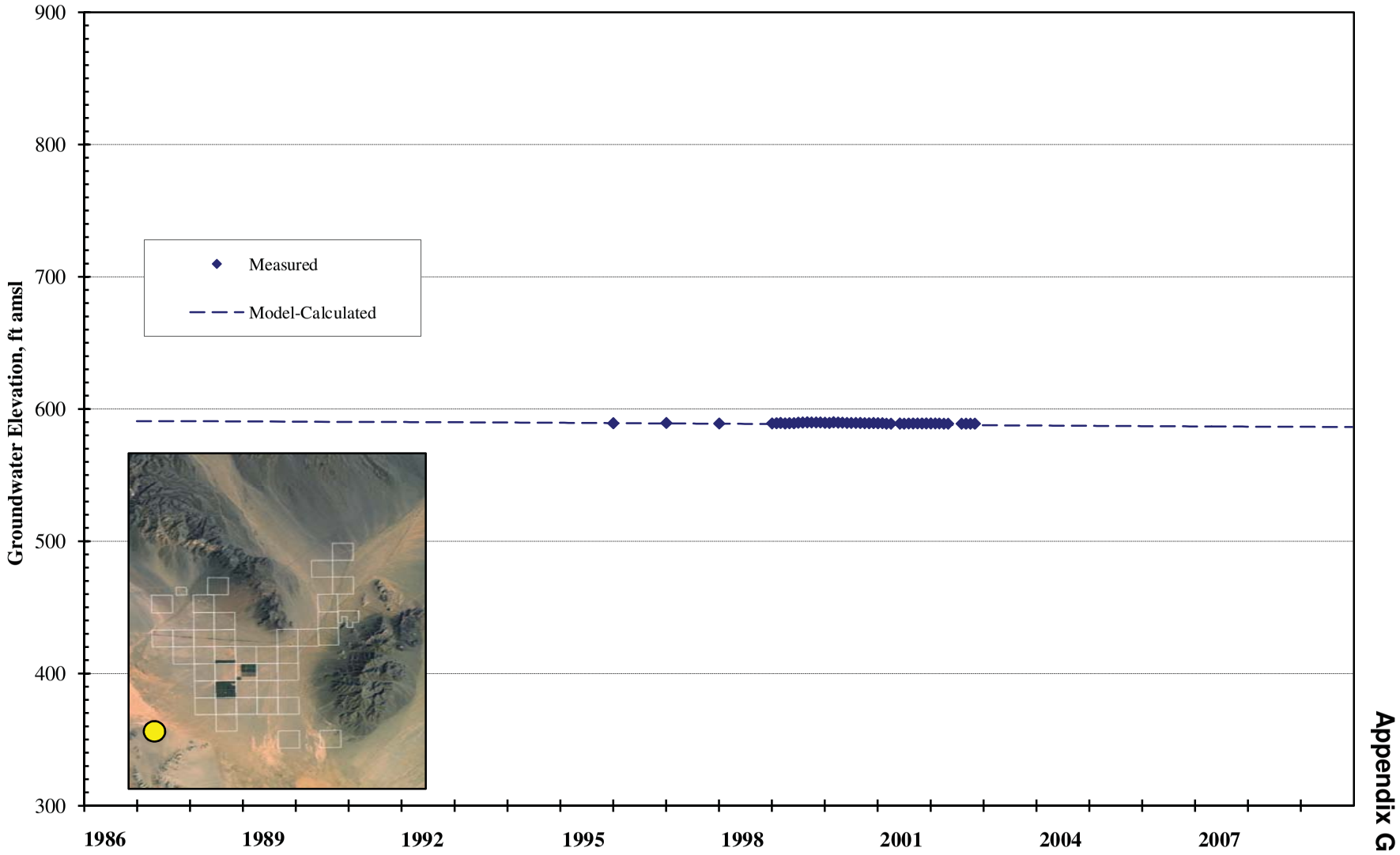
Appendix G

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



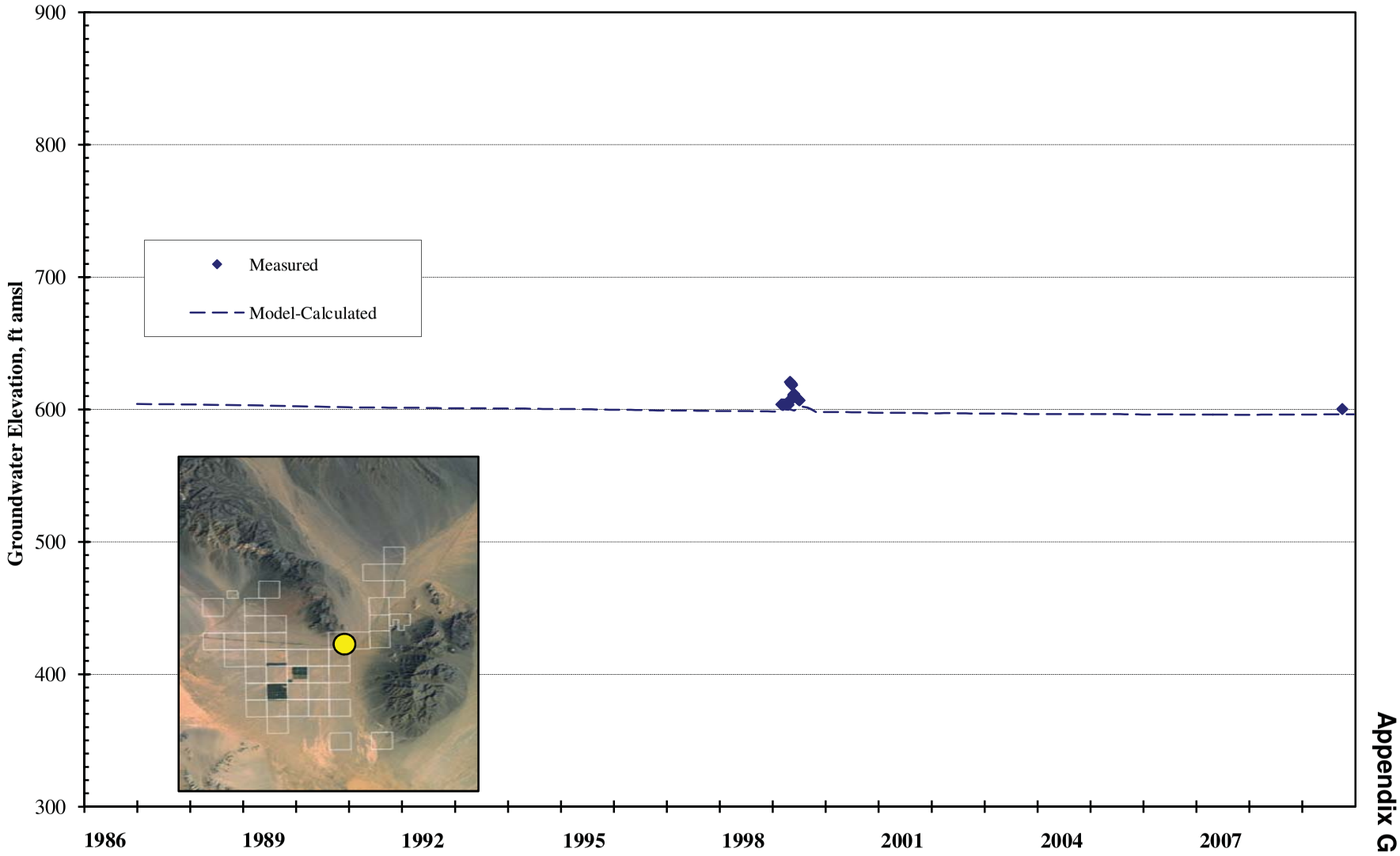
Appendix G

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



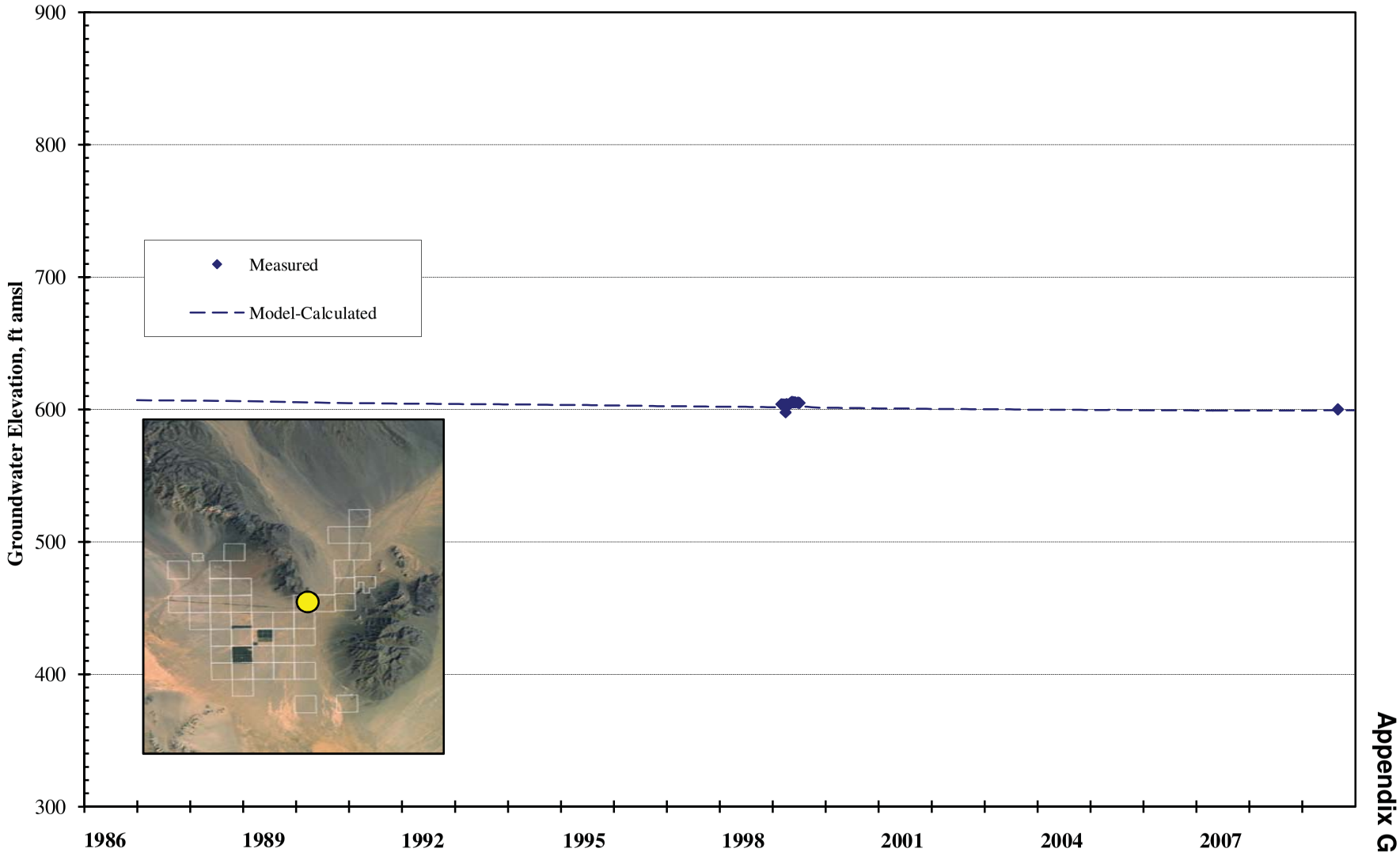
Appendix G

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



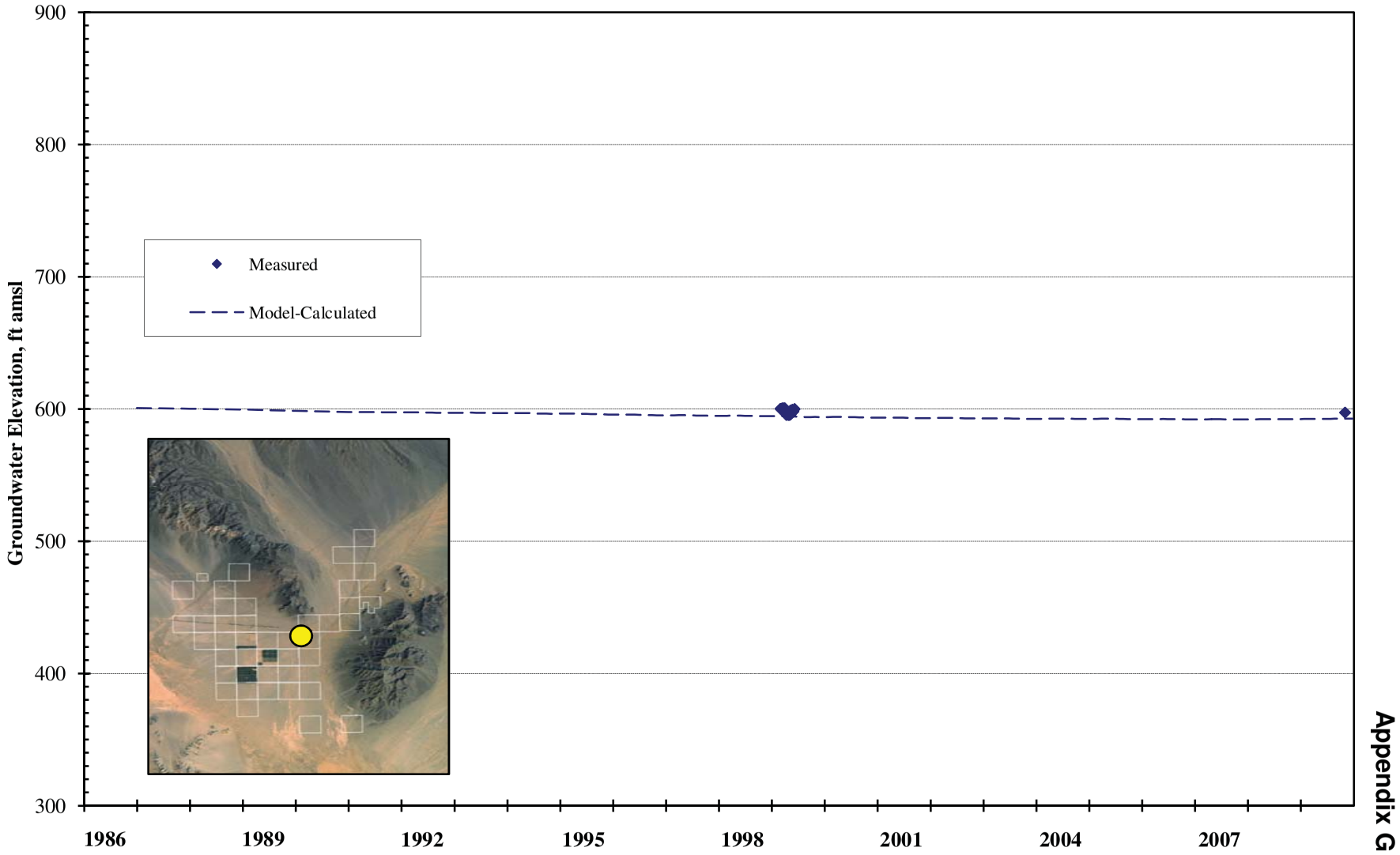
Appendix G

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



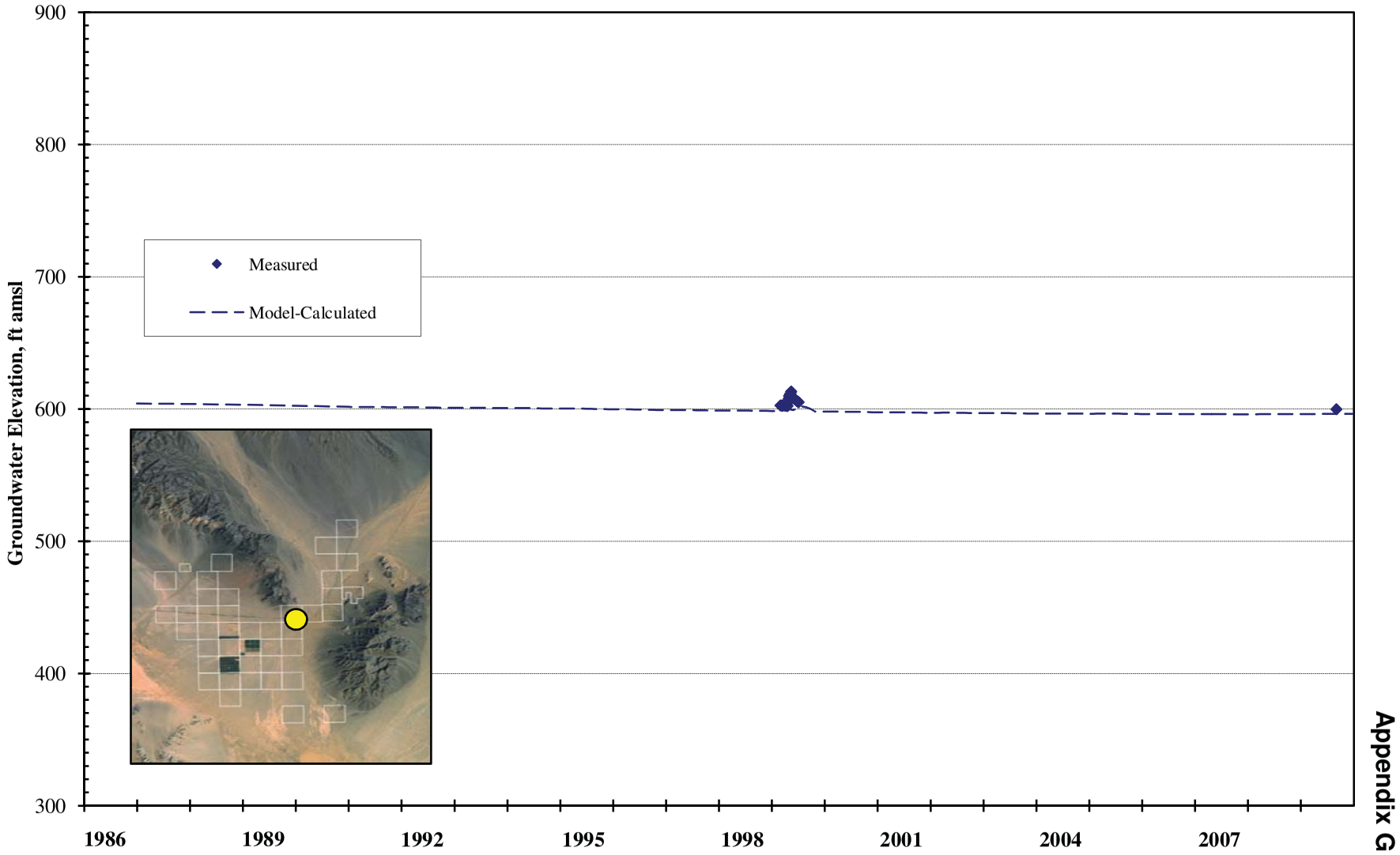
Appendix G

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



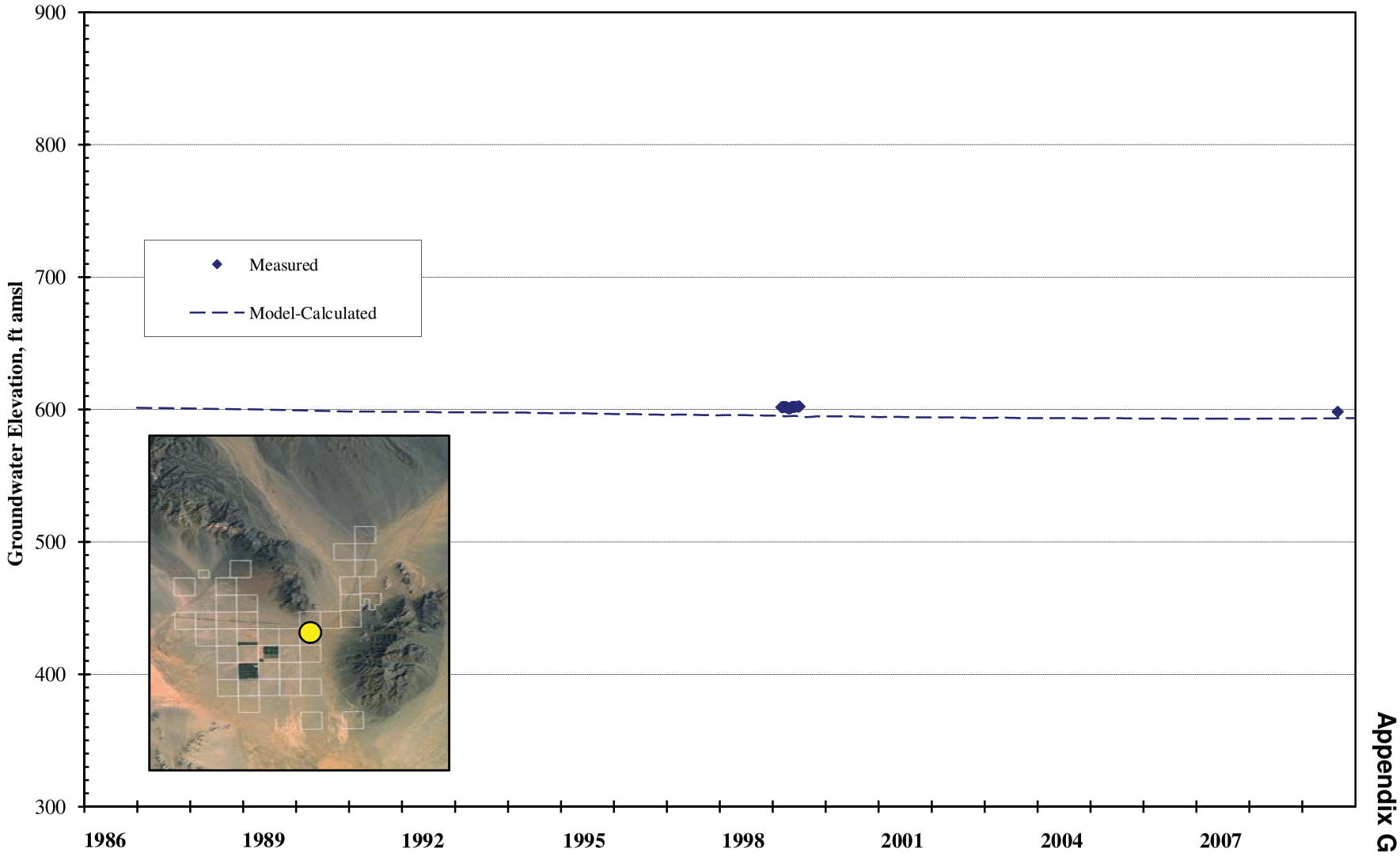
Appendix G

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



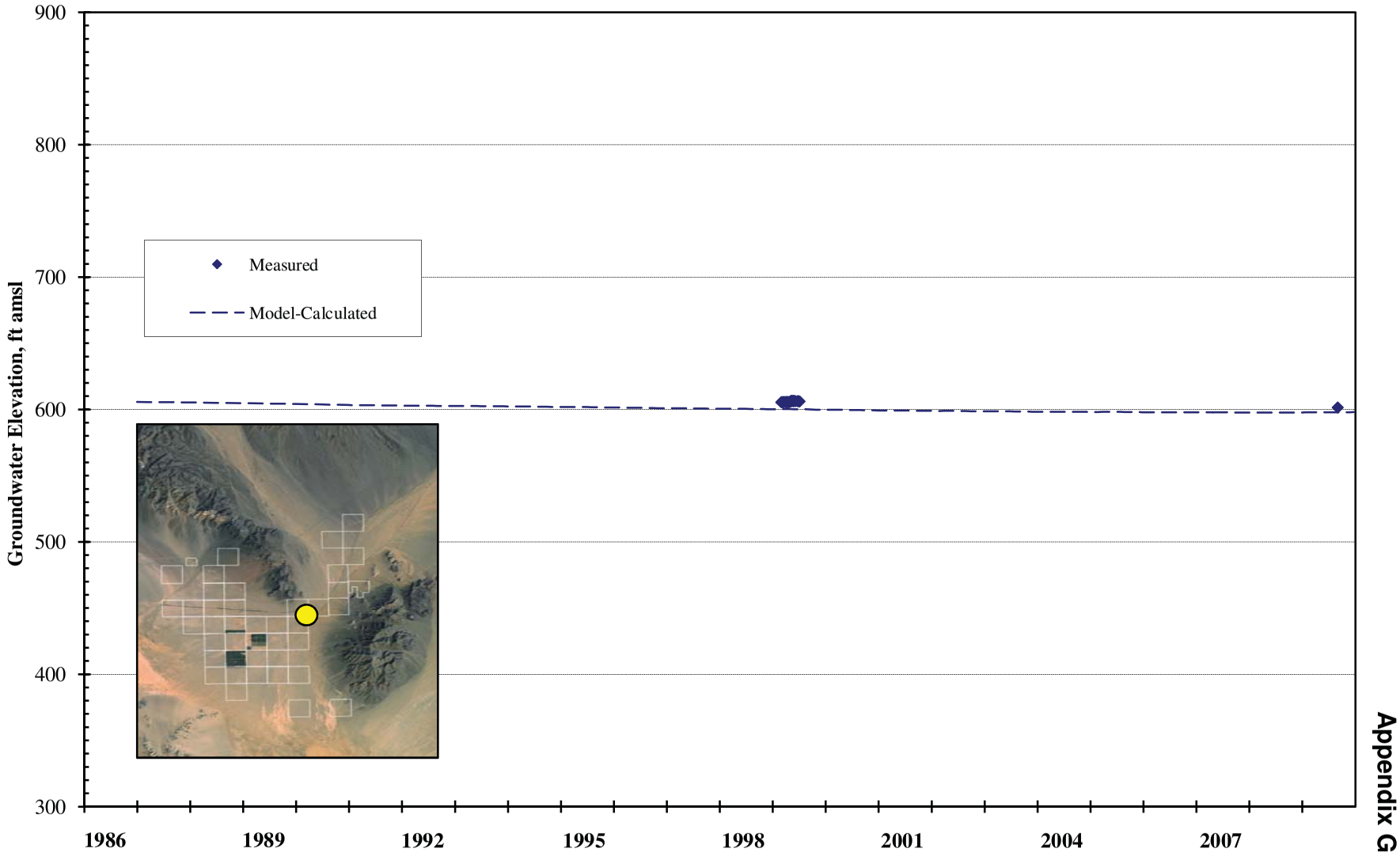
Appendix G

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



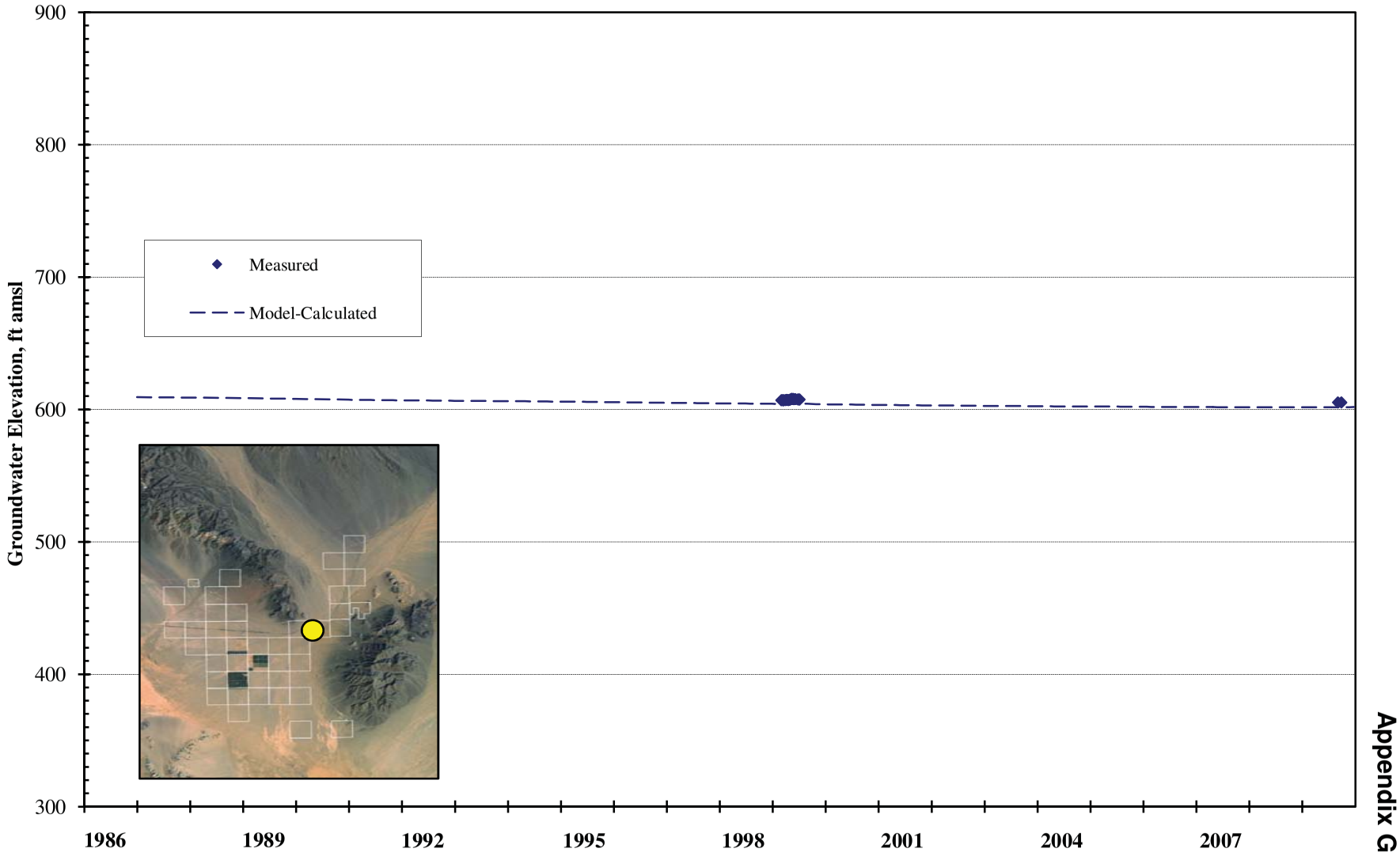
Appendix G

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



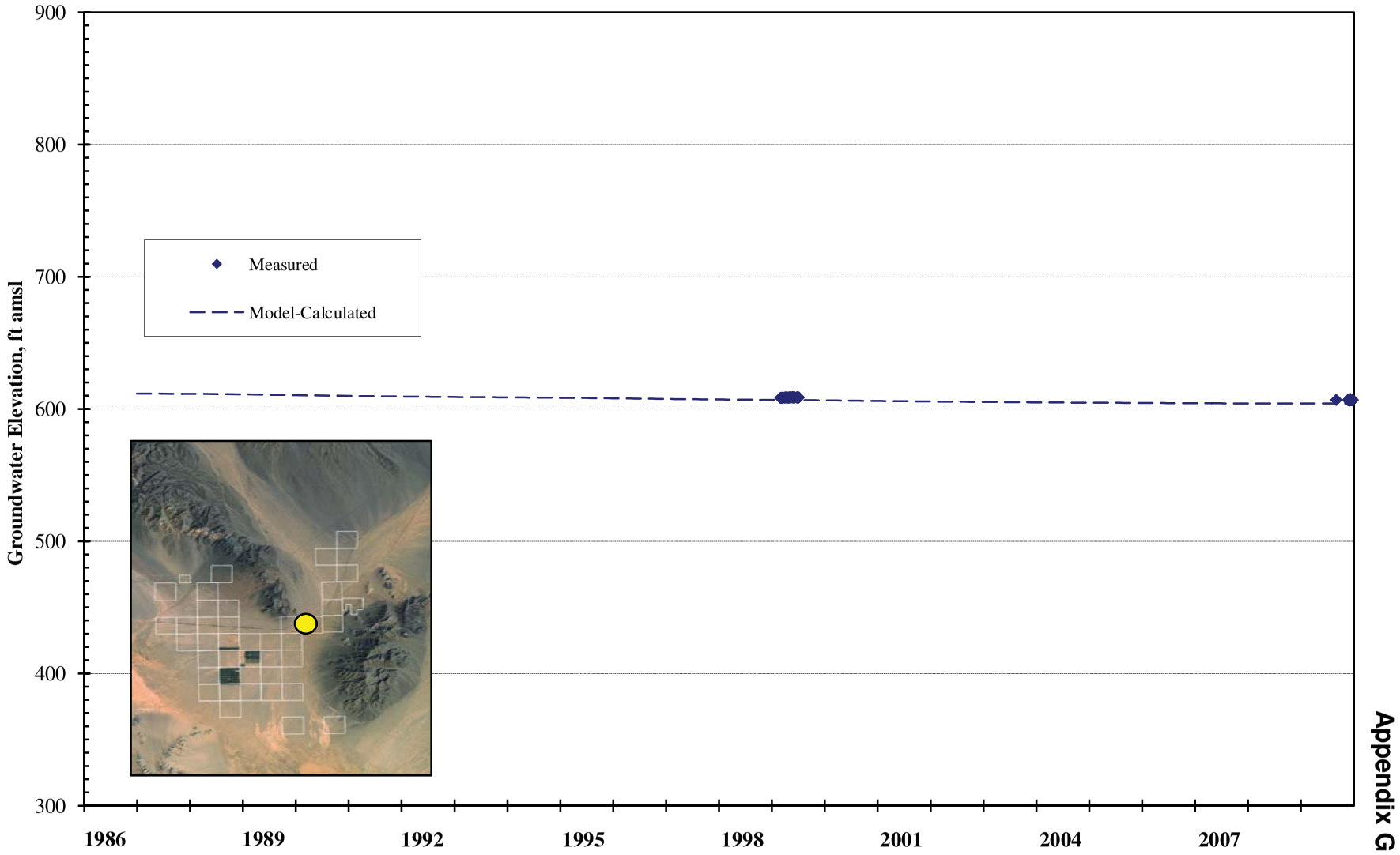
Appendix G

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



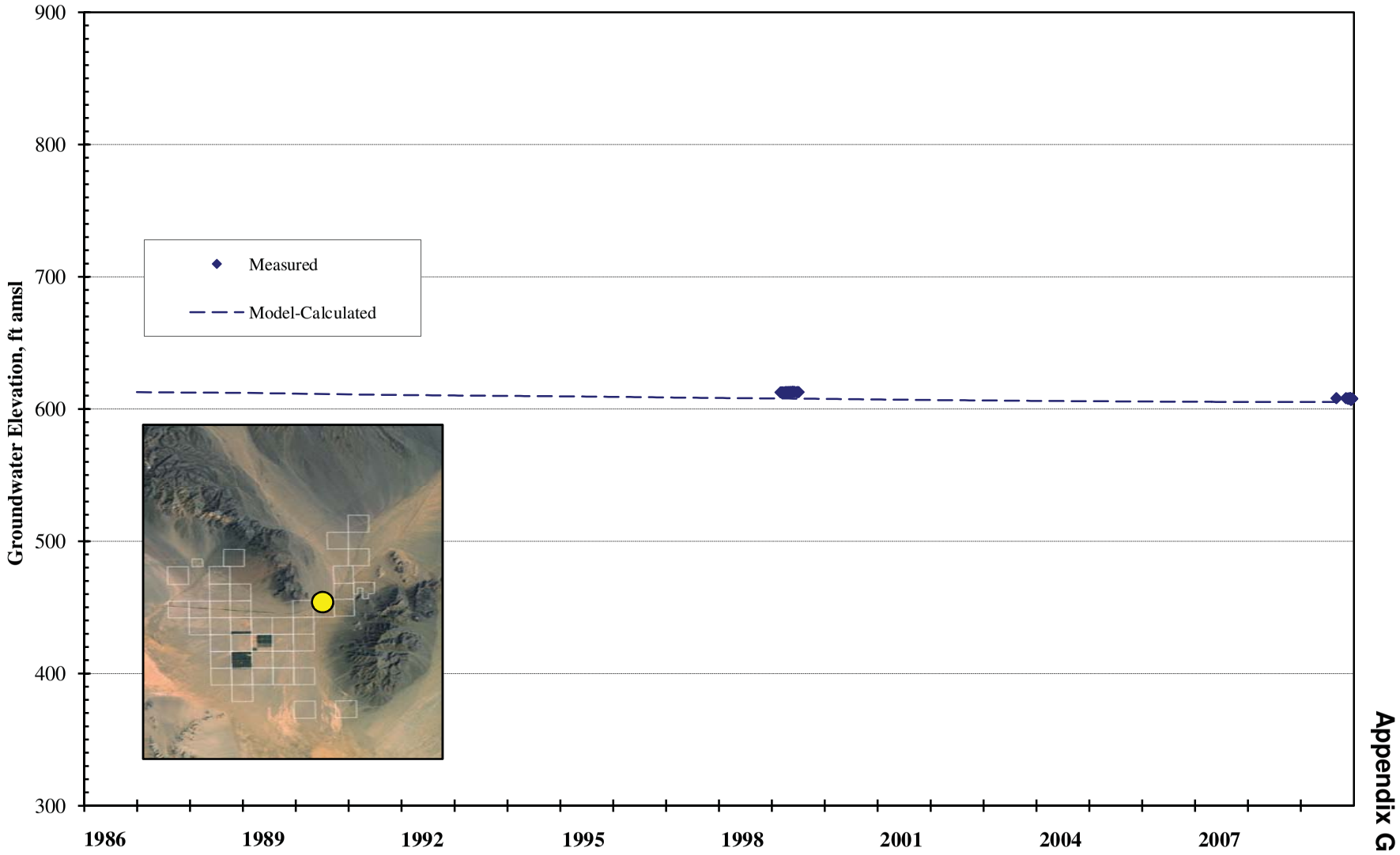
Appendix G

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



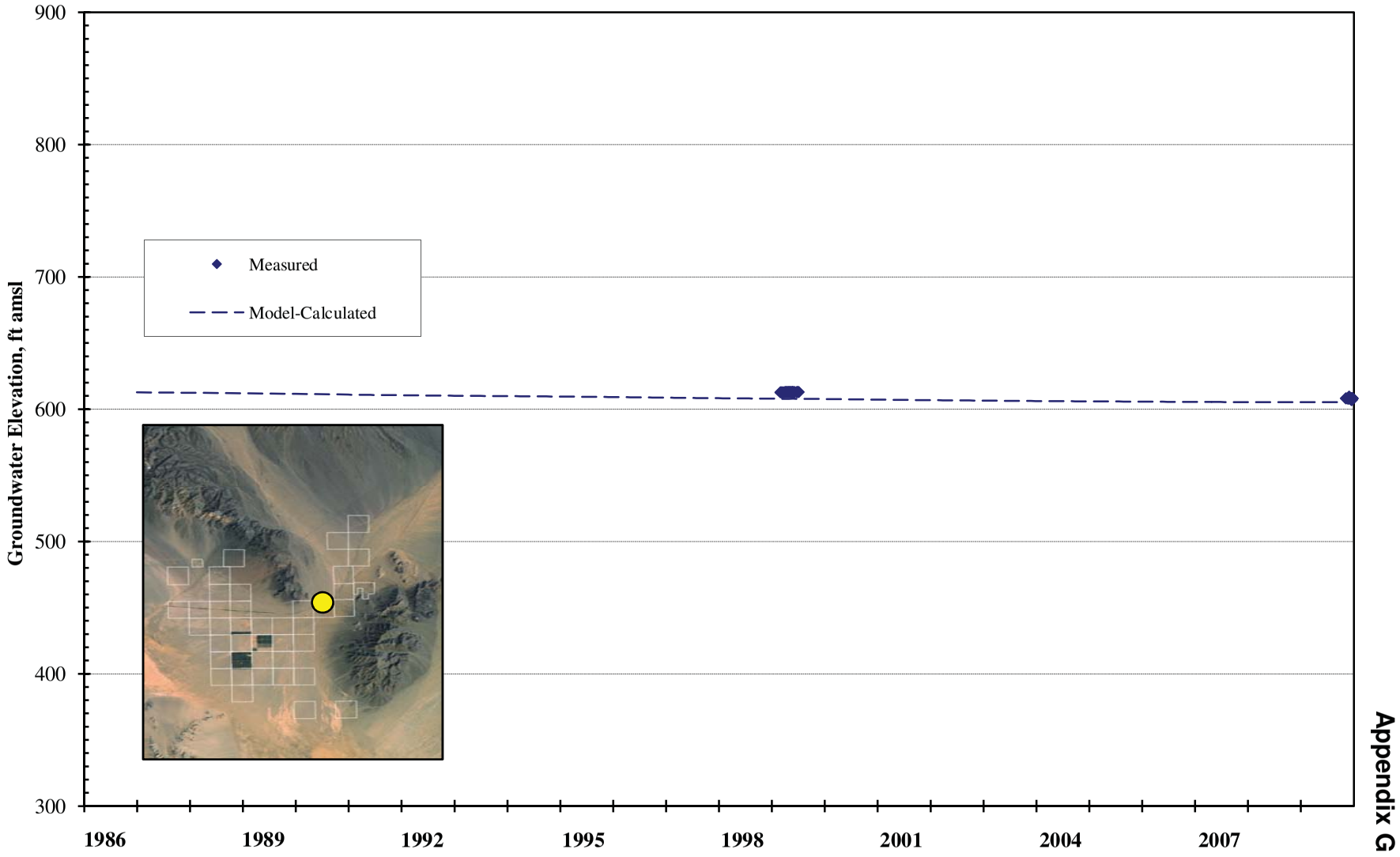
Appendix G

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



Appendix G

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



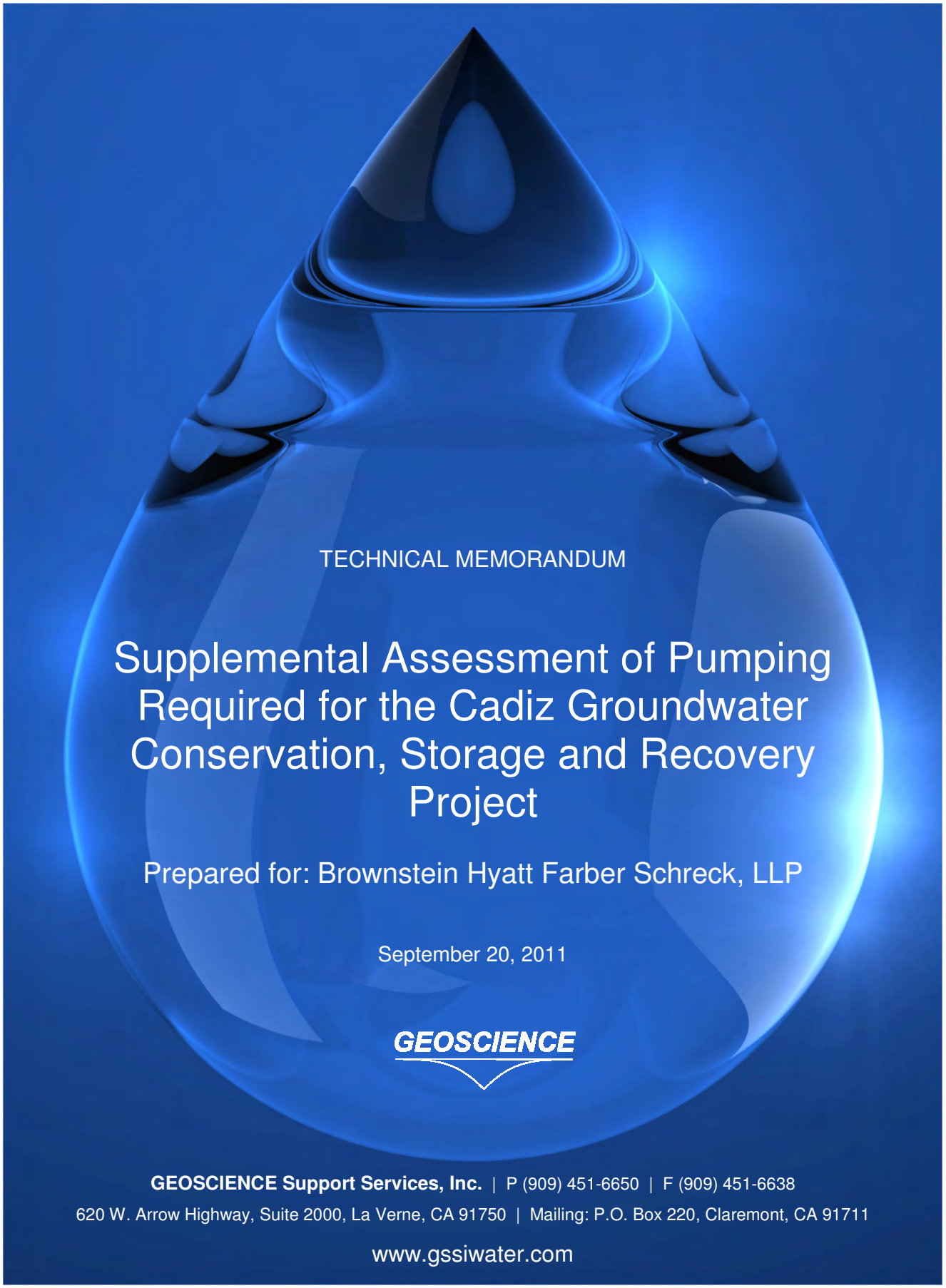
Appendix G

VOLUME 3

GEOSCIENCE

www.gssiwater.com

GEOSCIENCE Support Services, Inc.,
Ground Water Resources Development
P.O. Box 220, Claremont, CA 91711
P: 909.451.6650 | F: 909.451.6638



TECHNICAL MEMORANDUM

Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation, Storage and Recovery Project

Prepared for: Brownstein Hyatt Farber Schreck, LLP

September 20, 2011

GEOSCIENCE

GEOSCIENCE Support Services, Inc. | P (909) 451-6650 | F (909) 451-6638

620 W. Arrow Highway, Suite 2000, La Verne, CA 91750 | Mailing: P.O. Box 220, Claremont, CA 91711

www.gssiwater.com

Technical Memorandum

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

To:	Mr. Scott S. Slater, Esq. Brownstein Hyatt Farber Schreck, LLP 21 East Carrillo Street Santa Barbara, California 93101-2706
From:	Dennis E. Williams, Ph.D. President GEOSCIENCE Support Services, Inc.
Date:	September 20, 2011
Subject:	**Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation, Storage and Recovery Project**

1.0 PURPOSE

The Cadiz Groundwater Conservation, Storage and Recovery Project (Project) is a water conservation supply and conjunctive use storage project that would actively manage the groundwater basin within the Fenner Watershed and the Orange Blossom Wash located in the Eastern Mojave Desert (see Figure 1). The Project will develop a new water supply and storage facility for the Santa Margarita Water District (SMWD) and other participating water agencies. The first phase of the Project, the Conservation Component, would extract and convey an average of approximately 50,000 acre-ft/yr of groundwater from a wellfield in Fenner Gap via a pipeline to the Colorado River Aqueduct (CRA) (see Figure 1). The long-term average annual natural recharge of the Fenner Watershed has been estimated to be approximately less than 5,000 acre-ft/yr to 40,000 acre-ft/yr (see Appendix D of GEOSCIENCE, 2011). This memorandum provides supplemental information to explain the strategy of pumping

groundwater above the cumulative natural recharge rate in the Fenner, Orange Blossom, Cadiz, and Bristol Watersheds.

2.0 CONTROLLING FACTORS OF EVAPORATIVE LOSSES

The primary goal of the Project is to optimize the use of the underlying groundwater basin to maximize the reasonable and beneficial use of groundwater while minimizing environmental harm by capturing natural recharge and minimizing the present waste of water to evaporation at the Bristol and Cadiz Dry Lakes. Conservatively, there is approximately 17 to 34 million acre-ft of groundwater in storage in this alluvial aquifer system and of that approximately 4 to 10 million acre-ft of fresh groundwater (i.e., total dissolved solids concentration is less than 1,000 mg/L) in storage below the Fenner Gap alone (CH2M Hill, 2010). The elevation of the water table at Fenner Gap based on groundwater measurements collected in 2009, is approximately 610 ft above mean sea level (amsl), whereas the low areas of Bristol and Cadiz Dry Lakes are 580 and 545 ft amsl, respectively (see Figure 2). This difference in elevation provides the driving hydraulic gradient of fresh groundwater flowing to the dry lakes. It is the goal of the Project to capture this fresh groundwater flowing to the dry lakes, thereby conserving the water for beneficial use.

There are three factors that control the extent to which Cadiz can maximize capture of natural recharge which is flowing to the dry lakes. These factors are:

- Natural recharge rate,
- Location of the wellfields, and
- Rate and timing of pumping.

As the natural recharge is somewhat uncertain, Cadiz is evaluating a range of recharge rates in order to examine potential impacts from the operation of the Project. The location of the wellfields is limited to Cadiz's property and hydrogeology (i.e., productive areas of the basin). The wellfields (proposed new wellfield and existing Cadiz agricultural wellfield) are located near Fenner Gap which is distant from the dry lakes. The wellfields needs to flatten the hydraulic gradient to prevent loss by flow to the dry lakes. The location and timing of pumping rates will determine how quickly and what volumes of fresh

groundwater can be conserved for beneficial use instead of being lost to evaporation. Higher rates of pumping earlier in the development of the Project will result in the establishment of a cone of depression and a more extended capture zone compared to lower rates of pumping. Cadiz desires to intercept as much fresh groundwater as practical and put this water to beneficial use, without creating adverse impacts or causing harm.

3.0 WATER SAVING FROM THE PROPOSED PROJECT PUMPING SCHEDULE

Cadiz proposes to pump an average of 50,000 acre-ft/yr over the 50-year term of the Project. As project participants require project water to meet drought or emergency demands, their annual delivery requirements may be variable in quantity as opposed to taking a constant delivery of water. To simulate the project, model simulations conducted by GEOSCIENCE (2011) varied pumping rates between 25,000 acre-ft/yr and 75,000 acre-ft/yr, but maintained a long-term average of 50,000 acre-ft/yr (see Figure 3). The variable pumping rates were based on projected deliveries of Table A water from Metropolitan Water District. Projected pumping was increased in years when projected deliveries would be lower and decreased during periods when projected delivery volumes would be greater. Given that the goal of the Project is to recover and conserve fresh groundwater for beneficial use, the net water savings from the pumping operation was calculated using the following equation:

$$NWS = REL - DS$$

Where:

NWS = Net Water Savings from the Project, acre-ft

REL = Reduction of Evaporative Loss from the Project, acre-ft

DS = Depletion of Storage under Project Conditions, acre-ft

3.1 Reduction of Evaporative Loss

Reduction of evaporative loss from the Project was calculated as the difference between the evaporative loss under no Project conditions (i.e., no pumping) and Project pumping conditions. Based on the results of the steady-state model calibration (GEOSCIENCE,2011), the projected cumulative loss of fresh groundwater to evaporation under no project conditions for the 32,000, 16,000, and

5,000 acre-ft/yr natural recharge cases, which over 100 years results in cumulative volumes of 3,200,000, 1,600,000, and 500,000 acre-ft, respectively (see Figure 4). Therefore, with no development of groundwater, these are the volumes of fresh groundwater that would be lost and not put to beneficial uses.

Figure 5 shows the model-predicted cumulative fresh groundwater loss for pumping under Project conditions of 50,000 acre-ft/yr as described in GEOSCIENCE (2011) for the 32,000, 16,000, and 5,000 acre-ft natural recharge cases (i.e., Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2, respectively). The total losses at the end of 50 years (i.e., end of Project pumping) are approximately 240,000, 55,000, and 30,000 acre-ft, respectively. At the end of 100 years, the losses are 990,000, 55,000 and 30,000 acre-ft, respectively.

Pumping an average of 50,000 acre-ft/yr reduces evaporative losses by 2,210,000 acre-ft (i.e., 3,200,000 acre-ft – 990,000 acre-ft = 2,210,000 acre-ft) for the 100-year period where natural recharge is 32,000 acre-ft/yr. The reduction of evaporative losses over a 100-year period for the 16,000 and 5,000 acre-ft/yr natural recharge scenarios are 1,545,000 (1,600,000 acre-ft – 55,000 acre-ft = 1,545,000 acre-ft) and 470,000 acre-ft (500,000 acre-ft – 30,000 acre-ft = 470,000 acre-ft), respectively. The following table summarizes the reduction of evaporative losses from the proposed Project pumping schedule at the end of 50 and 100 years.

Natural Recharge	Time	Scenario	Cumulative Evaporative Losses [acre-ft]	Cumulative Reduction of Evaporative Losses [acre-ft]
32,000 acre-ft/yr	At the End of 50 Years	No Pumping	1,600,000	1,360,000
		Project Scenario (Pumping 50,000 acre-ft/yr)	240,000	
	At the End of 100 Years	No Pumping	3,200,000	2,210,000
		Project Scenario (Pumping 50,000 acre-ft/yr)	990,000	
16,000 acre-ft/yr	At the End of 50 Years	No Pumping	800,000	745,000
		Sensitivity Scenario 1 (Pumping 50,000 acre-ft/yr)	55,000	
	At the End of 100 Years	No Pumping	1,600,000	1,545,000
		Sensitivity Scenario 1 (Pumping 50,000 acre-ft/yr)	55,000	
5,000 acre-ft/yr	At the End of 50 Years	No Pumping	250,000	220,000
		Sensitivity Scenario 2 (Pumping 50,000 acre-ft/yr)	30,000	
	At the End of 100 Years	No Pumping	500,000	470,000
		Sensitivity Scenario 2 (Pumping 50,000 acre-ft/yr)	30,000	

3.2 Depletion of Storage

The depletion of storage under Project conditions was calculated using the Cadiz Groundwater Model (GEOSCIENCE, 2011). The depletion of storage over the 50-year period for the 32,000, 16,000 and 5,000 acre-ft/yr natural recharge cases (i.e., Project Scenario, Sensitivity Scenario 1 and Sensitivity Scenario 2, respectively) are 1,090,000, 1,680,000 and 2,160,000 acre-ft, respectively (GEOSCIENCE, 2011). The depletion of storage over the 100-year period for the 32,000, 16,000 and 5,000 acre-ft/yr natural recharge cases are 220,000, 870,000 and 1,870,000 acre-ft, respectively. The depletion in storage at the end of 100 years is less than the depletion in storage for 50 years because the model assumes no pumping after 50 years.

3.3 Net Water Saving

The net water saving from the Project was calculated using the equation described above in Section 3.0. The following table summarizes the results.

Natural Recharge	Time	Cumulative Reduction of Evaporative Losses [acre-ft]	Cumulative Depletion of Storage [acre-ft]	Cumulative Net Water Saving from Project [acre-ft]
32,000 acre-ft/yr	At the End of 100 Years	2,210,000	220,000	1,990,000
16,000 acre-ft/yr	At the End of 100 Years	1,544,000	870,000	674,000
5,000 acre-ft/yr	At the End of 100 Years	470,000	1,870,000	-1,400,000

As shown in the table above, the 32,000 and 16,000 acre-ft/yr natural recharge scenarios, with an average pumping of 50,000 acre-ft/yr, would create a net savings of 1,990,000 and 674,000 acre-ft, respectively. These savings are calculated over a 100-year period, comparing the evaporative losses that would have occurred without the Project and the depletion in storage at the end of the 100-year period.

For example, the evaporative losses at the end of 100 years for the 32,000 acre-ft/yr natural recharge scenario is 3,200,000, whereas with the Project, the evaporative losses are reduced to 990,000 acre-ft and the depletion of storage after 100 year is 220,000 acre-ft. So, the net savings are 3,200,000 acre-ft that would have evaporated without the Project, less 990,000 acre-ft of evaporative losses that occur even with the Project, less 200,000 acre-ft of depleted storage with the Project, equals approximately 1,990,000 acre-ft of saved freshwater at the end of the 100-year period.

It is also interesting to note that the volumes of groundwater impacted by the migration of saline water due to project pumping (as calculated based on models runs reported in the GEOSCIENCE, 2011 report) are 173,000 and 215,000 acre-ft for the 32,000 and 16,000 acre-ft/yr natural recharge scenarios,

respectively. So, even with these volumes, there is still a net savings of fresh groundwater by implementing the Project versus not implementing it. The only scenario that has a negative net savings is the 5,000 acre-ft/yr natural recharge scenario (i.e., Sensitivity Scenario 2), which is very conservative; however, there are no adverse impacts associated even with this scenario. For the scenarios of 32,000 and 16,000 acre-ft/yr natural recharge (i.e., Project Scenario and Sensitivity Scenario 1), implementation of the Project results in making beneficial use of large quantities of groundwater that that would otherwise evaporate from the dry lakes.

4.0 CONSERVED WATER FROM THE ALTERNATIVE PUMPING SCENARIOS

4.1 Description of Alternative Pumping Scenarios

Since the Cadiz project goal is to maximize the conservation of fresh groundwater and put this water to beneficial use, we examined the possibility of pumping at higher rates in the early half of the Project and reducing pumping in the last half of the Project. As Cadiz desires to implement conjunctive use of the groundwater basin by storing imported water during times of surplus and retrieving this stored water during times of drought or emergencies, then an earlier development of storage space in the basin will accommodate larger conjunctive use projects quicker, in addition to potentially capturing more fresh groundwater that is flowing to the dry lakes.

An alternative pumping schedule was developed that included pumping 75,000 acre-ft/yr for 25 years, then reducing the pumping rate to 25,000 acre-ft/yr for the remaining 25 years (see Figure 6). The purpose of the alternative pumping schedule is to examine:

- The potential benefits of capturing more water in transit to the dry lakes that could be put to beneficial use, and
- The potential impacts of this pumping distribution as compared to the pumping distribution presented in previous analyses (GEOSCIENCE, 2011).

Two model runs were made using the alternative pumping schedule:

- Sensitivity Scenario 3: Natural Recharge of 32,000 acre-ft/yr with Alternative Pumping Schedule

- Sensitivity Scenario 4: Natural Recharge of 16,000 acre-ft/yr with Alternative Pumping Schedule

Sensitivity Scenarios 3 and 4 can be compared to the Project Scenario and Sensitivity Scenario 1 (as described in GEOSCIENCE, 2011), respectively.

4.2 Modeling Results from Alternative Pumping Scenarios

Figures 7, 8 and 9 show the groundwater elevations, regional drawdown and migration of the saline groundwater front for the Sensitivity Scenario 3 (natural recharge of 32,000 acre-ft/yr with alternative pumping schedule). Figure 10 shows the predicted drawdown for the Sensitivity Scenario 3 during the 100-year model simulation period at selected locations, including the center of the new wellfield, the existing Cadiz wellfield, the edge of Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake.

Figures 11, 12 and 13 show the groundwater elevations, regional drawdown, and migration of the saline groundwater front for the Sensitivity Scenario 4 (natural recharge of 16,000 acre-ft/yr with alternative pumping schedule). Figure 14 shows the predicted drawdown for the Sensitivity Scenario 4 during the 100-year model simulation period at selected locations, including the center of the new wellfield, the existing Cadiz wellfield, the edge of Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake.

Figure 15 shows the cumulative change in groundwater storage for Sensitivity Scenario 3 as compared to the Project Scenario. Similarly, Figure 16 shows the cumulative change in groundwater storage for Sensitivity Scenario 4 as compared to Sensitivity Scenario 1.

These figures show that differences between the pumping distributions are not very significant. The maximum drawdown is reached earlier but begins to recover when pumping is reduced (see Figures 10 and 14), which is the same situation for groundwater storage (see Figures 15 and 16). There is minimal change in the saline front, which is only 400 ft at its maximum.

Figure 17 shows the reduction in fresh groundwater losses to evaporation between the two pumping scenarios for the 32,000 acre-ft/yr natural recharge case. This shows that pumping at the higher rates early in the Project reduces evaporative losses by about 130,000 acre-ft in the first 50 years and about 70,000 acre-ft over the 100-year period. Figure 18 shows the reduction in fresh groundwater losses to evaporation between the two pumping scenarios for the 16,000 acre-ft/yr natural recharge case. Figure 18 shows a reduction of about 15,000 and 13,000 acre-ft over the 50- and 100-year periods, respectively.

This analysis clearly indicates the potential to recover and conserve additional fresh groundwater and put it to beneficial use, which will otherwise flow to the dry lakes and evaporate. In addition, pumping at a higher rate would create more storage space earlier, which would condition the basin for a larger conjunctive use project earlier than if pumping is limited to lower rates. This assessment shows that Cadiz has considerable flexibility to alter pumping rates early in the Project without causing significant adverse impacts.

5.0 FINDINGS

The following findings are based on the results from the supplemental assessment of pumping required for the Project:

- Conservatively, there is approximately 17 to 34 million acre-ft of groundwater in storage in the alluvial aquifer system, and approximately 4 to 10 million acre-ft of fresh groundwater (i.e., total dissolved solids concentration is less than 1,000 mg/L) in storage below the Fenner Gap alone. The elevation of the water table at Fenner Gap is approximately 610 ft above mean sea level (amsl), whereas the low areas of Bristol and Cadiz Dry Lakes are 580 and 545 ft amsl, respectively. This difference in elevation provides the driving hydraulic gradient of fresh groundwater flowing to the dry lakes.

- The location and timing of pumping rates will determine how quickly and what volumes of fresh groundwater can be conserved for beneficial use instead of being lost to evaporation. Higher

rates of pumping earlier in the development of the Project will result in the establishment of a cone of depression and a more extended capture zone compared to lower rates of pumping.

- The 32,000 and 16,000 acre-ft/yr natural recharge scenarios, with an average pumping of 50,000 acre-ft/yr, would create a net savings of 1,990,000 and 674,000 acre-ft, respectively. These savings are calculated over a 100-year period, comparing the evaporative losses that would have occurred without the Project and the depletion in storage at the end of the 100-year period.

- The volumes of groundwater impacted by the migration of saline water are 173,000 and 215,000 acre-ft for the 32,000 and 16,000 natural recharge scenarios, respectively. Even considering these volumes, there is still a net savings of fresh groundwater by implementing the Project versus not implementing it.

- The only scenario that has a negative net savings is the 5,000 acre-ft/yr natural recharge scenario (i.e., Sensitivity Scenario 2), which is very conservative; however, there are no adverse impacts associated even with this scenario. For the scenarios of 32,000 and 16,000 acre-ft/yr natural recharge (i.e., Project Scenario and Sensitivity Scenario 1), implementation of the Project results in making beneficial use of large quantities of groundwater that would otherwise become evaporate from the surface of the dry lakes.

- For the natural recharge of 32,000 acre-ft/yr, pumping at the higher rates early (i.e., 75,000 acre-ft/yr in the first 25 years of the alternative pumping schedule) in the Project reduces evaporative losses by about 130,000 acre-ft in the first 50 years and about 70,000 acre-ft over the 100-year period. This indicates there is potential to conserve additional fresh groundwater and put it to beneficial use, which otherwise would migrate to the dry lakes where it will evaporate

- For the natural recharge of 16,000 acre-ft/yr, pumping at the higher rates early (i.e., 75,000 acre-ft/yr in the first 25 years of the alternative pumping schedule) in the Project

reduces evaporative losses by about 15,000 and 13,000 acre-ft over the 50- and 100-year periods, respectively.

- Differences between the alternative pumping schedule and the proposed Project pumping schedule are not very significant. The maximum drawdown is reached earlier for the alternative pumping schedule but begins to recover when pumping is reduced, which is the same response as groundwater storage. There are minimal changes in the distribution of the saline front, which is only 400 ft at its maximum.

- Pumping at a higher rate would create more storage space earlier, which would condition the basin for a larger conjunctive use project earlier than if pumping is limited to lower rates. This assessment shows that Cadiz has the flexibility to alter pumping rates early in the Project without causing significant adverse impacts.

6.0 REFERENCES

CH2M Hill, 2010. *Cadiz Groundwater Conservation and Storage Project*. Prepared for Cadiz, Inc., July, 2010.

GEOSCIENCE Support Services, Inc., 2011. *Cadiz Groundwater Modeling and Impact Analysis. DRAFT*. Prepared for Brownstein Hyatt Farber Schreck, LLP. September 1, 2011.

Metropolitan Water District of Southern California (MWD), 2009. *Table of State Project Deliveries for the Period 1922 to 2003*.

FIGURES

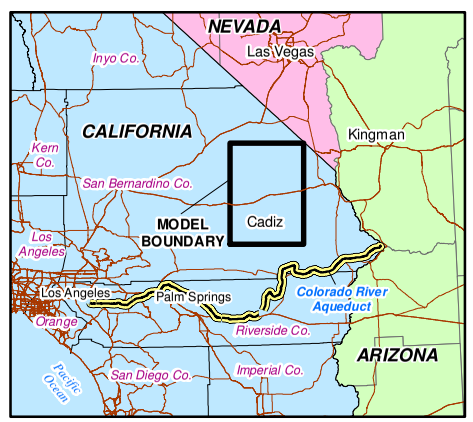
BROWNSTEIN HYATT FARBER SCHRECK, LLP

SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE
CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

GENERAL PROJECT LOCATION

EXPLANATION

- Selected Watershed Boundaries
- Proposed Wellfield Development Areas and Pipeline
- Cadiz Owned Land
- Railroad
- State Boundary
- Colorado River Aqueduct



20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

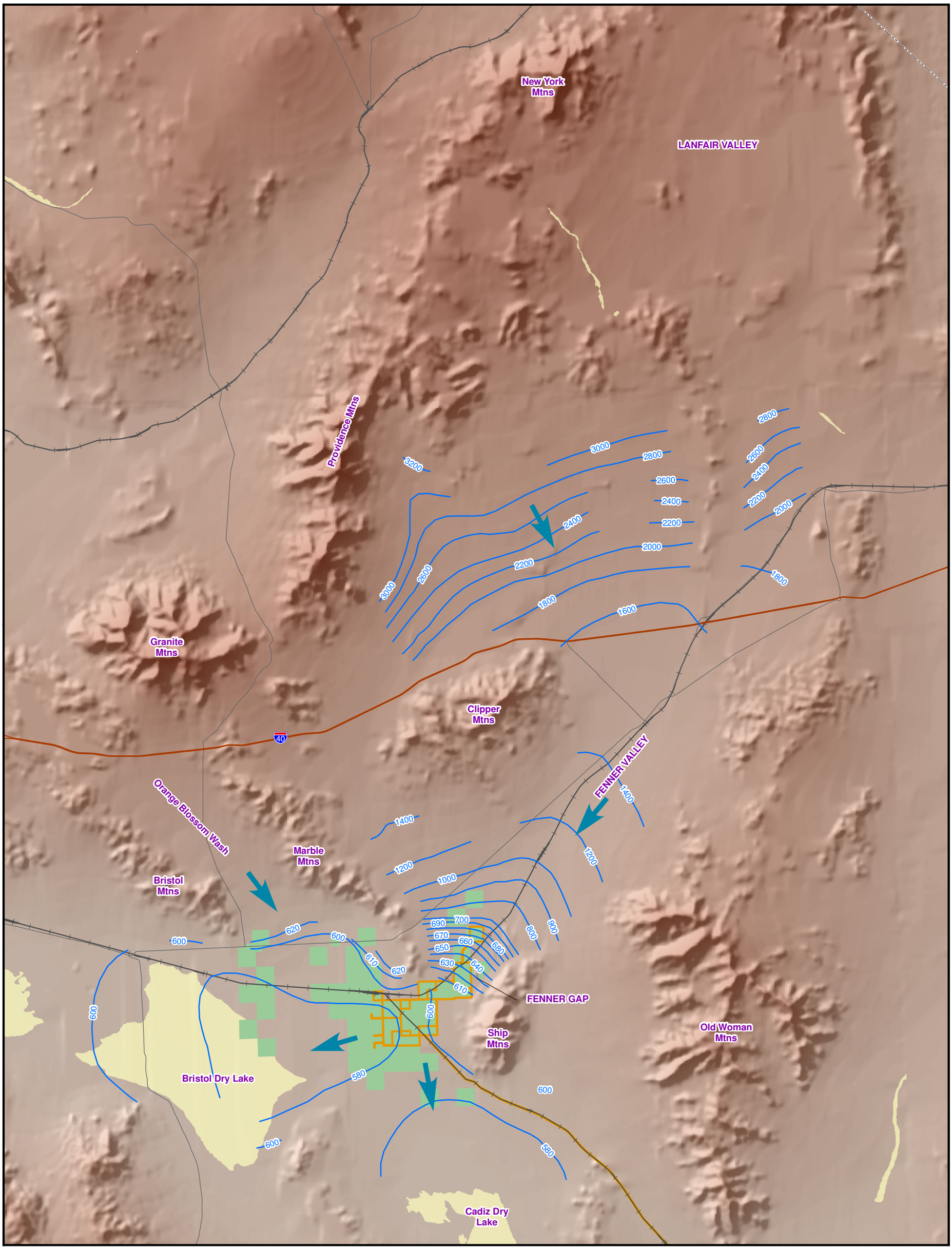
NORTH

0 10 20 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 1

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_01_proj_loc_9-11.mxd



Proposed Wellfield Development Areas and Pipeline

Cadiz Owned Land

580 — 2009 Groundwater Elevations (ft amsl) (Source: CH2M-Hill, 2010)

Groundwater Flow Direction

NORTH

0 2.5 5 Miles

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

2009 GROUNDWATER ELEVATIONS

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 2

Cadiz Groundwater Conservation, Storage and Recovery Project
Annual Pumping for Project Conservation Scenario

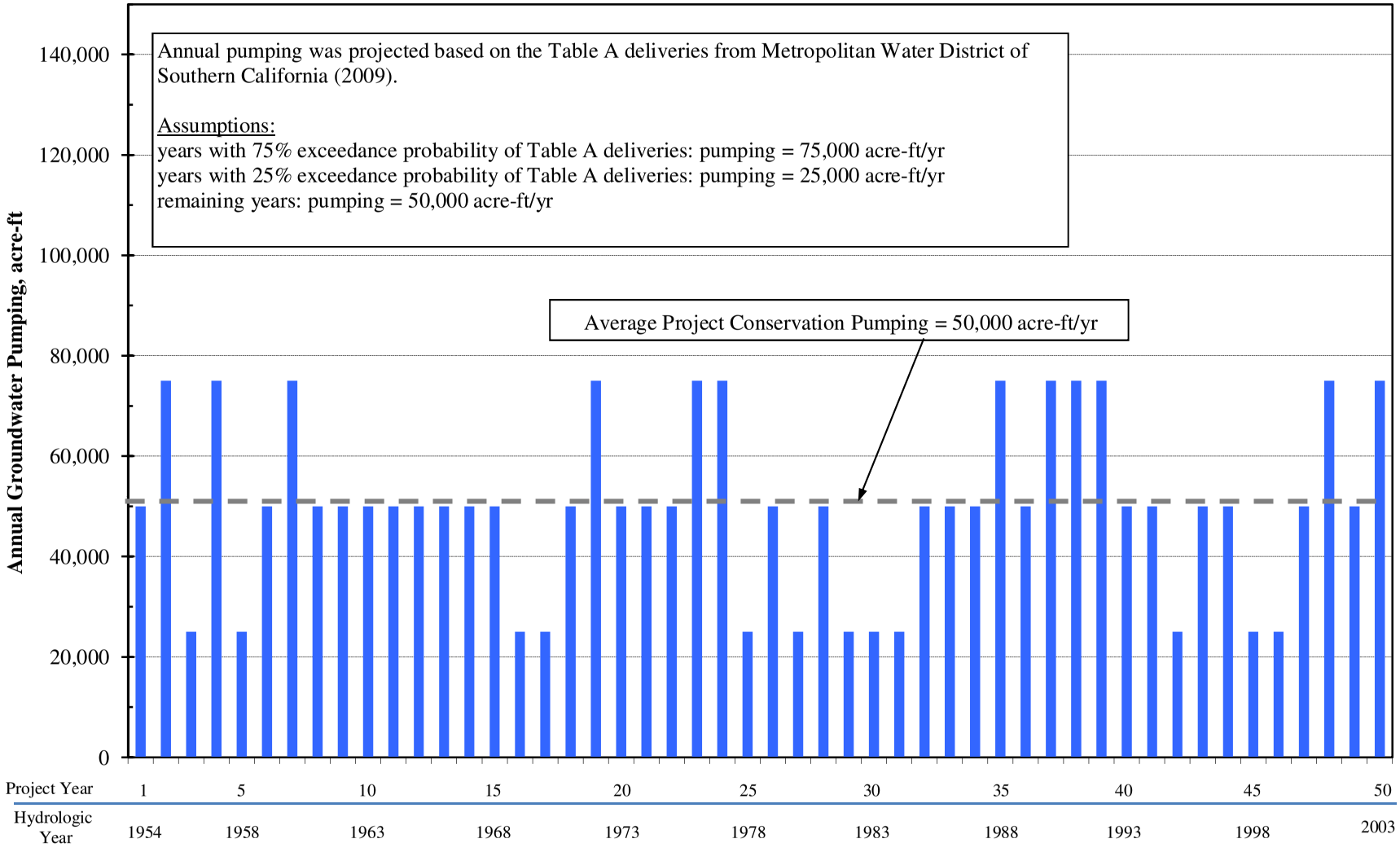


Figure 3

Cumulative Fresh Groundwater Loss to Evaporation
No Groundwater Pumping

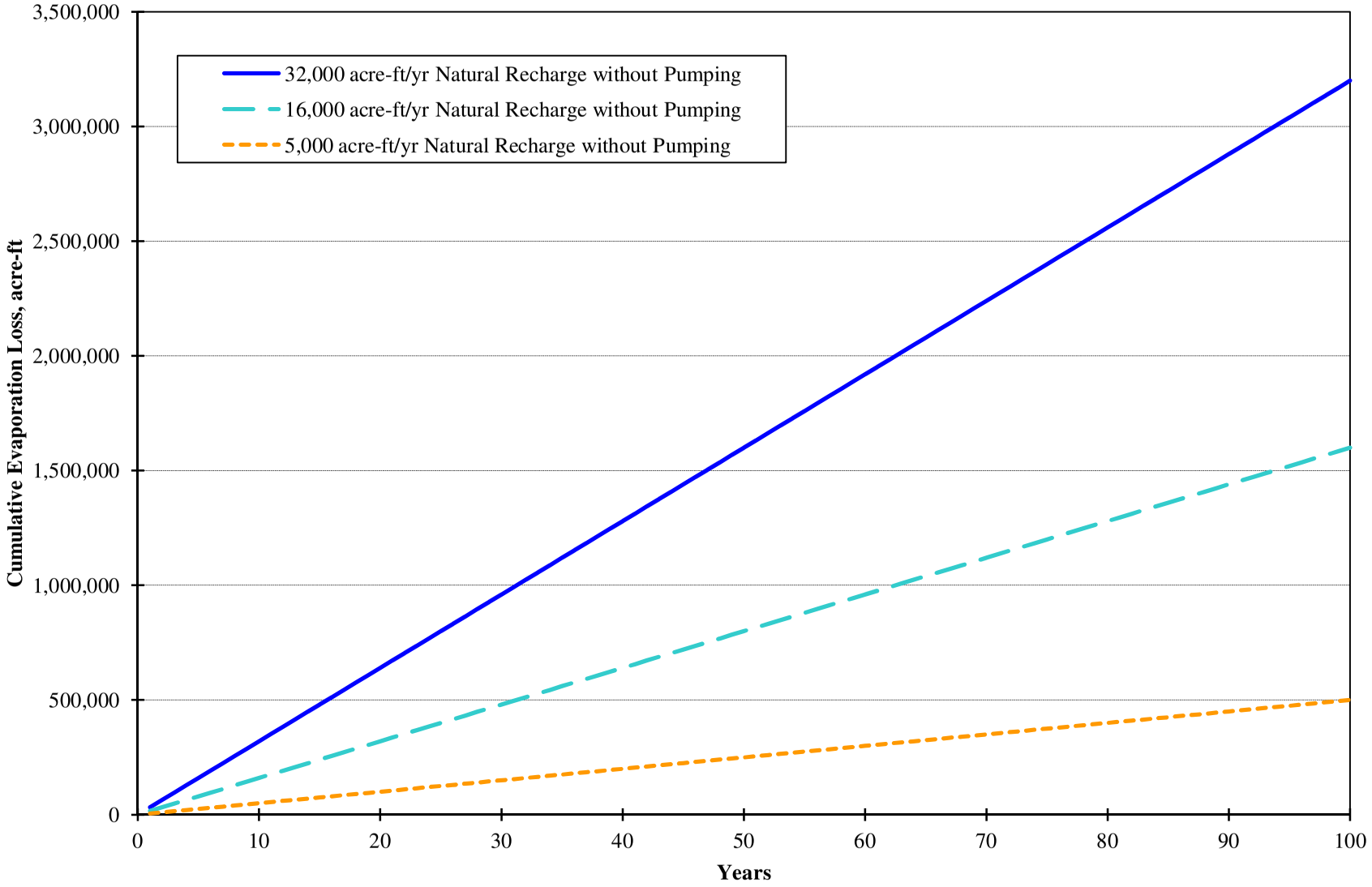


Figure 4

Cumulative Fresh Groundwater Loss to Evaporation
Project Conservation Scenario

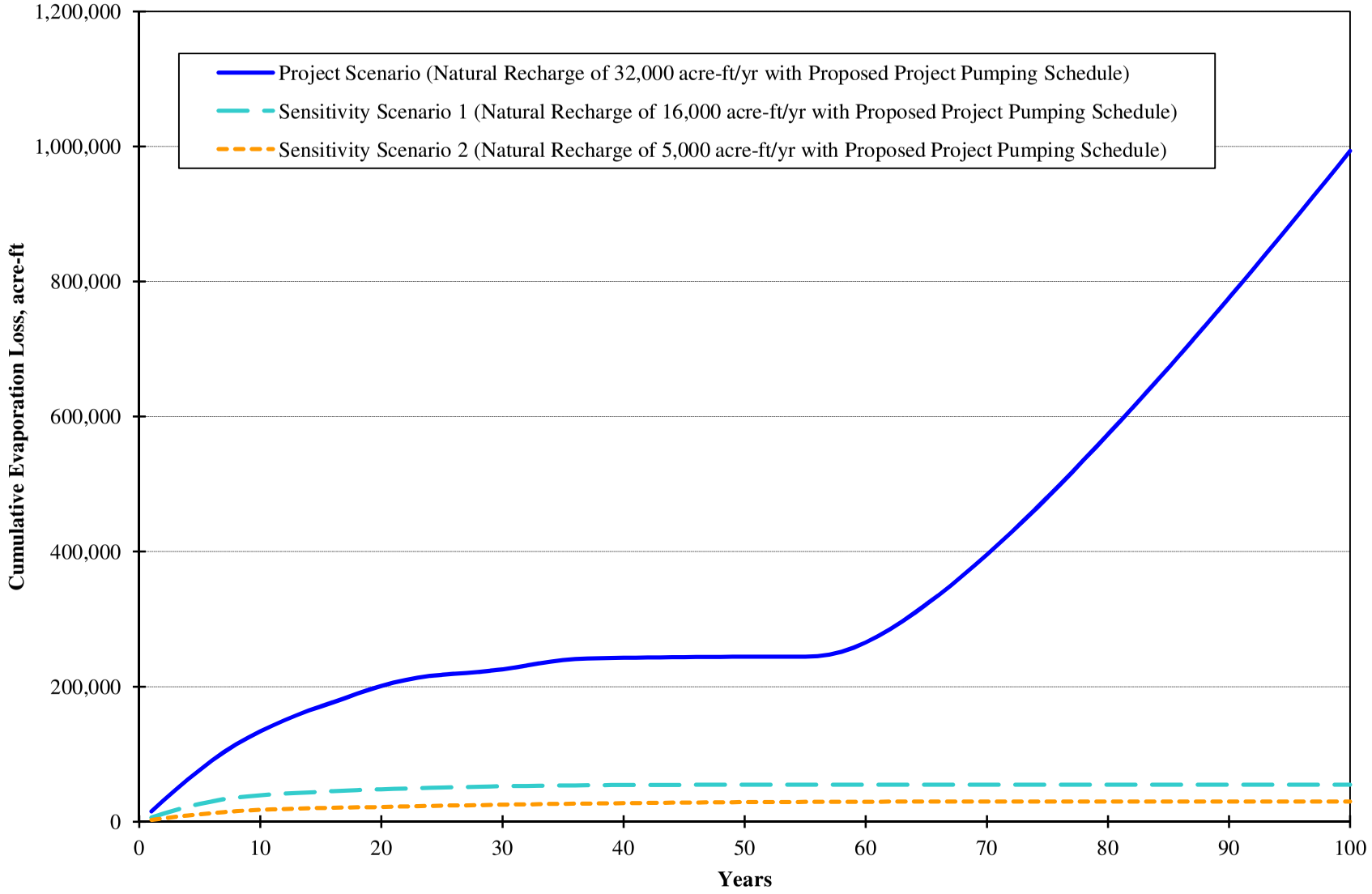


Figure 5

Cadiz Groundwater Conservation, Storage and Recovery Project
Annual Pumping for Alternative Pumping Scenario

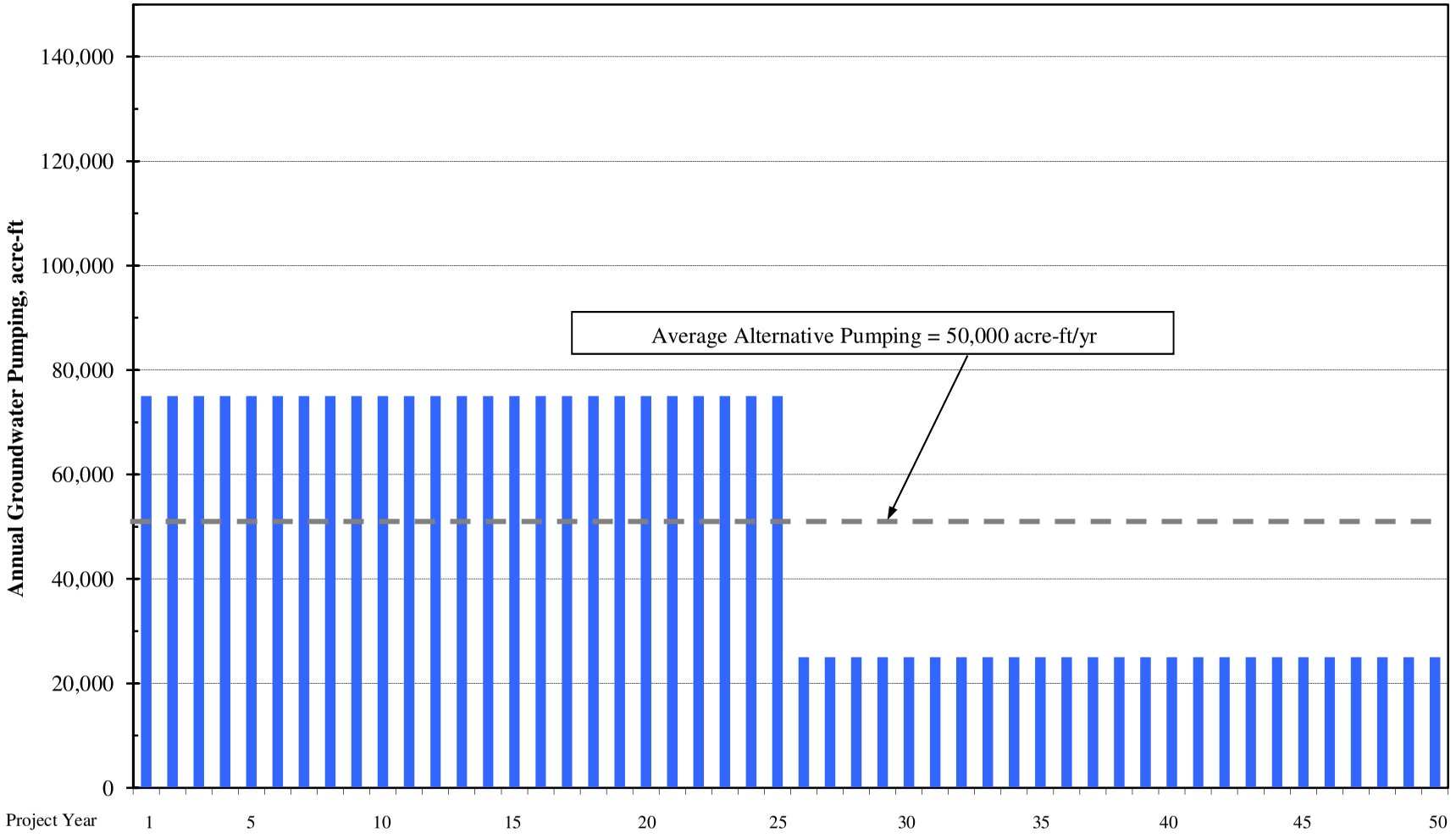
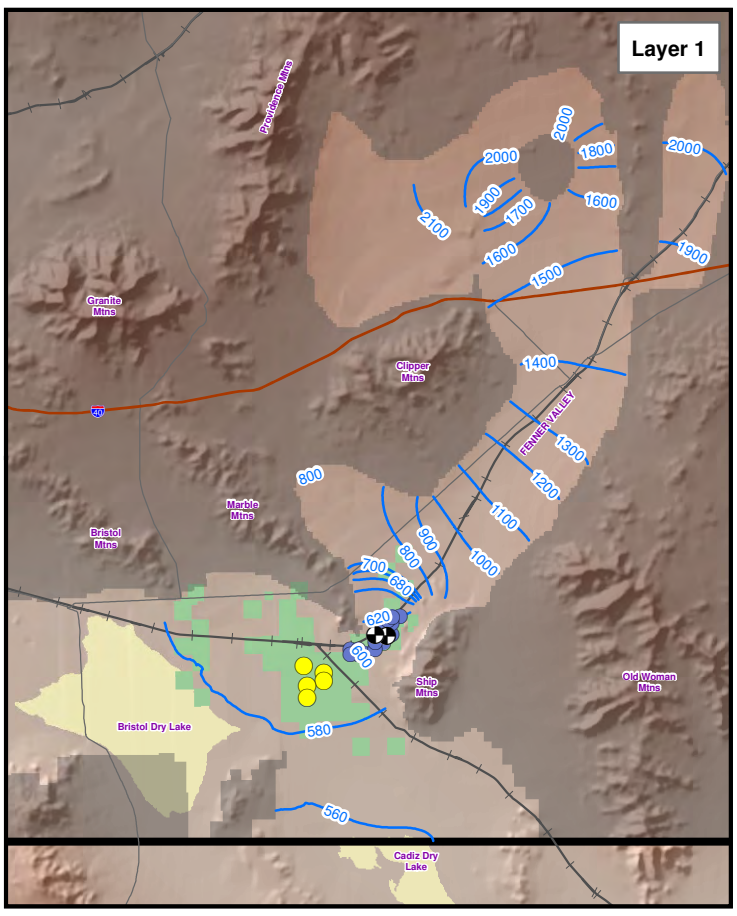
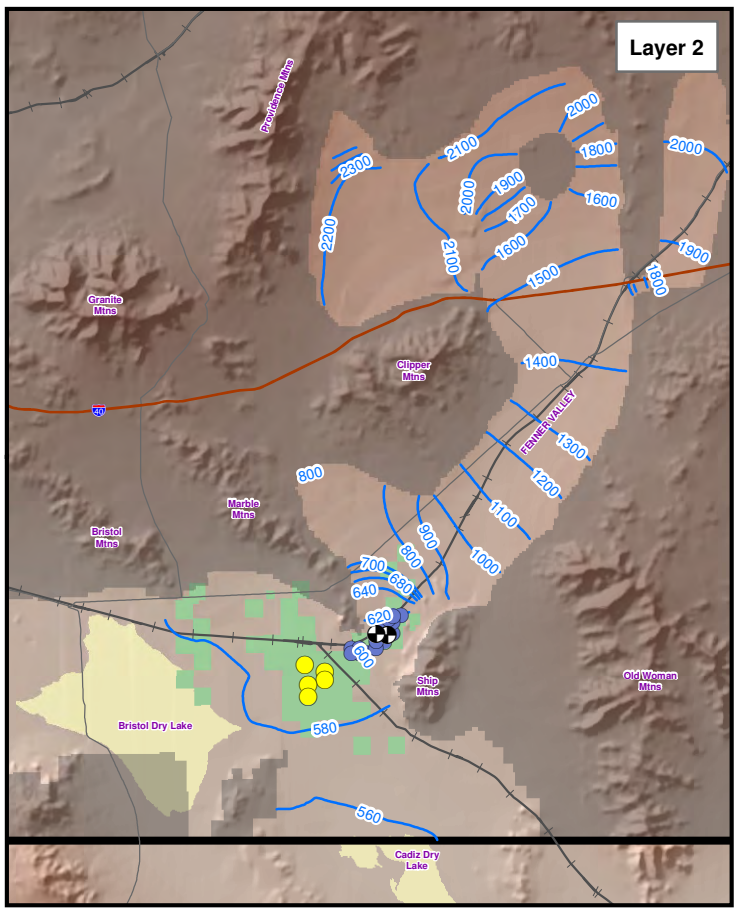


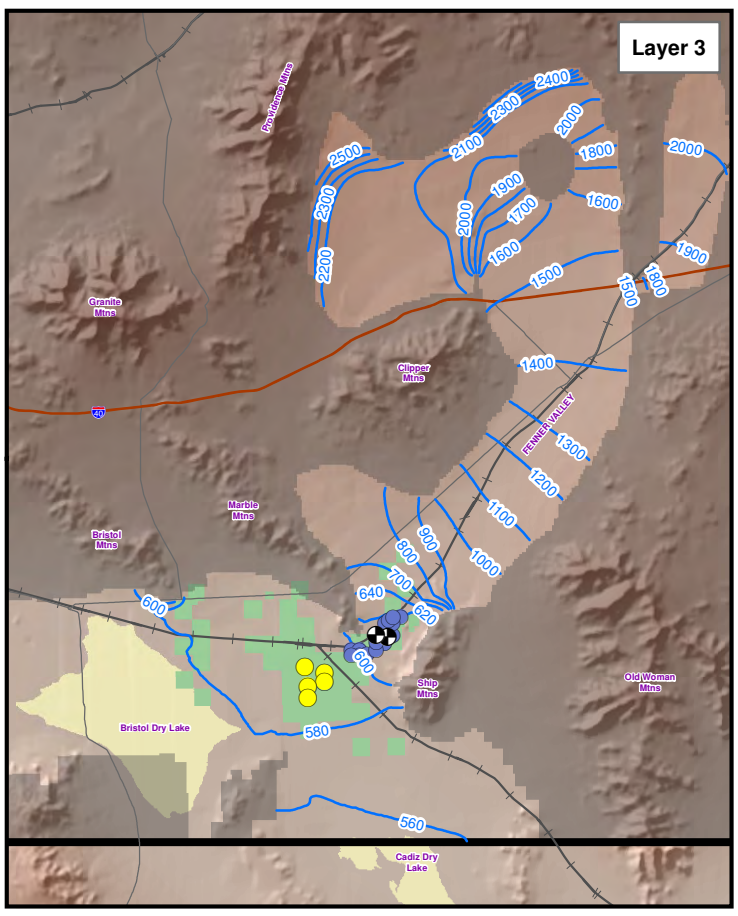
Figure 6

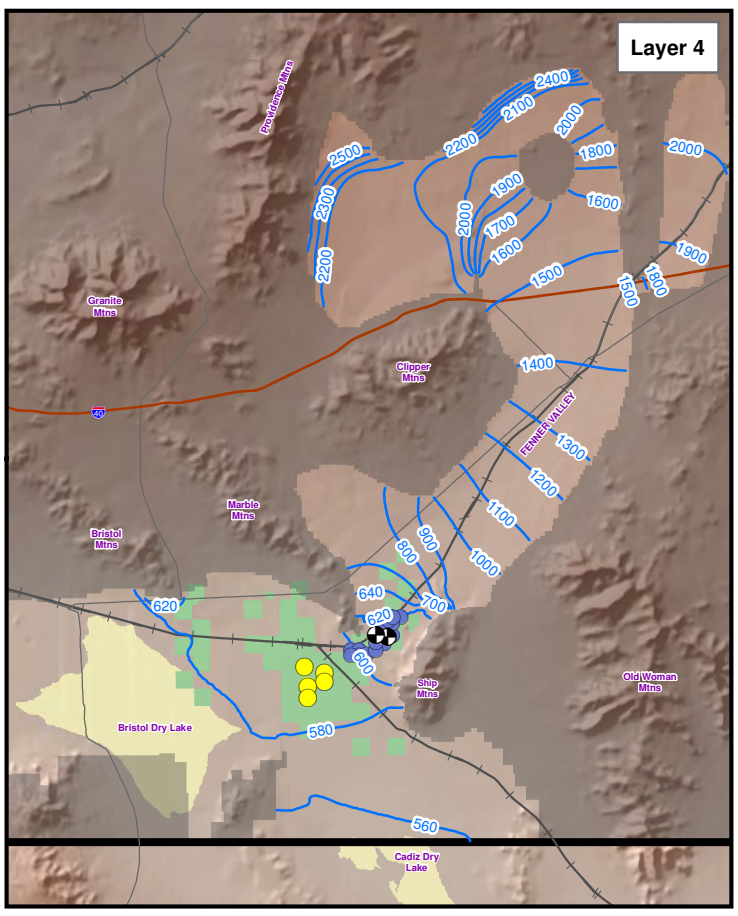
BROWNSTEIN HYATT FARBER SCHRECK, LLP

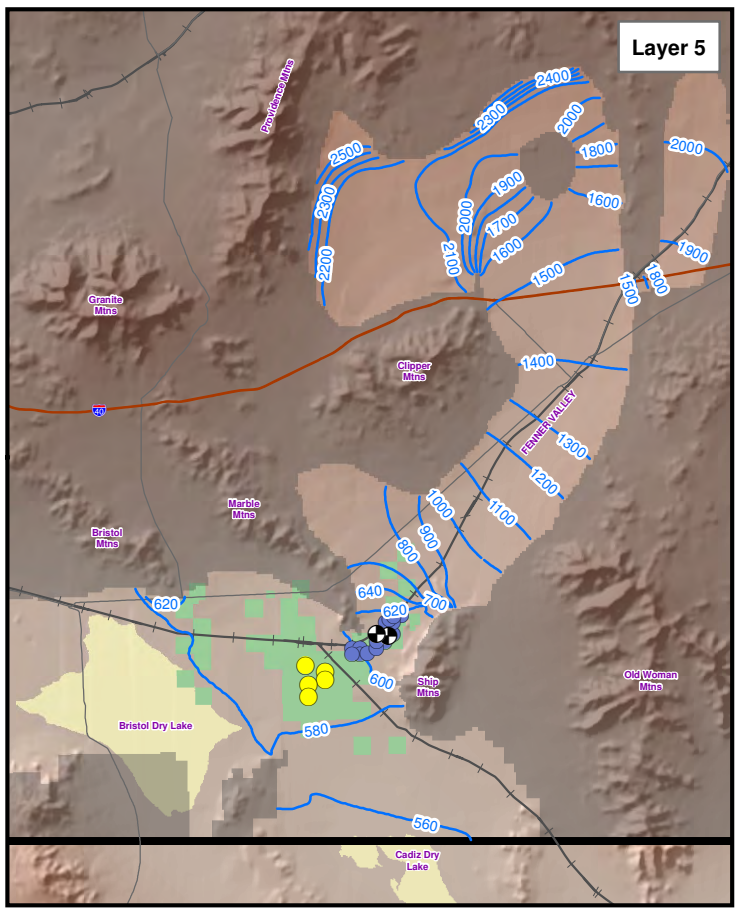
SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

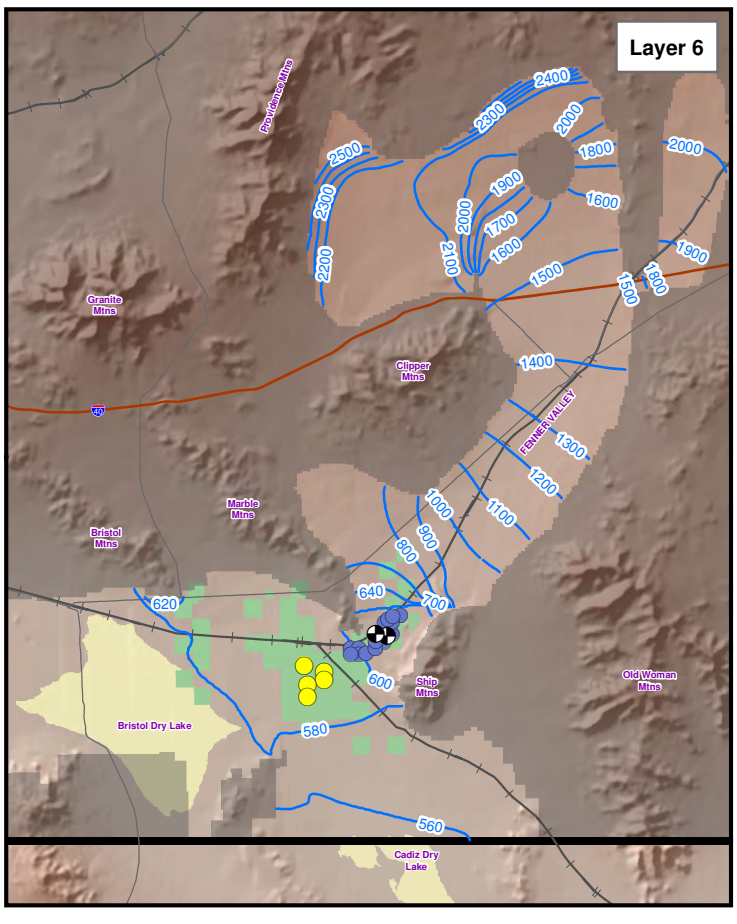












EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Sensitivity Scenario 3

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 3

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

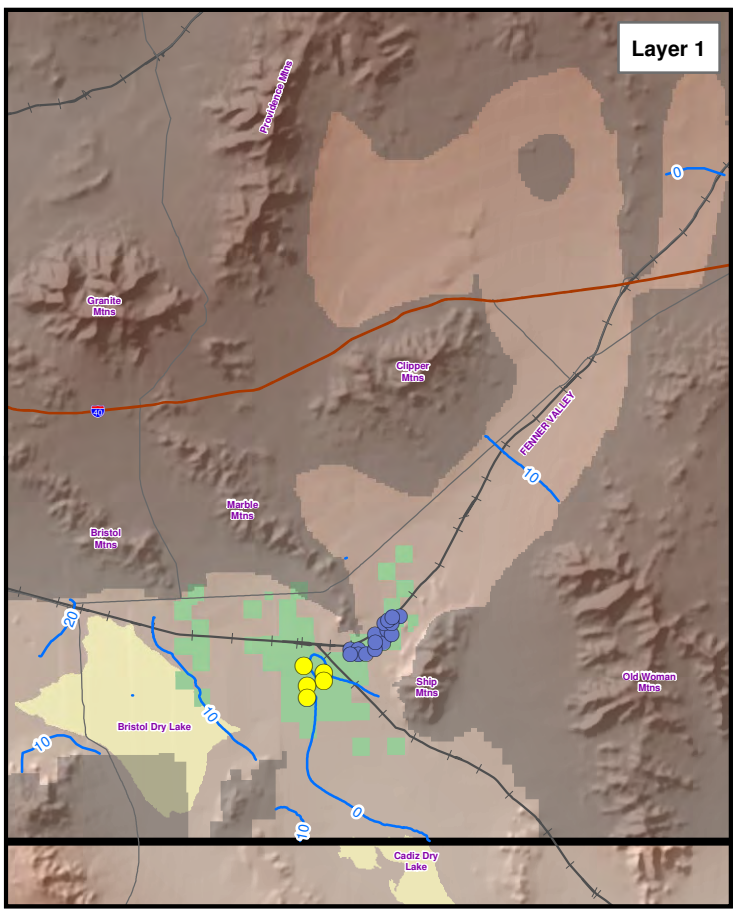
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

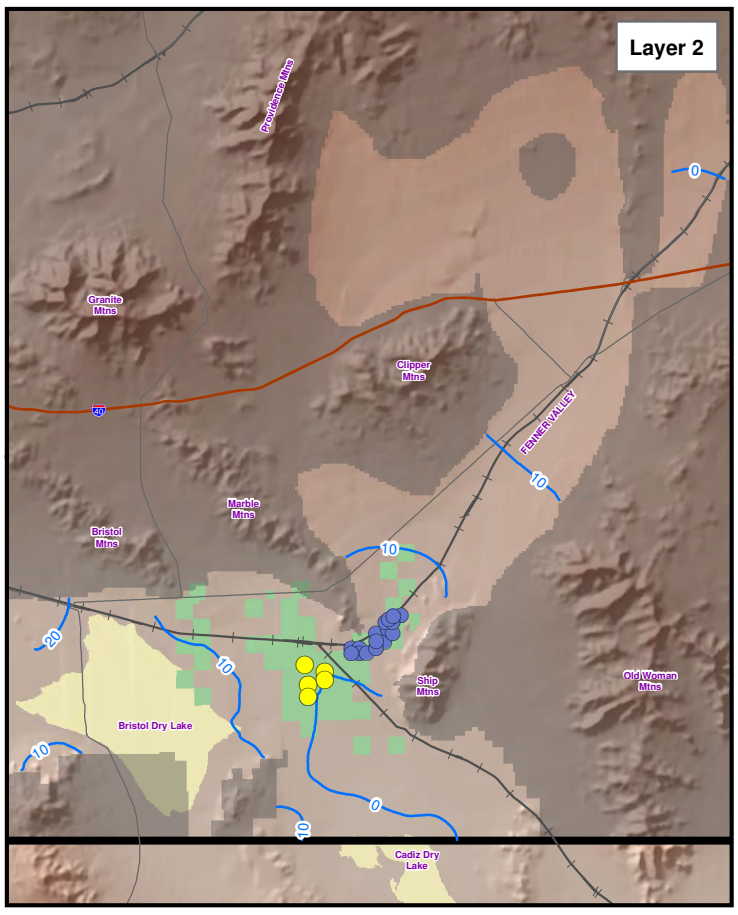
Figure 7

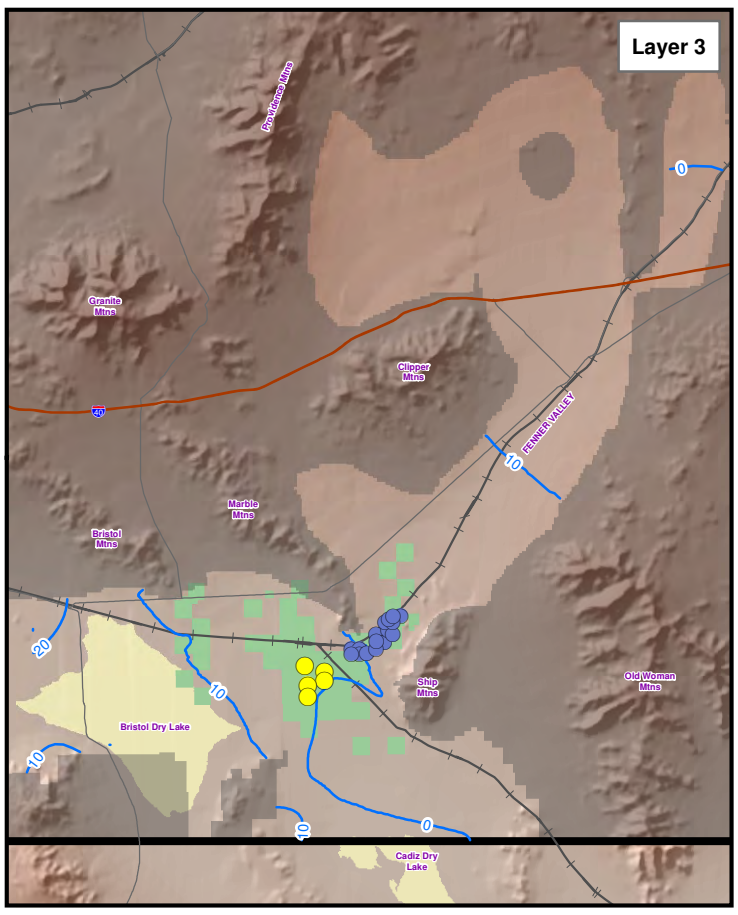
GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_07_32k_Scen3_gw_elev_100yr_9-11.mxd

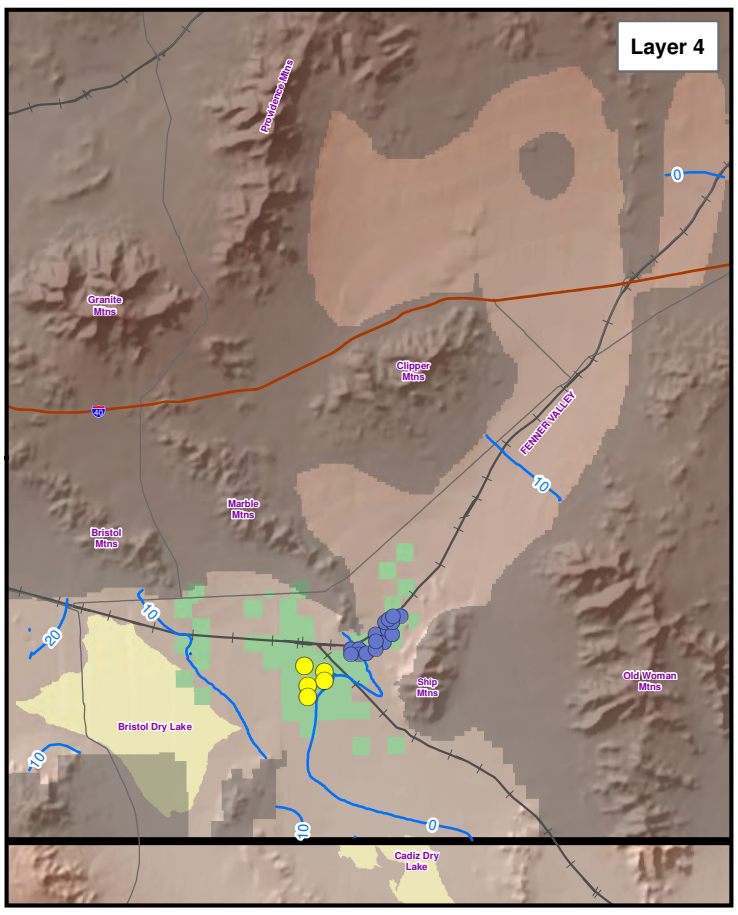
BROWNSTEIN HYATT FARBER SCHRECK, LLP

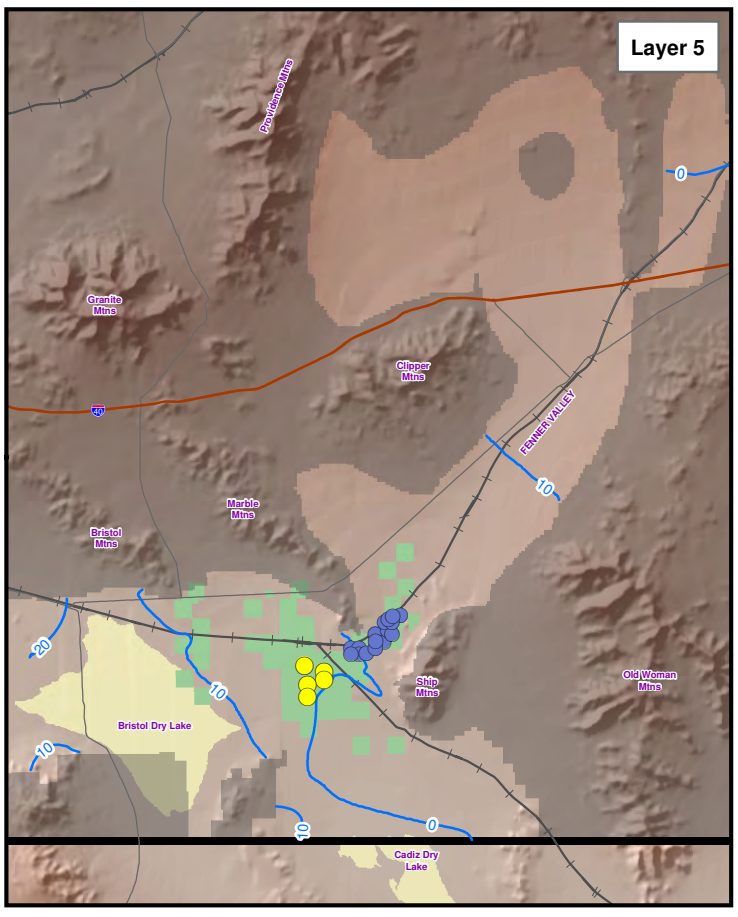
SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

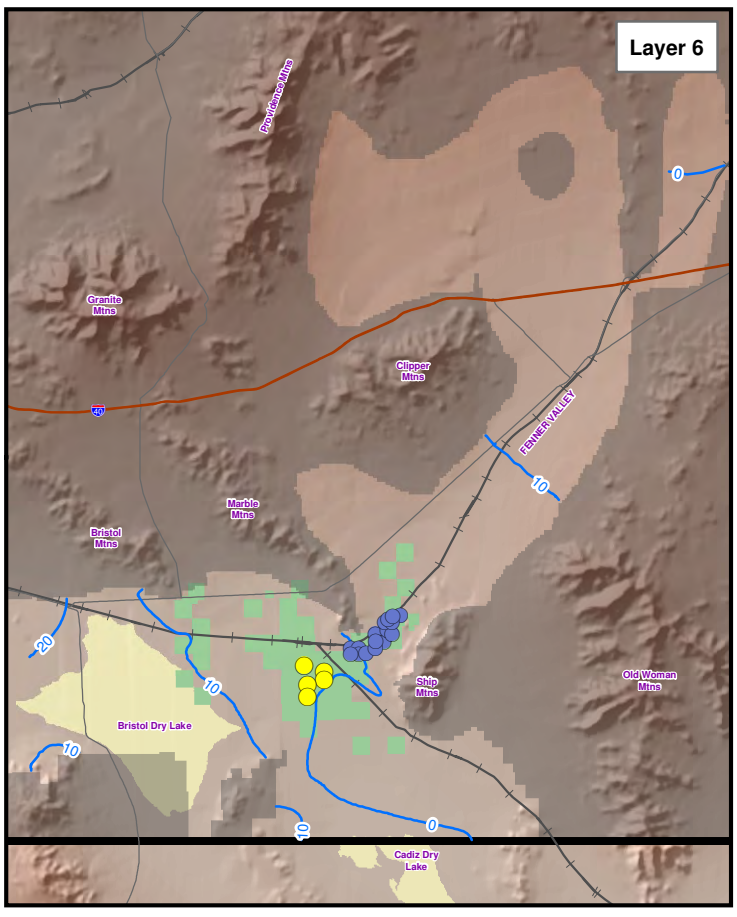












EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Proposed High Capacity Well
- Cadiz Owned Land

Sensitivity Scenario 3

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 3

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

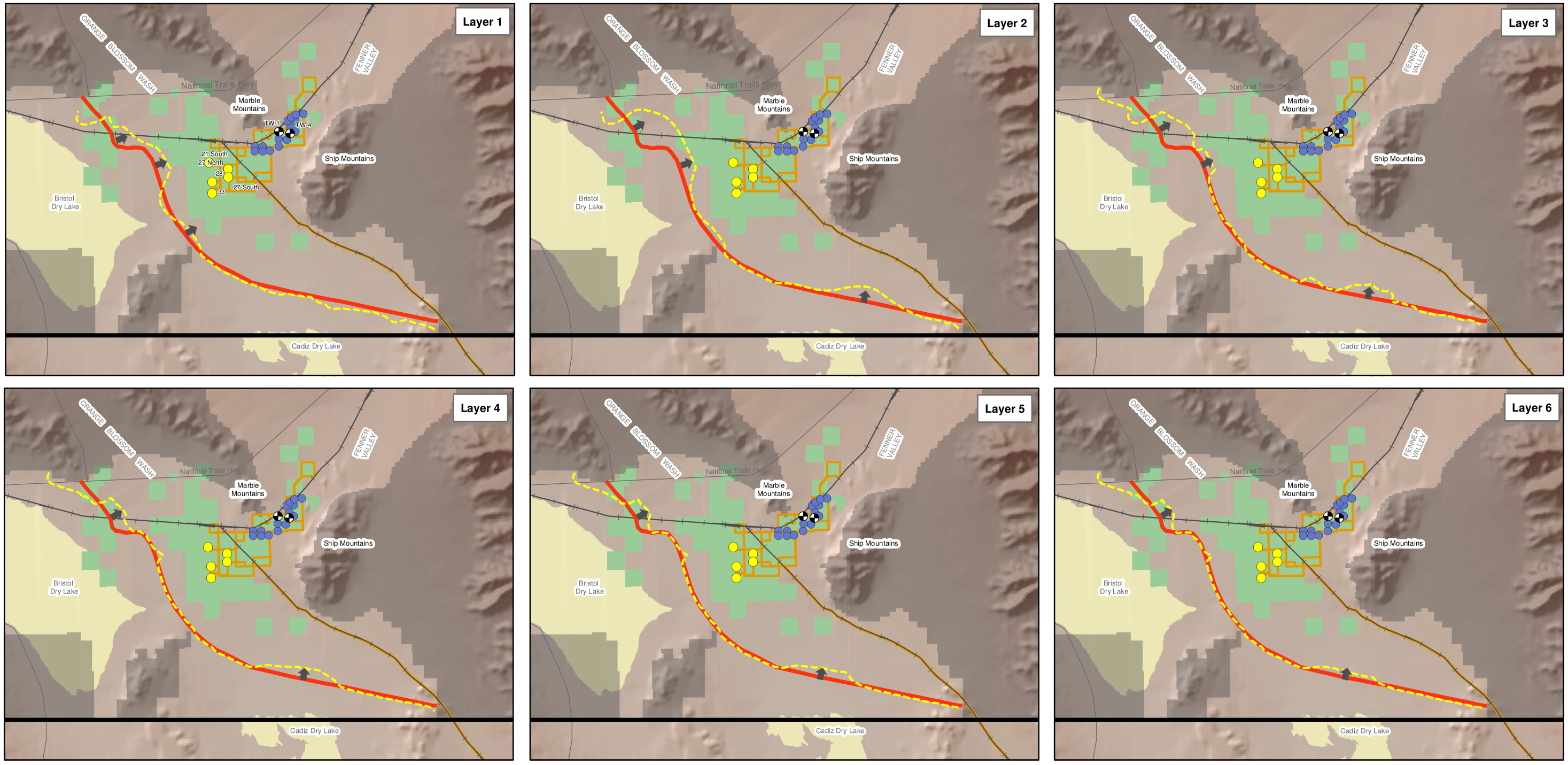
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 8

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_08_32k_Scen3_dd_100yr_9-11.mxd

BROWNSTEIN HYATT FARBER SCHRECK, LLP

SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Proposed Wellfield Development Areas and Pipeline

Existing Cadiz Agricultural Well

Proposed New Well

Proposed High Capacity Well

Direction of Saline Water / Freshwater Interface Movement

Current Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

Model-Generated
Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

At the End of 100 Years (end of model simulation)

NORTH

0 6 12 Miles

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

Sensitivity Scenario 3

Natural Recharge of
32,000 acre-ft/yr

Wellfield Configuration A
(5 Existing Cadiz Wells
and 17 New Wells)

MODEL-GENERATED SALINE WATER AND FRESHWATER INTERFACE (TDS = 1,000 mg/L)

SENSITIVITY SCENARIO 3

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

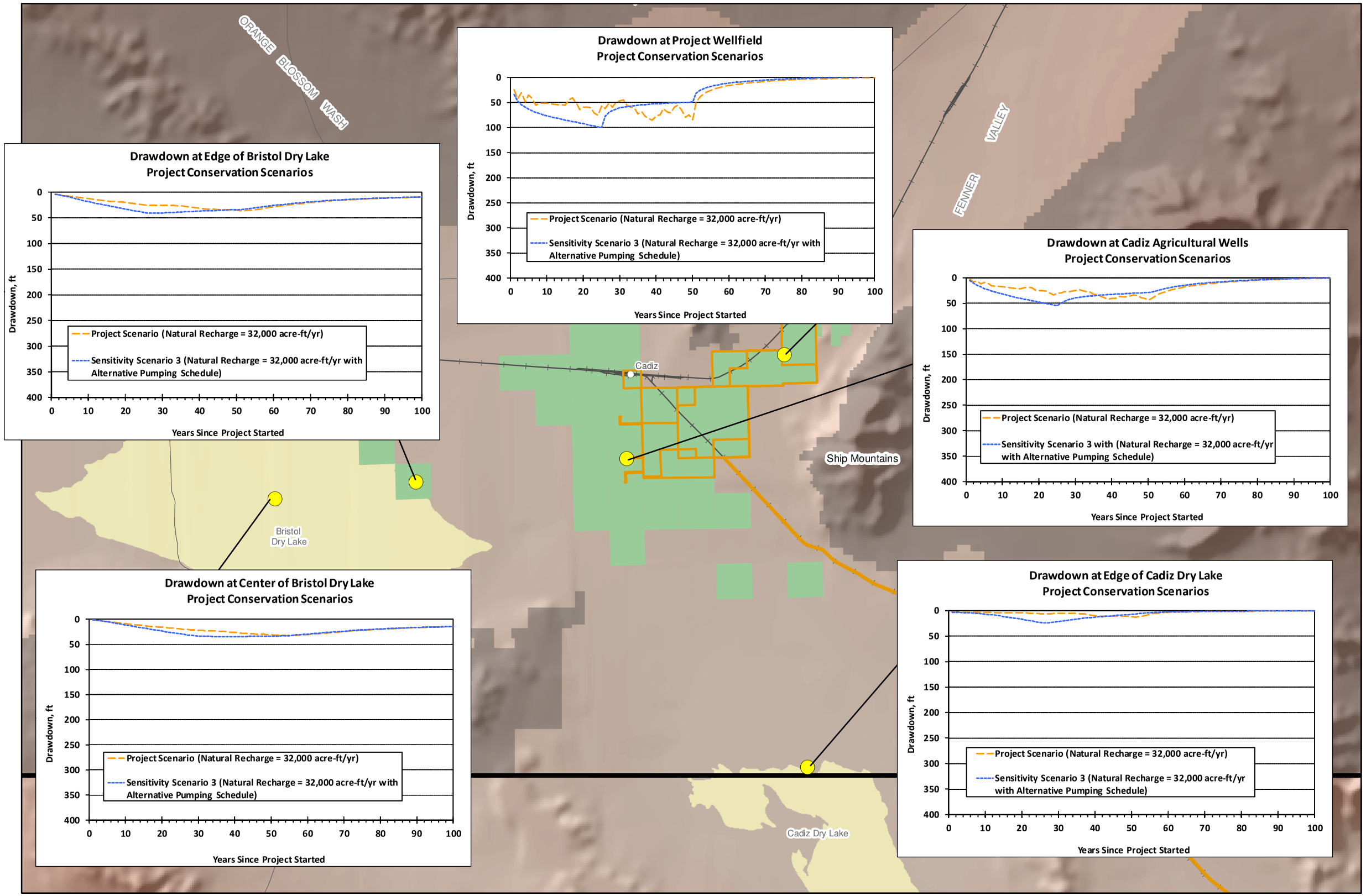
Figure 9

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_09_6panel_saline_32k_scen3_q75_100yr_9-11.mxd

BROWNSTEIN HYATT FARBER SCHRECK, LLP

SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

MODEL-CALCULATED DRAWDOWN AT SELECTED LOCATIONS PROJECT SCENARIO VERSUS SENSITIVITY SCENARIO 3



Drawdown at Project Wellfield
Project Conservation Scenarios

Drawdown at Edge of Bristol Dry Lake
Project Conservation Scenarios

Drawdown at Cadiz Agricultural Wells
Project Conservation Scenarios

Drawdown at Center of Bristol Dry Lake
Project Conservation Scenarios

Drawdown at Edge of Cadiz Dry Lake
Project Conservation Scenarios

EXPLANATION

- Location with Drawdown Over Time
- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- No Flow Model Cell

Sensitivity Scenario 3

Natural Recharge of 32,000 acre-ft/yr

Wellfield Configuration A (5 Existing Cadiz Wells and 17 New Wells)

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 3 6 Miles

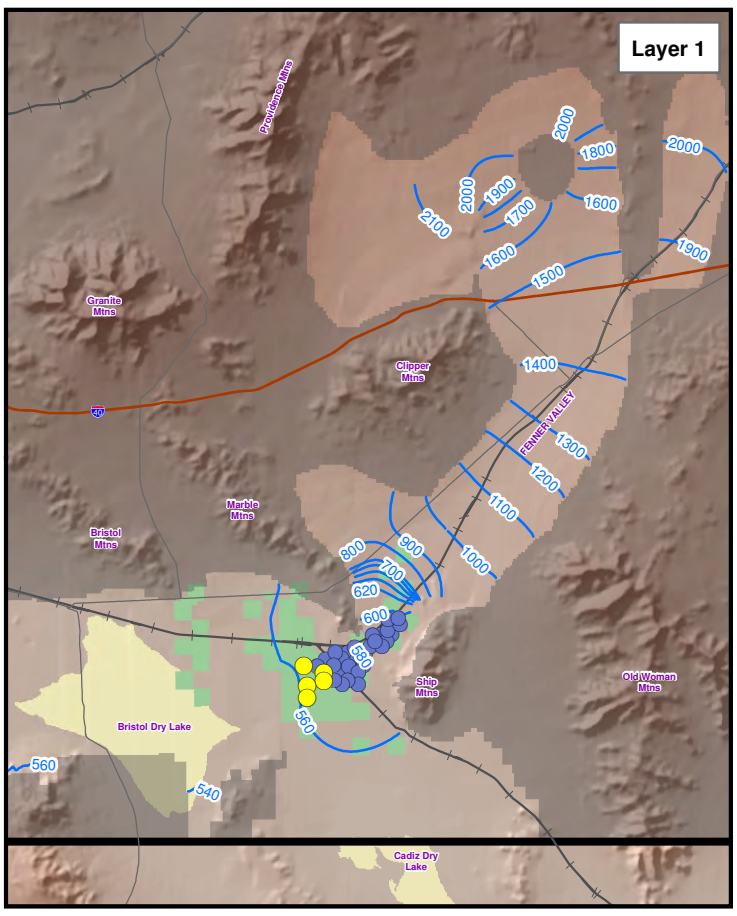
GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

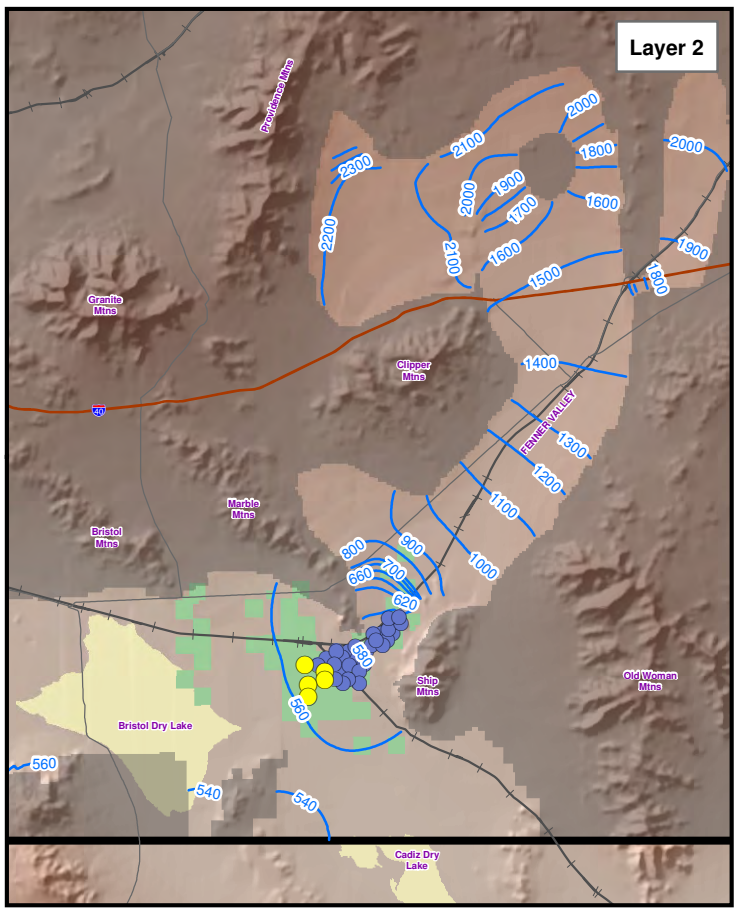
Figure 10

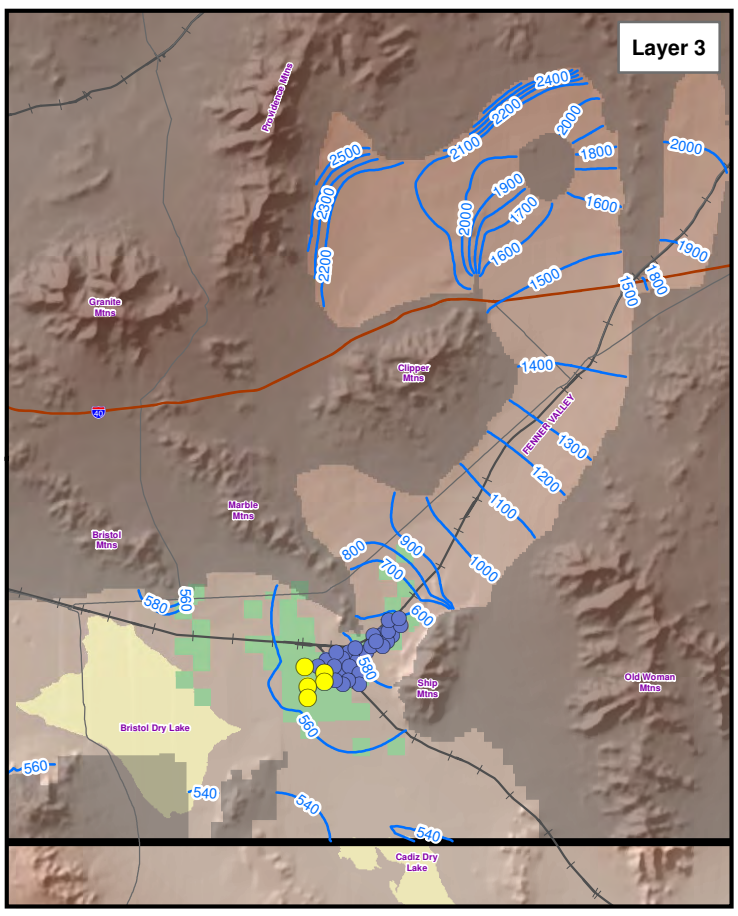
GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_10_DD_32k_hydrographs_9-11.mxd

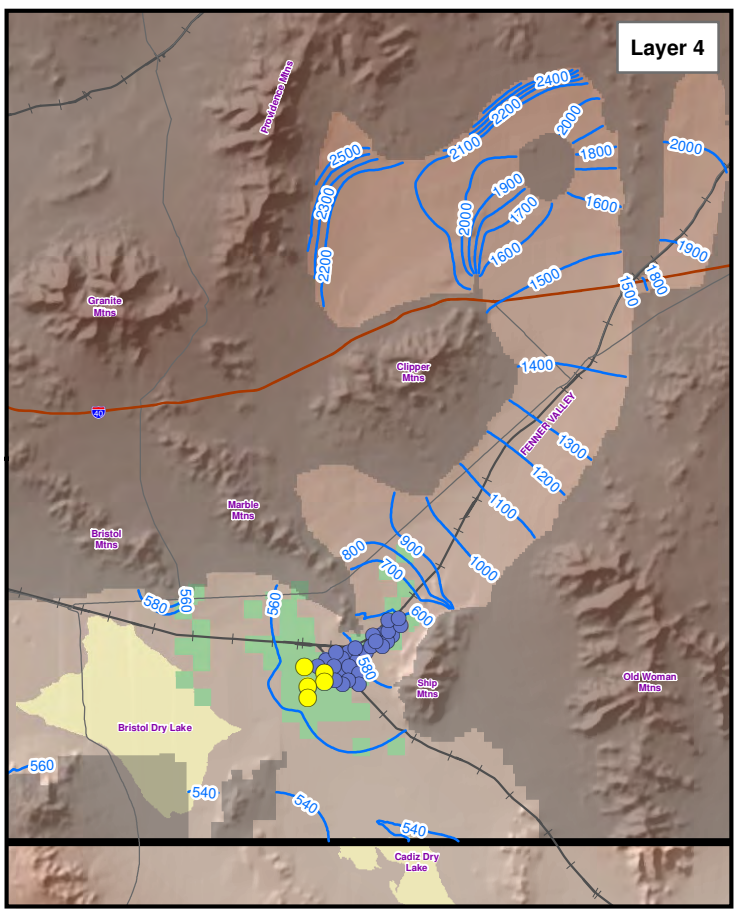
BROWNSTEIN HYATT FARBER SCHRECK, LLP

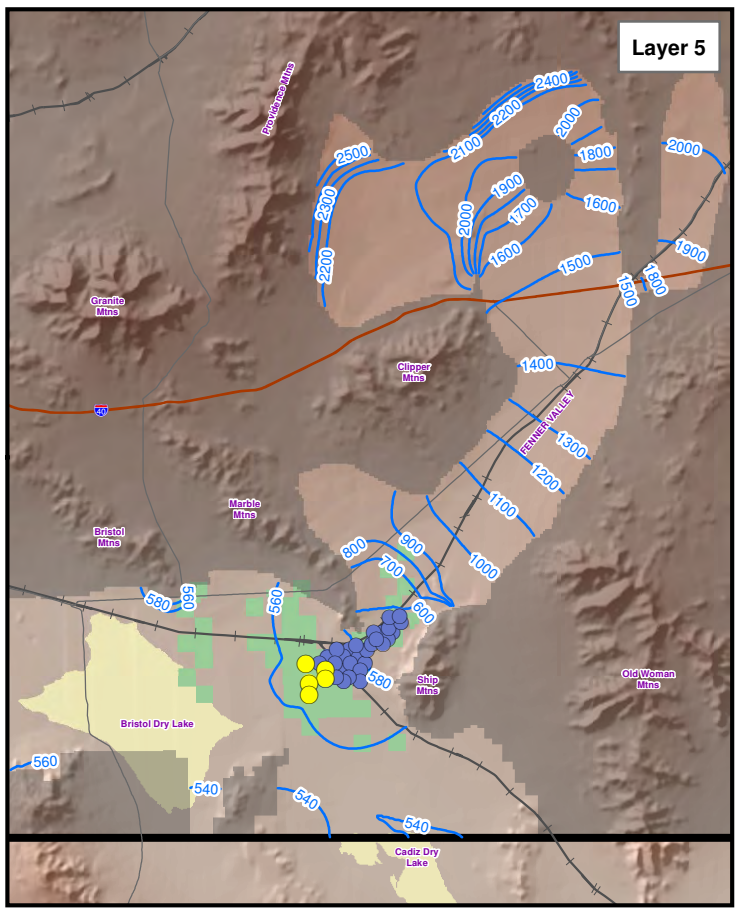
SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

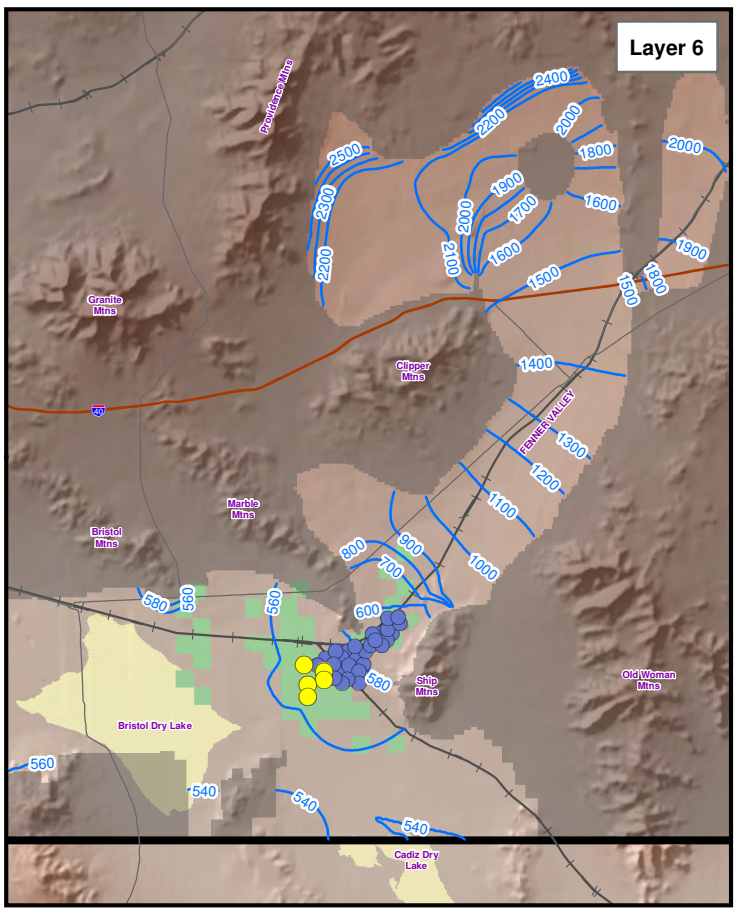












EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 700 — Groundwater Elevations (ft amsl)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 4

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

MODEL-CALCULATED GROUNDWATER ELEVATIONS AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 4

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

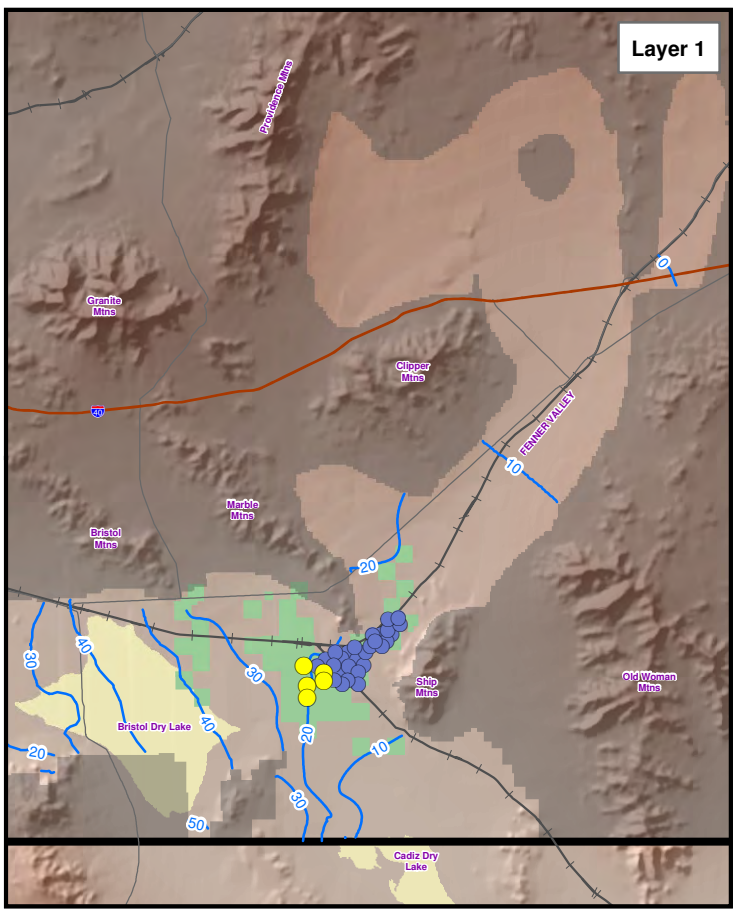
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

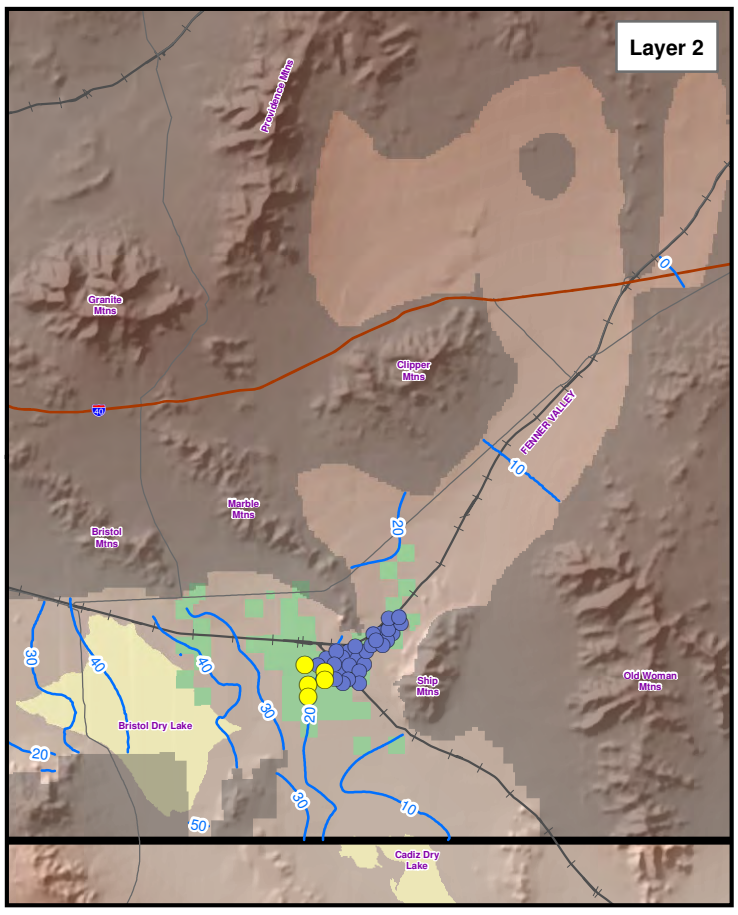
Figure 11

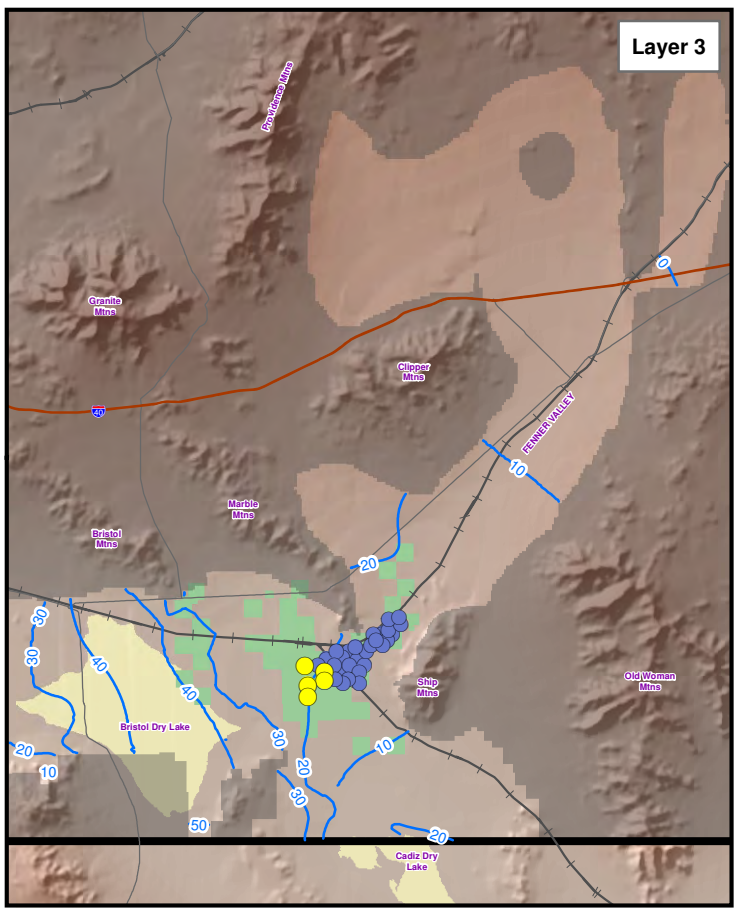
GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_11_16k_Scen4_gw_elev_100yr_9-11.mxd

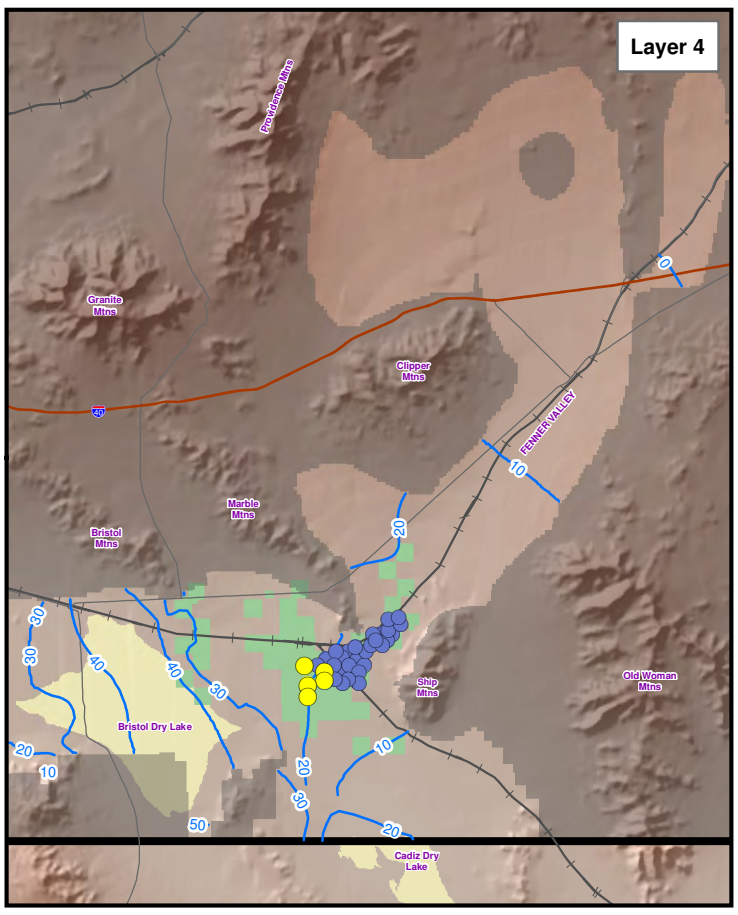
BROWNSTEIN HYATT FARBER SCHRECK, LLP

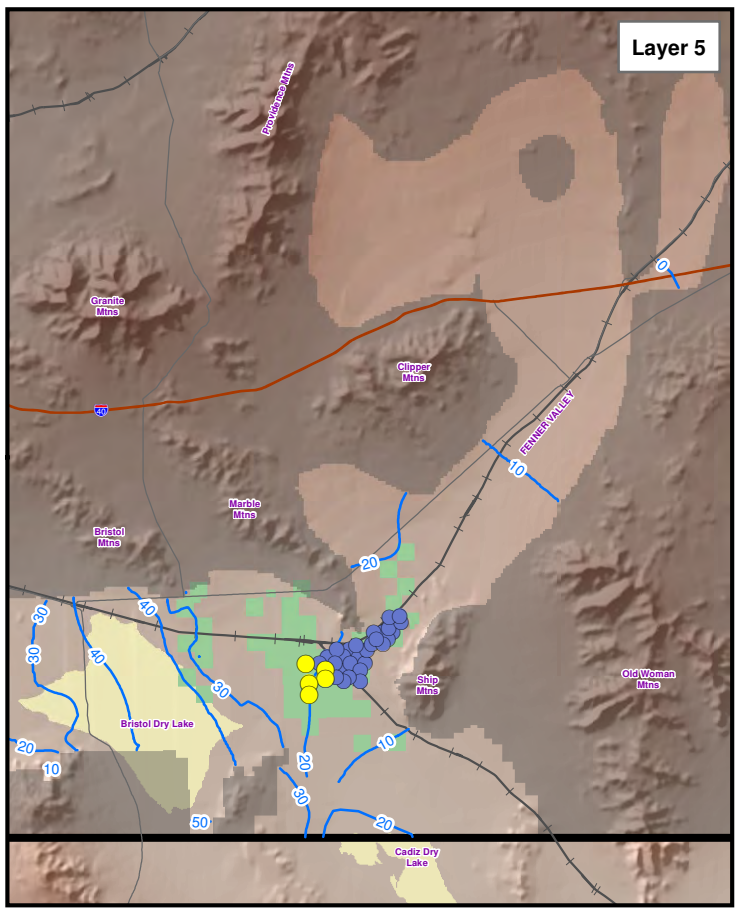
SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

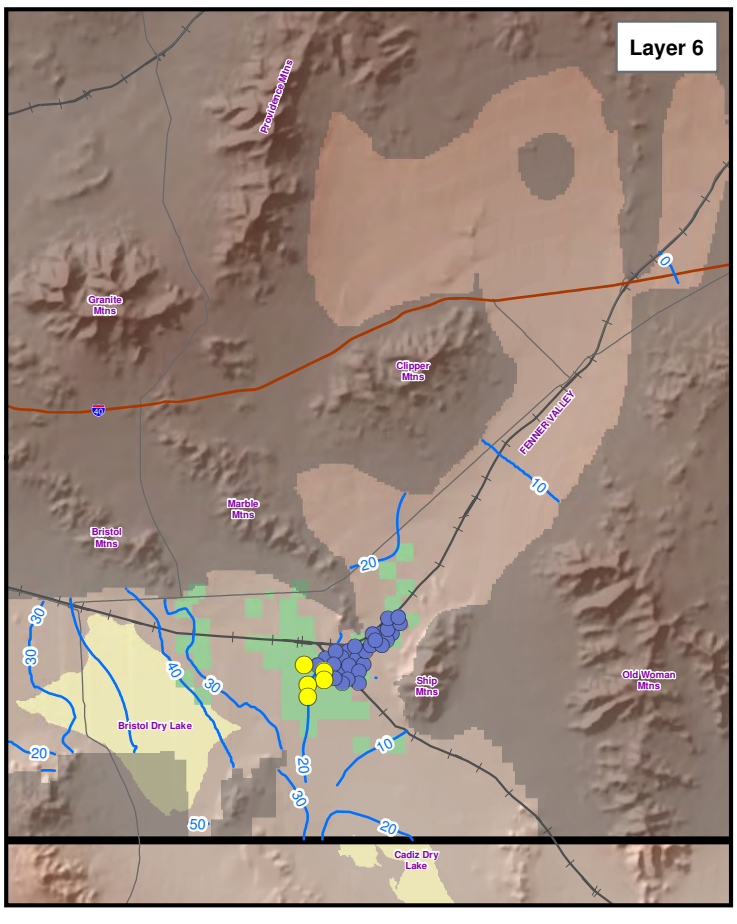












EXPLANATION

- Groundwater Model Boundary
- No Flow Model Cell
- 40 — Regional Drawdown (ft)
- Existing Cadiz Agricultural Well
- Proposed New Well
- Cadiz Owned Land

Sensitivity Scenario 4

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 4

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 5.5 11 Miles

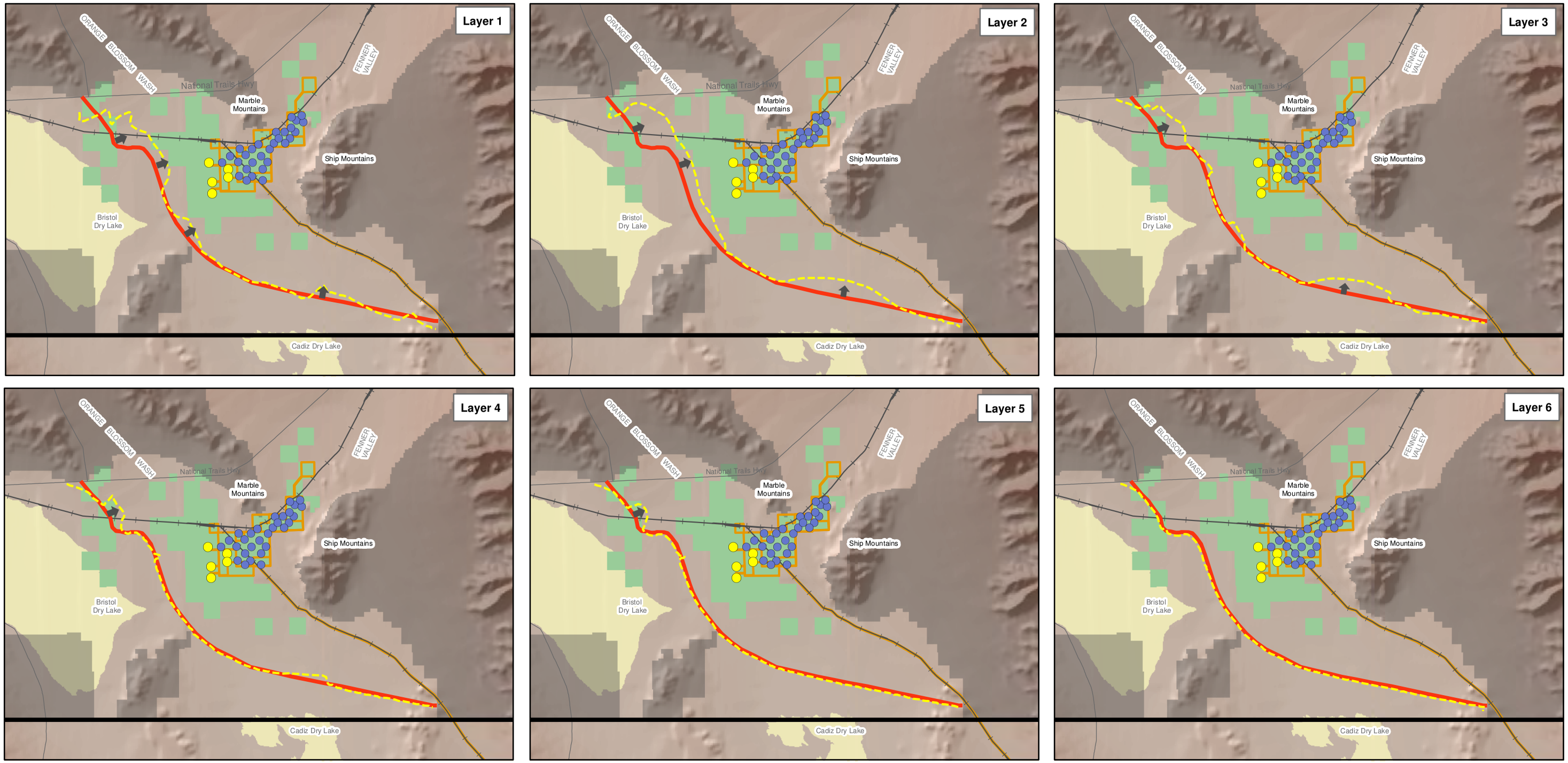
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 12

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_12_16k_Scen3_dd_100yr_9-11.mxd

BROWNSTEIN HYATT FARBER SCHRECK, LLP

SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT



Groundwater Model Boundary

No Flow Model Cell

Cadiz Owned Land

Proposed Wellfield Development Areas and Pipeline

Existing Cadiz Agricultural Well

Proposed New Well

Direction of Saline Water / Freshwater Interface Movement

Current Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

Model-Generated
Saline Water / Freshwater Interface (TDS = 1,000 mg/L)

At the End of 100 Years (end of model simulation)

NORTH

0 6 12 Miles

Sensitivity Scenario 4

Natural Recharge of
16,000 acre-ft/yr

Wellfield Configuration B
(5 Existing Cadiz Wells
and 29 New Wells)

MODEL-GENERATED SALINE WATER AND FRESHWATER INTERFACE (TDS = 1,000 mg/L)

SENSITIVITY SCENARIO 4

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

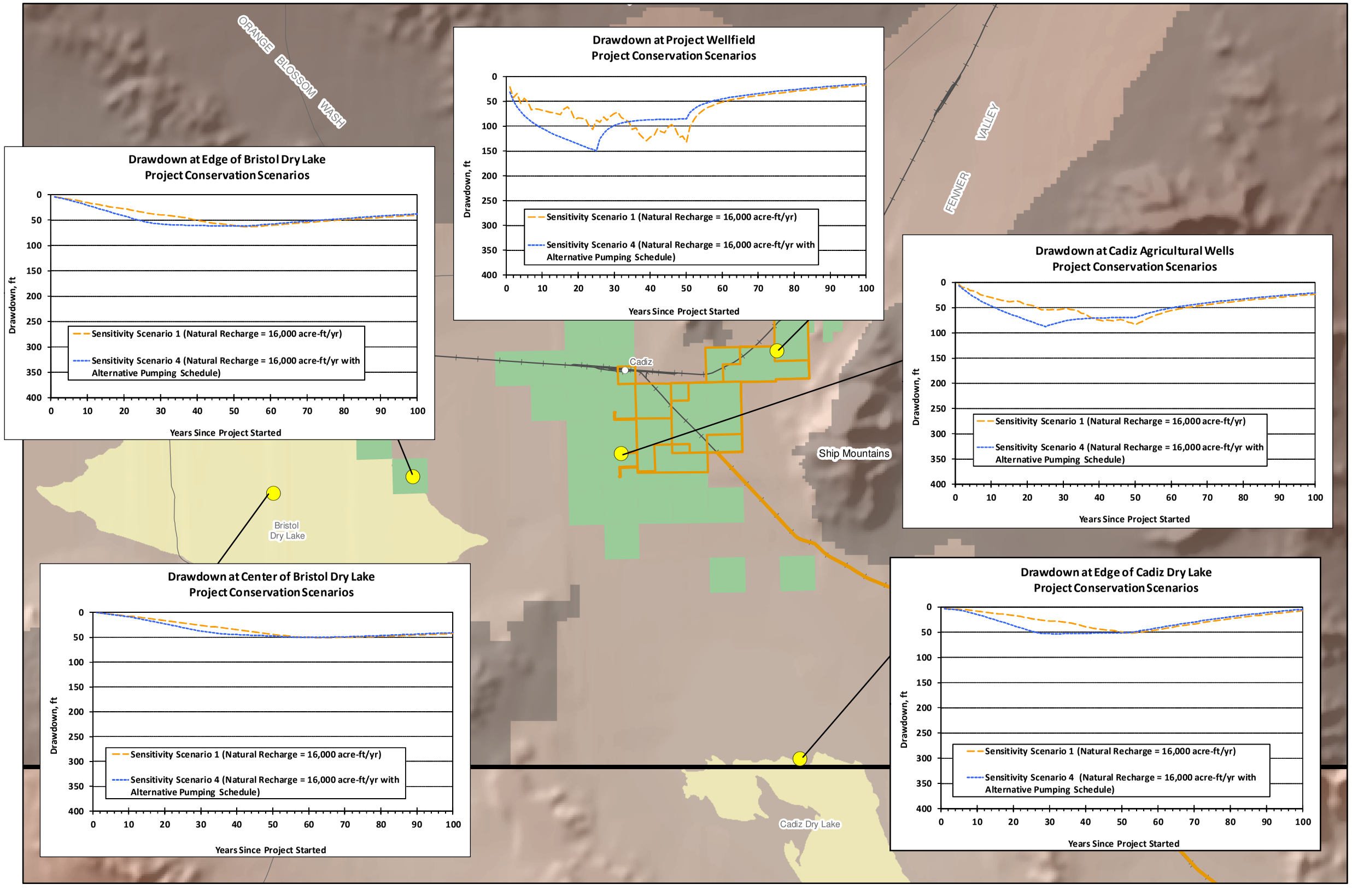
Figure 13

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_13_6panel_saline_16k_scen4_q75_100yr_9-11.mxd

BROWNSTEIN HYATT FARBER SCHRECK, LLP

SUPPLEMENTAL ASSESSMENT OF PUMPING REQUIRED FOR THE CADIZ GROUNDWATER CONSERVATION, STORAGE AND RECOVERY PROJECT

MODEL-CALCULATED DRAWDOWN AT SELECTED LOCATIONS SENSITIVITY SCENARIO 1 VERSUS SENSITIVITY SCENARIO 4



EXPLANATION

- Location with Drawdown Over Time
- Cadiz Owned Land
- Proposed Wellfield Development Areas and Pipeline
- No Flow Model Cell

Sensitivity Scenario 4

Natural Recharge of 16,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

20-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

© 2011, GEOSCIENCE Support Services, Inc. All rights reserved.

NORTH

0 3 6 Miles

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 14

GIS_proj/brownstein_cadiz_model_analysis_9-11/0_TECH_MEMO_Scen3_Scen4_9-11/0_Fig_14_DD_16k_hydrographs_9-11.mxd

Cumulative Annual Change in Groundwater Storage
Project Scenario versus Sensitivity Scenario 3

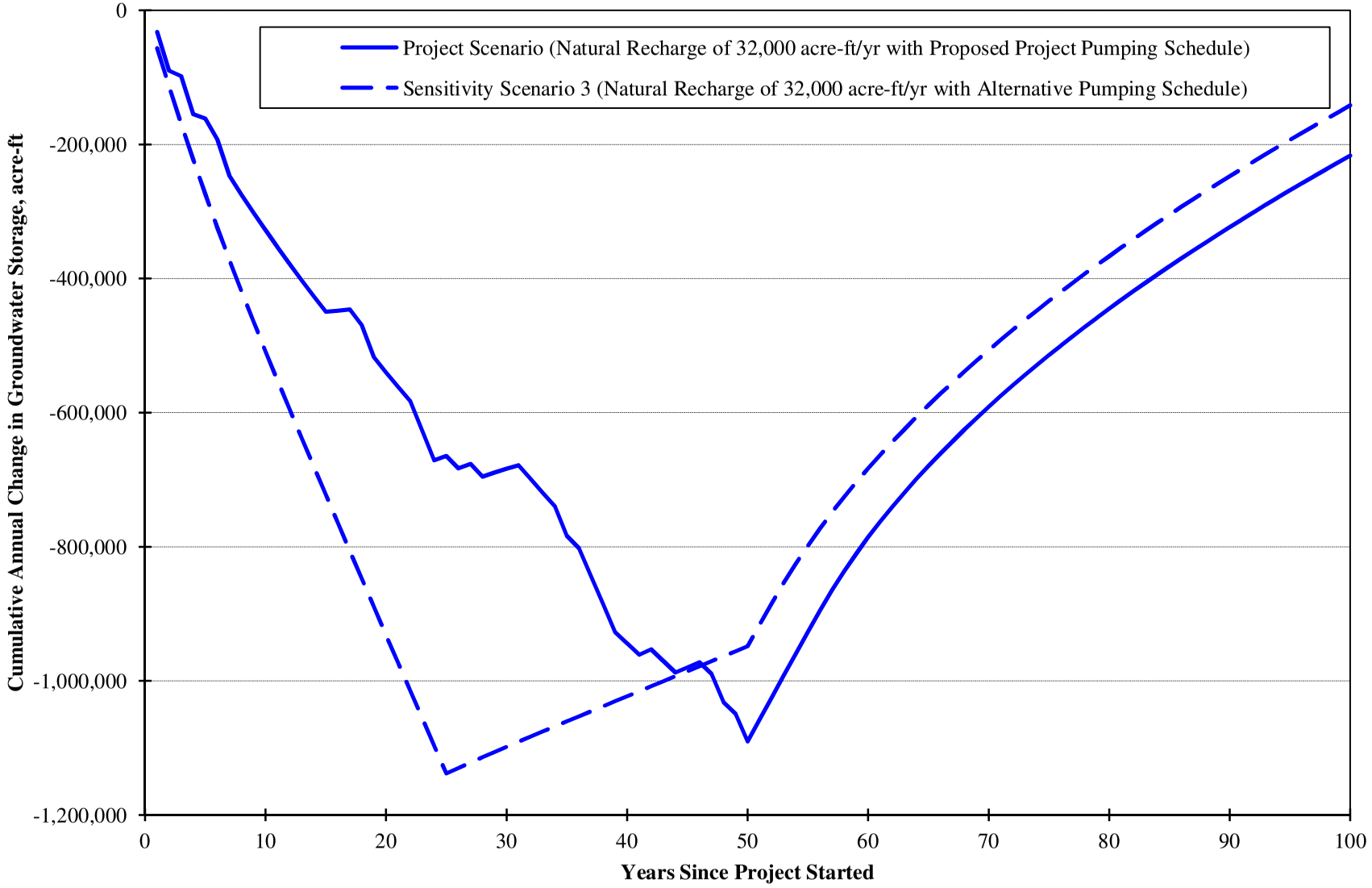


Figure 15

Cumulative Annual Change in Groundwater Storage
Sensitivity Scenario 1 versus Sensitivity Scenario 4

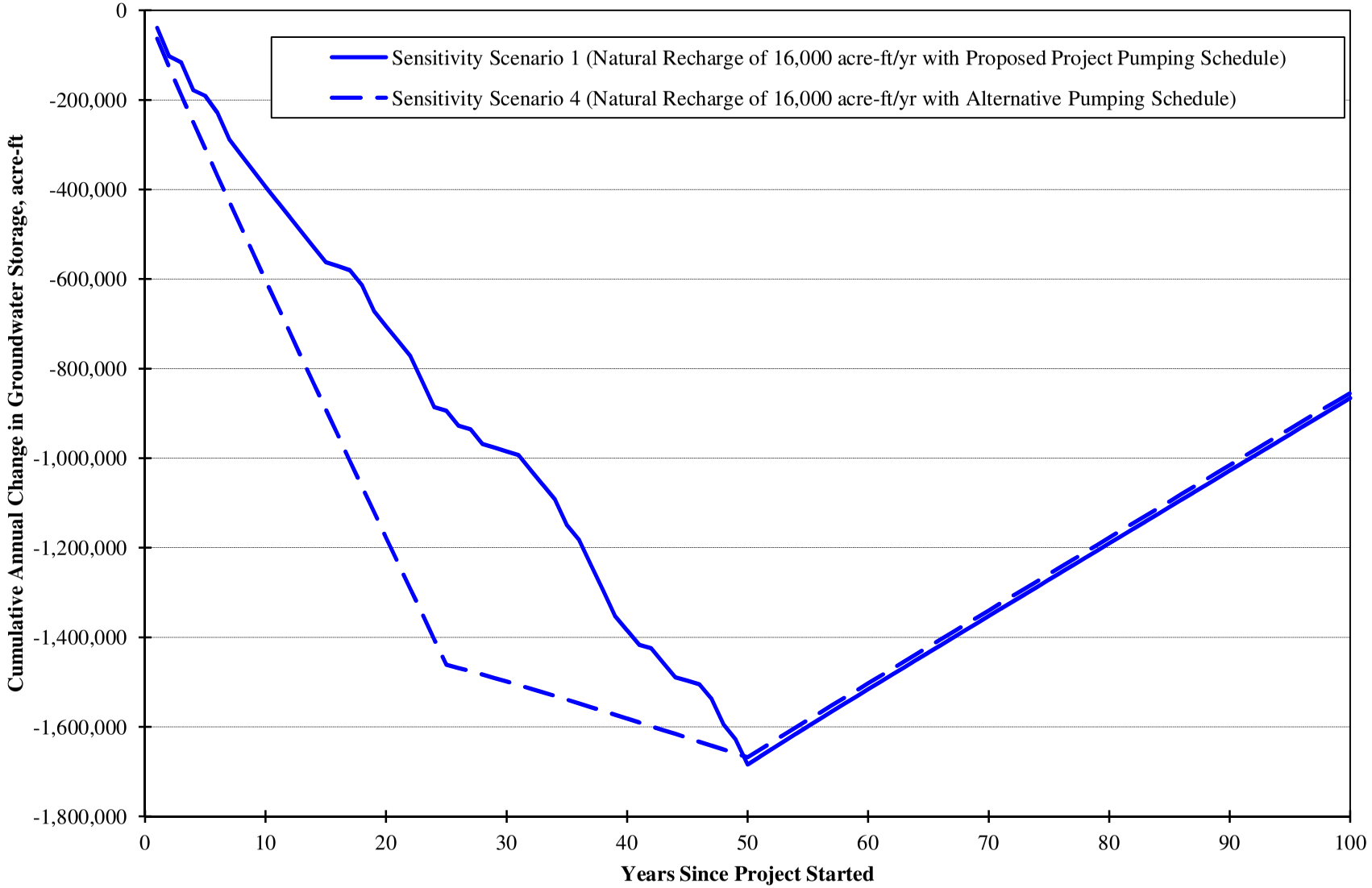


Figure 16

Cumulative Fresh Groundwater Loss to Evaporation
Project Scenario versus Sensitivity Scenario 3

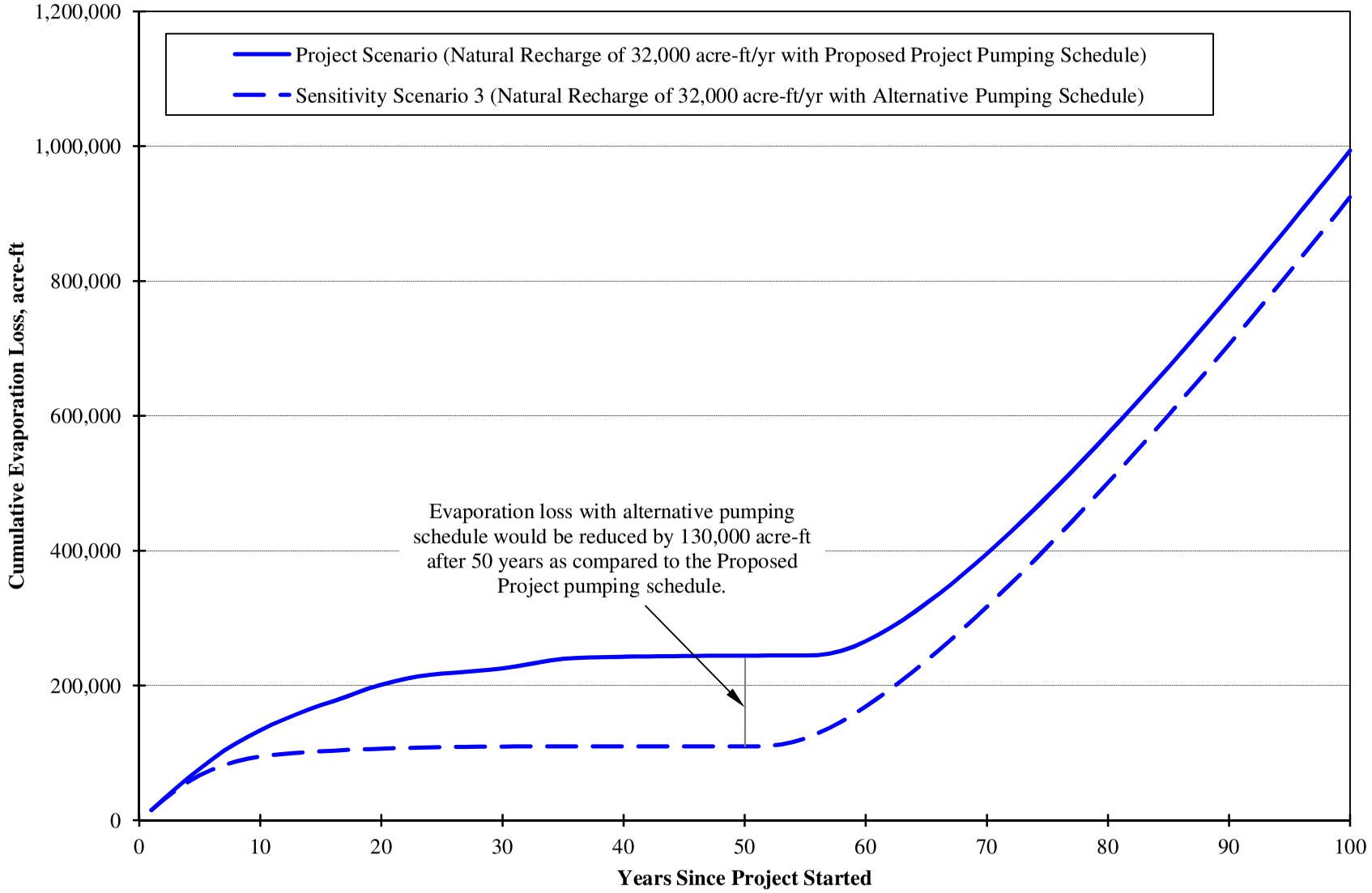


Figure 17

Cumulative Fresh Groundwater Loss to Evaporation
Sensitivity Scenario 1 versus Sensitivity Scenario 4

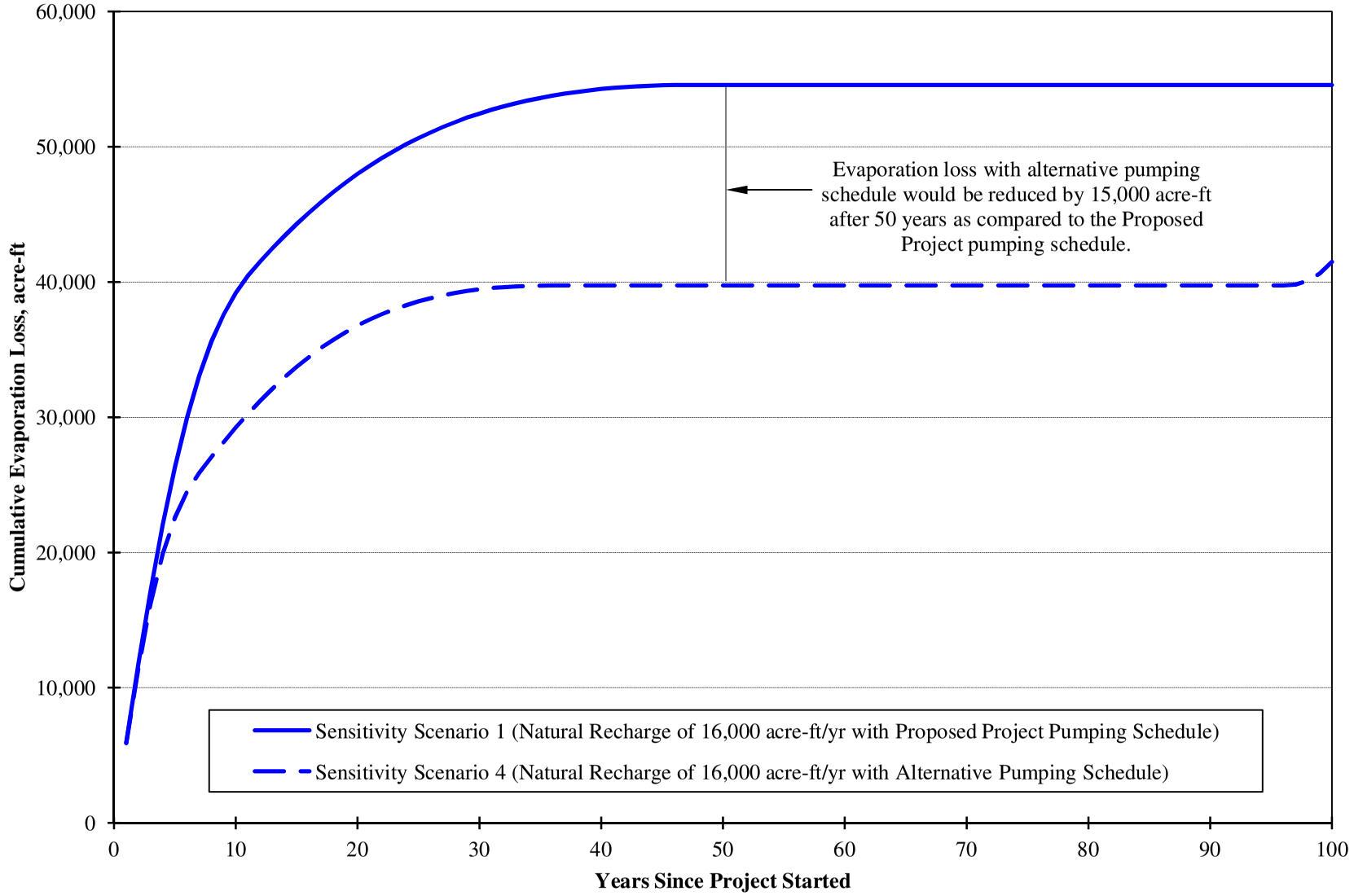


Figure 18

Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs

PREPARED FOR: Scott Slater, Brownstein Hyatt Farber Schreck, LLP

PREPARED BY: CH2M HILL

DATE: August 3, 2011

Executive Summary

Cadiz is proposing to implement the Groundwater Conservation Recovery and Storage Project (Project) in the Fenner-Bristol-Cadiz watershed, which will include installation of extraction wells to lower groundwater levels and thereby facilitate the capture of groundwater that would otherwise flow to Bristol and Cadiz Dry Lakes, where it would evaporate. Cadiz plans to extract an average of 50,000 acre-feet per year (AFY) from an extraction wellfield in the vicinity of Fenner Gap (Figure 1). There are no springs within 11 miles of the Project. However, many springs exist in the Fenner Watershed that support habitat of the desert environment and it is Cadiz's intent to operate the Project in a manner that avoids impacts to any of these distant springs. This technical memorandum presents an assessment of the potential impact of the proposed operation of the extraction wellfield on springs in the Fenner Watershed.

There is no information demonstrating a physical connection of those identified springs in the local mountains to groundwater in the alluvial aquifer where Cadiz's pumping will take place. In addition, the alluvium west of Clipper Mountains is likely to be unsaturated as it thins over bedrock highs, which further limits hydraulic continuity between the alluvial aquifer and springs located in the mountains on the west side of the valley. There is no observed hydraulic continuity between groundwater in fractured granitic bedrock where the springs exist and the regional groundwater table of the alluvial aquifer. Consequently, because there is little or no hydraulic connection the Project will not likely have any impact on springs.

In order to address more completely assess concerns about potential impacts on springs, this memorandum also presents and analysis as to whether there could be a potential impact of the Project on the identified springs by assuming the existence of hydraulic continuity between the groundwater feeding springs and groundwater in the alluvial aquifer. The results of this assessment demonstrates that for many reasons, including distance between drawdown in the alluvial aquifer and springs, change in elevation, the required low transmissivity of fractured bedrock, and hydraulic connectivity, that any impact would be very minor and likely within the natural climatic variability.

Springs in the Fenner Watershed

Many springs have been identified in the Fenner Watershed and documented in United States Geological Survey (USGS) reports dating as far back as 1908 and 1929 (Mendenhall, 1909 and Thompson, 1929, respectively). Figure 2 shows the location of wells and springs largely documented in 1984 by the USGS based on a literature review and a field survey of groundwater resources of the Lanfair and Fenner Valleys (Freiwald, 1984).

Those springs closest to the proposed Cadiz extraction wellfield are located in the adjacent mountains and include: Bonanza Spring, Hummingbird Spring, and Chuckwalla Spring in the Clipper Mountains to the north; Willow Spring, Honeymoon Spring, Barrel Spring and Fenner Spring in the Old Woman and Piute Mountains on the east; and Van Winkle Spring, Dripping Spring, Unnamed-17BS1, Unnamed-17GS1, Granite Cove Spring, Cove Spring, BLM-1 and BLM-2 springs at the Southern End of the Providence Mountains. The Bonanza Spring in the Clipper Mountains, which is the closest spring to the proposed extraction wellfield, is over 11 miles from the center of the Fenner Gap. Mendenhall (1909) briefly describes the following springs in the USGS Water Supply Paper 224 on "Some Desert Water Places in Southeastern California and Southwestern Nevada:" Cove Springs and Bonanza Springs, as well as several other springs in the northern reaches of the watershed. Thompson (1929) describes the following springs: Van Winkle Spring, Cove Springs, Cottonwood Springs, Dripping Springs, Arrow Weed Spring (possibly the same as Cottonwood Spring) in the southern part of the Providence Mountains; Bonanza Spring (also called Danby Spring) and an unnamed spring in the Clipper Mountains; Fenner Spring (which originates as a tunnel dug 200 feet into the mountain side) and Barrel Spring in the Piute Mountains; and Honeymoon Spring (derived from a dug tunnel into granite) in the Old Woman Mountains.

Thompson (1929) did not physically locate those springs in the Southern Providence Mountains, but locations were based on the "best available information that could be obtained." The Bonanza Spring (or Danby Spring) is reported by Thompson (1929) to consists of a tunnel 360 feet long, dug in clay, "cement," and gravel and was reported to yield about 10 gallons per minute, approximately 16 acre-feet per year (AFY). The spring supplied water to Danby via pipeline for locomotive use. Thompson (1929) reported that the water from the Fenner Spring comes from a tunnel 200 feet long that served the railroad via pipeline at Fenner. The Honeymoon Spring also originates as a tunnel dug into the granite mountain, which was used to supply the Golden Fleece Mine.

Freiwald (1984) completed a study for the Bureau of Land Management to develop hydrogeologic information on the Lanfair and Fenner Valleys for water-resources planning and development. This study included a review of literature and a field canvass of wells, springs, and mine shafts. The field canvass included locating wells and springs, measurement of groundwater levels and collection of samples of groundwater for chemistry, and measurements of spring flow. Figure 2 is based largely on Freiwald's field canvass of wells and springs, which have been incorporated into the USGS online data base (http://waterdata.usgs.gov/ca/nwis/inventory and http://waterdata.usgs.gov/nwis/gwconstruction). Figure 3 shows the altitude of each of these springs and observed discharges, where there was flow observed during Freiwald's survey, as many of these springs were reported as dry. The largest flows were observed at

the Bonanza Spring (3.5 gallons per minute [gpm], 5.6 AFY) and Van Winkle Springs (0.5 gpm, 0.8 AFY) during Freiwald's survey.

Physical Setting

The Fenner Watershed encompasses approximately 1,100 square miles (mi^2). It is bounded by the Granite, Providence and New York Mountains on the west and north and the Piute, Old Woman, Ship and Marble Mountains on the east and south. Fenner Gap occurs between the Marble and Ship Mountains, where the surface drainage exits Fenner Watershed and enters the Bristol and Cadiz watersheds. The Clipper Mountains rise from the southern portion of the watershed, just north of Fenner Gap.

Topography

Figure 4 shows a topographic map of the larger area of study based on the National Elevation Dataset (USGS, 2006a). The New York Mountains rise to elevations of approximately 7,532 feet above the National Geodetic Vertical Datum of 1988 (NGVD). The Granite and Providence Mountains range from 6,786 feet to 7,178 feet above NGVD, respectively. The Piute Mountains range up to 4,165 feet above NGVD. The Clipper Mountains rise to an elevation of over 4,600 feet above NVGD. Finally, the Marble and Ship Mountains range up to 3,842 and 3,239 feet above NGVD, respectively. Generally, the Fenner Valley slopes southward toward the Fenner Gap, at an elevation of about 900 feet above NGVD, which is the surface water outlet from the valley.

Precipitation

Davisson and Rose (2000) describe environmental factors that complicate the distribution of precipitation through southeastern California and western Nevada, which include, the rain shadow effect of the Sierra Nevada, San Gabriel, and San Bernardino Mountains, and storms moving up from the Gulf of California that create more precipitation in the eastern Mojave Desert than in the western Mojave Desert. The rain shadow effect of the Sierra Nevada has its greatest impact on precipitation just east of the Sierra Nevada and decreases eastward into Nevada. In general, Davisson and Rose (2000) show that precipitation versus elevation is higher east of the 116° W longitude than west of it. The Fenner Watershed lies to the east of this demarcation, so this watershed is expected to have higher precipitation with increases in elevation as compared to watersheds in the western Mojave Desert.

Figure 5 shows precipitation and temperature stations in the study area. Those stations with relatively long and complete records in the immediate area of study include Mitchell Caverns and Amboy stations. Stations with short and less complete records in the area and vicinity include San Bernardino County stations of Goffs, Essex, and Kelso. The long-term annual average precipitation at Mitchell Caverns, located at an altitude of 4,350 feet, is 10.47 inches. Amboy is represented by two stations, Amboy – Saltus #1, with an elevation of 624 feet and a long-term annual average precipitation of 3.28 inches (from 1967 to 1988) and Amboy – Saltus #2, with an elevation of 595 feet and long-term annual average precipitation of 2.71 inches (1972-1992)

Figure 6 shows isohyets of average annual precipitation for the larger area of study based on the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) map for the

period 1971 through 2000. PRISM was developed by Dr. Christopher Daly of Oregon State University starting in 1991. PRISM uses point estimates of climate data and a digital elevation model (DEM) to generate estimates of climate elements, such as average annual, monthly and event-based precipitation among other elements (www.prism.oregonstate.edu). This isohyet map shows average annual precipitation that varies from about four inches in Bristol Valley to over 12 inches in the New York Mountains.

Figure 7 shows the cumulative departure from mean precipitation for Mitchell Caverns and Amboy stations. The trend of relatively dry conditions prior to the mid-1970's (overall declining trend in the cumulative departure curve) and relatively wet conditions (overall rising trend in the cumulative departure curve) since the mid-1970's is typical of much of Southern California.

Regional Geology

The Fenner Watershed is located within the Basin and Range province of North America. Figure 8 is a simplified geologic map of the larger area of study showing the distribution of "bedrock" and "alluvial/dune/lacustrine" deposits. Bedrock includes igneous, metamorphic and consolidated sedimentary rocks (including carbonates) and alluvial/dune/lacustrine deposits are unconsolidated sediments deposited by streams, wind, or in playa lakes for the purposes of this map. In general, bedrock forms the perimeter of the major watersheds. Large bedrock masses occur within watersheds such as Clipper Mountains, which are located in the Fenner Watershed.

The Bristol and Cadiz watersheds form a broad depression that is referred to as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). This depression is thought to be six to ten million years old (Rosen, 1989), having formed as a result of regional movement along faults.

The crystalline basement rocks exposed in the mountain ranges of the project area consist primarily of Precambrian granitic and metamorphic rocks, which are locally overlain by a sequence of Paleozoic sedimentary rocks. The Paleozoic rocks consist of sandstones, shales, slates, limestones and dolomites. These Paleozoic sediments and the underlying basement rocks have been faulted and folded by numerous periods of regional tectonism. The crystalline basement rocks are generally much less permeable than alluvium and typically yield only small quantities of water to wells (Freiwald, 1984 and results of investigations for this Project). Some of the Paleozoic sedimentary sections, particularly those limestone and dolomites sections that are fractured or contain solution cavities, can and do yield large quantities of water to wells (as found as a part of this Project). Mitchell Caverns, located on the eastern side of the Providence Mountains, occur in karstic limestone of this section. These carbonate units are expected to be significant aquifers where dissolution features are present in the subsurface.

The basement complex and the overlying Paleozoic section were locally metamorphosed and intruded by granitic plutons during Mesozoic time. In the Old Woman Mountains, the Precambrian and Paleozoic section was also intensely deformed by ductile thrusting which accompanied the Mesozoic plutonism (Karlstrom et. al., 1993). Throughout the project area, mostly fractured crystalline basement rocks form the boundaries of the groundwater aquifer system.

In the Fenner Valley, the Paleozoic section is unconformably overlain by clastic sediments and interbedded volcanic rocks of mid- to late-Tertiary age. The Tertiary volcanic rocks consist of lava flows of basaltic to andesitic composition, and pyroclastic tuffs of rhyolitic to dacitic composition. The USGS (2006b) reports that a shallow trap-door caldera roughly 10 km in diameter is centered in the eastern Woods Mountains, based on gravity and aeromagnetic anomalies, that was formed from a major eruption 15.8 million years ago, with resurgent eruptions filling the caldera with rhyolitic flows and tuffs. Dikes of similar composition are exposed in the Marble and Ship Mountains. The Tertiary sediments consist of conglomerate, fanglomerate, sandstone, siltstone, water-laid tuff, and lake sediments, which form a composite section more than 7,000 feet thick (Dibblee 1980a and 1980b). The Tertiary sediments and interlayered volcanic rocks are gently dipping, due to extensional normal faulting of late-Tertiary age.

The Quaternary and late-Tertiary alluvial fill in the basins is largely derived from the Precambrian basement rocks, Paleozoic sediments and Tertiary volcanic rocks. The USGS (2006b) mapped alluvial deposits exceeding 300 m in thickness in the northern Fenner Valley. Geophysical evidence indicates that this alluvial fill locally exceeds 3,500 feet in thickness beneath a portion of the southern Fenner Valley (Maas 1994) and is even thicker under Bristol Valley. These alluvial sediments form one of the principal aquifers in the study area.

The playa sediments underlying Bristol, Cadiz and Danby dry lakes consist of brine-saturated clay, silt, fine-grained sand and evaporite deposits. The clastic sediments were deposited when stream flow and sheet flow from the surrounding alluvial fans spread onto the playas during major storm events (Gale 1951). The evaporite deposits formed from evaporation of both surface water and groundwater, which seeps into the playa sediments from the adjacent alluvial fans (Rosen 1989).

Bristol, Cadiz and Danby dry lakes have static groundwater levels at or near the playa surfaces (Moyle 1967; Rosen 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on all three of these playas. Thompson (1929), Gale (1951), Bassett et. al., (1959), Handford (1982) and Rosen (1989) concur that the principal recharge to the playas occurs as diffuse seepage of groundwater onto the playas from the adjacent alluvial fans.

Cadiz and Bristol dry lakes are locally bordered by active dunes formed by fine to medium-grained windblown sand. These Holocene deposits overlie older playa deposits of differentiated Quaternary age (Moyle 1967).

Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lave field believed to be as young as 6,000 years (Parker 1963; Hazlett 1992).

Structural Geology

The larger area of study is located at the eastern margin of the "eastern California shear zone" a broad seismically active region dominated by northwest trending right-lateral strike-slip faulting (Dokka and Travis 1990). Roughly a dozen fault zones showing evidence of Quaternary movement (during the last 1.6 million years) have been identified in and adjacent to Bristol, Cadiz and Fenner valleys (Howard & Miller 1992).

Cadiz Valley is underlain by two major northwest trending faults, inferred on the basis of gravity and magnetic data (Simpson et. al., 1984). These fault zones have strike lengths of at least 25 miles, and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones (Howard & Miller 1992; Metropolitan 2001).

Right-lateral slip along the Cadiz Valley fault zone of as much as 16 miles has been postulated on the basis of correlation of a distinctive Precambrian gneiss unit across the zone (Howard & Miller 1992). Slickenside surfaces, produced by fault movement, and steeply dipping sediments recovered from cored frill holes beneath Cadiz Dry Lake, suggest that the fault zone displaces sediments of Pleistocene age (Bassett et. al., 1959).

Bristol Dry Lake is bordered by probable extensions of the Cadiz Valley and South Bristol Mountains fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west (Howard & Miller 1992). Geophysical data indicate this structural depression may exceed 6,000 feet in depth (Simpson et. al., 1984; Maas 1994). Drill cores recovered from depths of over 1,000 feet beneath Bristol Dry Lake suggest that subsidence of this basin began by Pliocene time and continues to the present (Rosen 1989), and therefore may be tectonically active.

Fenner Gap appears to be a structural half-graben, formed by a system of northeast trending, northwest dipping normal faults, some of which are exposed in outcrops of the bedrock that flank the gap. The presence of these northeast trending faults beneath the alluvial deposits that underlay the gap can be inferred from surface geology mapping, gravity surveys, a seismic reflection survey conducted across the gap by NORCAL Geophysical Consultants, Inc. (1997), and recent test wells drilled as a part of the this current study.

Kinney (2011) conducted an extensive geologic investigation of the Fenner Gap. The structure of the Gap is dominated by Jurassic intrusions and Miocene extension. Jurassic intrusives caused major folding of Paleozoic sediments, with uplifting resulting in substantial erosion of these older rocks. Miocene extension resulted in a series of north-south striking upper plate listric normal faults through the Gap, which are believed to be associated with a deeper detachment fault. Those upper plate rocks along these normal faults and the detachment fault are highly fractured and are expected to be very transmissive.

Hydrogeology

The primary sources of replenishment to the groundwater system in the project area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the regional watershed occurs in the higher elevations (Metropolitan 2001; USGS 2000, Davisson and Rose, 2000).

Precipitation infiltrates and moves downward to the water table. In some cases, the infiltrating water may be diverted to the land surface or groundwater may intersect land surface creating a spring prior to seeping downward through the unsaturated soil and rock,

where it ultimately reaches the regional groundwater system and continues to flow downgradient through principal aquifer systems.

Groundwater occurrence in fractured bedrock of the watershed-perimeter mountains has been known since before the turn of the twentieth century (Mendenhall, 1909). The USGS documented the occurrence of wells and springs (see discussion above) throughout Southeastern California and Southwestern Nevada for the benefit of travelers and prospectors (Mendenhall, 1909). The USGS documented at least ten wells and springs in the mountains and hills around the Fenner Watershed and a number of wells drilled into the alluvium by the Santa Fe Railroad. Another USGS study by Thompson (1929) provided additional information on more wells and springs in the study area in order to survey, mark and provide protection of watering places. Additional wells and springs were identified in the area of study and described by Thompson (1929). A more recent USGS survey of wells and springs in the area of study was conducted by Freiwald (1984). These studies provide evidence of the fractured nature of the surrounding bedrock and the continuous infiltration of precipitation and movement of water through these perimeter rocks.

Although some precipitation is tapped by vegetation near the range fronts, the remainder joins the regional groundwater table and moves slowly downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to Bristol and Cadiz dry lakes. Evaporation of groundwater and surface water from the dry lakes over the past several million years has resulted in thick deposits of salt (primarily calcium chloride and sodium chloride) and brine-saturated sediments (Rosen 1989).

Bristol, Cadiz, and Danby dry lakes have static groundwater levels at or near the playa surfaces (Moyle 1967; Rosen 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on all three of these playas. Thompson (1929), Gale (1951), Bassett et. al., (1959), Handford (1982), and Rosen (1989) concur that the principal source of groundwater recharge to the playas occurs as diffuse seepage of groundwater into the playa sediments from the adjacent alluvial fans.

The mountain ranges that define the boundaries of the regional watersheds are comprised predominantly of granitic and metamorphic basement rock, as described above. This less permeable basement complex forms the margins and bottoms of the aquifer systems (Freiwald 1984). More permeable carbonate bedrock of Paleozoic age occurs locally within the boundaries of these watersheds (see above discussion for general distribution).

Hydrogeologic Units

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater ("aquifers") have been divided into three general units: an upper (younger) alluvial aquifer; a lower (older) alluvial aquifer; and a carbonate rock unit aquifer (principally carbonate units are aquifers, but the unit contains interbedded quartzite and shale). In addition, fractured bedrock units, especially along fault zones, are capable of readily transmitting water (as determined as a part of this Project).

The younger alluvial aquifer consists of Quaternary and late-Tertiary alluvial sediments, including stream-deposited sand and gravel with lesser amounts of silt (Moyle 1967; GSSI

1999). The thickness of the upper alluvial sediments ranges to approximately 1,000 feet (GSSI, 1999, and field investigations as a part of recent investigations for the Cadiz Project). The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of mid- to late-Tertiary age. Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments (Moyle 1967; GSSI 1999, and field investigations as a part of recent investigations for the Cadiz Project). Production well PW-1, located in Fenner Gap, draws water primarily from the upper and lower aquifers and yields 3,000 gallons per minute with less than 20 feet of drawdown (GSSI 1999). The Cadiz Inc. agricultural wells draw water from the alluvial aquifers and typically yield 1,000 to more than 2,000 gallons per minute.

Based on findings from recent drilling in Fenner Gap, carbonate bedrock of Paleozoic age, located beneath the alluvial aquifers, contains groundwater and is considered a significant aquifer (GSSI 1999 and field investigations as a part of recent investigations for the Cadiz Project). Groundwater movement and storage in this carbonate bedrock aquifer primarily occurs in secondary porosity features (i.e. joints, faults, and dissolution cavities that have developed over time). The full extent, potential yield, and storage capacity of this carbonate aquifer have not been quantified at this time.

As noted above, granite and metamorphic basement rock form the subsurface margins of the aquifer system. This basement rock is generally less permeable and typically yields smaller quantities of water to wells (Freiwald, 1984) but is more permeable where fractured, especially along fault zones (as determined as a part of this Project).

Groundwater Movement

In general, groundwater within the watersheds flows in the same direction as the slope of the land surface. In the Fenner Valley, groundwater generally flows southward and discharges through Fenner Gap toward Bristol and Cadiz dry lakes.

Figure 9 presents a generalized contour map of groundwater elevations and horizontal flow directions in the alluvial aquifer in the area of study. The contours in this figure are based on water levels from the alluvial aquifers and calibration of a three-dimensional groundwater flow model to those water levels (as a part of this Project). There is no available information that indicates that the alluvial aquifer west of Clipper Mountains is saturated and it is reasonably expected to be unsaturated as the alluvium is projected to thin over bedrock highs.

Projected Impacts to Springs Due to Proposed Cadiz Project Operations

The Cadiz Groundwater Conservation Recovery and Storage Project includes extraction of an average of 50,000 acre-feet per year of groundwater over 50 years from a proposed wellfield in the Fenner Gap area. GSSI (2011) developed a three-dimensional groundwater flow and solute transport model of the Fenner, Bristol and Cadiz watershed areas to simulate the operation of the proposed wellfield and its effects on groundwater levels and the freshwater/saltwater interface near the dry lakes. GSSI simulated three recharge scenarios, including 5,000 AFY, 16,000 AFY, and 32,000 AFY to assess effects on

groundwater levels and the freshwater/saltwater interface near the dry lakes. The 32,000 AFY recharge scenario is based on INFIL3.0 modeling of the soil-moisture water budget for the Fenner and Orange Blossom Wash watershed areas. GSSI (2011) simulated this large range in long-term average annual recharge by reducing the projected recharge by 50 percent (16,000 AFY) and then to an amount that is generally equivalent to Cadiz historical agricultural pumping (5,000 AFY) in order increase the conservatism of the analysis (identify potential worst-case impacts).

GSSI (2011) simulated two wellfield configurations as shown in Figures 4 and 5 of Attachment A. These wellfield configurations allow for, 1) installation of two large-capacity wells in the karstic carbonate units encountered in the Fenner Gap area, which results in a more tightly clustered wellfield in the Fenner Gap area and, 2) a more dispersed wellfield with pumping more evenly distributed among the wells.

Figures 10 through 15 of Attachment A show groundwater-level drawdown for those various recharge scenarios simulated, both at the end of 50 years of pumping and then for 50 years since cessation of pumping (for a total of simulated period of 100 years). The following observations are made from these simulations:

- Drawdown in regional groundwater levels does not extend to the uppermost reaches of the watershed – in general, the drawdown is negligible at Interstate 40 under all scenarios.
- The extent of drawdown is greater for the higher recharge scenarios, which is expected as the average hydraulic conductivity of hydrogeologic units needs to be higher in order to transmit higher rates of recharge through the groundwater flow system. A higher hydraulic conductivity results in a "spreading out" of the cone of depression from the wellfield. For decreases in recharge, the average hydraulic conductivity of hydrogeologic units needs to be lower in order to transmit lower rates of recharge and maintain the observed regional hydraulic gradients. A lower hydraulic conductivity results in a more "focused" cone of depression centered around the wellfield, with greater drawdown locally and less drawdown further from the center of pumping compared to the higher hydraulic conductivity case.

GSSI extended the groundwater flow simulations for 450 years beyond the operation of the wellfield (for a total simulation period of 500 years) in order to assess the equilibration of the groundwater system after pumping ceases. Figures 10 and 11 show hydrographs for two locations in the alluvial aquifer in Fenner Valley: at Interstate 40 (I-40) and approximately at Danby. In general, the drawdown effects from pumping in the higher recharge scenarios reach their maximum drawdown earlier and tend to recover quicker than in the lower recharge scenarios. Figure 10 shows that groundwater levels at I-40 never drop more than 8 feet for the recharge scenario of 32,000 AFY per year and even less for lower recharge-rate scenarios. These effects are even more attenuated with distance upgradient toward the mountain ridges and at transitions in geologic media, such as from alluvium to lower permeability bedrock units (as further shown below). Figure 11 shows similar responses as Figure 10, except drawdown is greater and recovery begins sooner after cessation of pumping compared to alluvial groundwater levels up gradient. Based on these simulations, the potential for impacts of the Cadiz Project pumping on any springs north of Interstate 40 are extremely remote.

The potential for impacts on springs south of Interstate 40 is also very remote because either, 1) there is no observed and likely direct physical hydraulic connection of these spring to the regional groundwater levels in the alluvium and/or, 2) even if there were a hydraulic connection, any changes in gradients between groundwater in the alluvial aquifer and springs due to the Project is unlikely to create fluctuations in groundwater levels at the springs that exceed natural fluctuations due to natural climatic variations as described below.

The closest spring to proposed extraction wellfield in Fenner Gap is the Bonanza Spring in Clipper Mountains. This spring is located at an altitude of 2100 feet above NGVD. Groundwater modeling by GSSI (2011) shows that groundwater-level declines in the alluvial aquifer, although not significant, would be greatest near this spring of all the identified springs south of Interstate 40. Accordingly, to address any remaining doubts, we also analyzed whether the Project would have an impact even assuming for purposes of this analysis that there is hydraulic continuity. If any impacts were to occur as a result of the project, then the Bonanza Spring would be impacted first given it is the closest. Therefore, the remainder of this assessment is focused on the Bonanza Spring and whether any impact would be material under an assumed hydraulic continuity scenario.

Conceptual Models

There are two conceptual models of the Bonanza Spring, which are expected to apply to all the springs in the Fenner Watershed. Each is summarized below. In both cases, the source of water to the springs is precipitation in the mountains that infiltrates into the ground and travels to the springs. There is no information that suggests that these springs are a result of any other source of water, such as deeply circulating groundwater, confined groundwater, or other similar mechanisms attributable to spring formation.

Concept 1: Disconnected from A Deep Regional Water Table

Concept 1 is based on observations of available data on groundwater levels in wells, geology, and observations of characteristics of identified springs. Figure 12 is a surficial geologic map of the Clipper Mountains and surrounding area based on the Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California (Bedford et. al., 2006). Many of those springs that have been observed in the lower Fenner Watershed area and reported by the Freiwald (1984) are shown on this map. Attachment B includes the Bedford et. al., (2006) Amboy 30x60 Minute Quadrangle map, which provides the explanation of geologic symbols used in Figure 12. The Bonanza Spring is located in granitic rocks, near the contact with partially consolidated sediments. Cross sections E-E' (northwest to southeast) and F-F' (southwest to northeast) are taken through the Clipper Mountains and shown in Figures 13 and 14, respectively. The water table in the alluvial aquifer adjacent to Clipper Mountains is shown as a solid line, based on groundwater level measurements and steady-state groundwater flow model calibrations. Concept-1, as shown in Figures 13a and 14a assumes that the water table is connected through the Clipper Mountains, with little influence (i.e., limited mounding) from recharge that occurs over these mountains and that groundwater flow through fractures in the rock feed these springs, and that this fracture flow occurs entirely above the regional water table. In other words, the fractures are poorly connected with one another, and the flow to the springs

represents an isolated flow path that is independent of subsurface flow at elevations lower than the spring.

Concept 2: Connected to A Regional Water Table

Although there is no available information that demonstrates hydraulic continuity of groundwater at the springs with the regional groundwater table, Concept-2 assumes that fractures in the bedrock are sufficiently interconnected to form an "equivalent porous medium." In this case, there would be a relatively uniformly sloping water table below the Clipper Mountains, from the peak to the contact with the alluvial aquifer as shown in Figures 13b and 14b and Plate 1. Subsurface flow would be driven by the hydraulic gradient based on the water table, and the equivalent "bulk" hydraulic conductivity of the bedrock fractures. In this concept, the low elevation area of Bonanza Spring (and other springs in the area) intersects the water table, and the flow to the springs is driven by the water table. Accordingly, under Concept-2, if one assumes hydraulic continuity between the springs and the regional groundwater table through fractured porous medium, a decline in the water table could affect flow to the springs if the regional water table was lowered at the elevation of these springs. Concept 2 considers whether a potential impact is material even where it is assumed that there is hydraulic continuity.

Evaluation of Potential Impacts and Timing

This section evaluates potential impacts to springs as a result of the Project. Potential impacts are summarized for each of the two conceptual models.

Potential Impacts, Concept 1

Under this concept, the spring is fed by upstream fracture flows that are not hydraulically connected to the water table. Accordingly, the flow rates at the spring are independent of groundwater levels in the alluvium, and no impacts would occur to the spring as a result of project operations. In this concept, the springs get their water supply first and any remaining water continues to the underlying regional groundwater system (note that water supplied to the spring may re-infiltrate downstream and continue to percolate to the regional groundwater system as well).

Potential Impacts, Concept 2

A simple numerical model was developed to evaluate potential impacts under Concept-2, where hydraulic continuity is assumed, in which the regional water table forms the source of water to the springs. The model is a simple representation of a generic mountain system with similar characteristics to the Clipper Mountains, intended to evaluate the general response of a water table in fractured bedrock of mountains under various assumptions that are specific to the Bonanza Spring hydrogeologic conditions.

Model Setup

The groundwater flow model consists of one layer, two rows, and 100 columns. It is designed to simulate groundwater flow through continuous fractured bedrock from a mountain ridge to alluvium at the base of a mountain, as may be the case for Clipper Mountains. Column width was set to 250 feet for all columns, for a total of 25,000 feet from the simulated mountain ridge to the alluvium at the base. This is roughly the distance from

the ridge of the Clipper Mountains southeast to the extent of the alluvium simulated in the groundwater model. Rows were specified to be 5,000 feet wide each.

Recharge was applied to the first 40 cells (a distance of 10,000 feet), which approximately represents the area between the mountain ridge and the surficial contact between bedrock outcrops and (unsaturated) alluvium in the area of Bonanza Spring in the Clipper Mountains. Recharge was applied at a rate of 0.00033 feet per day, or a total of 280 acre-feet per year (AFY), which would be the equivalent of 1,400 AFY across the length of the Clipper Mountains. This recharge rate is about half of the total recharge estimated from the INFIL3.0 model of 2,800 AFY in the Clipper Mountains, with the assumption that half of this recharge would flow northwest and half would flow southeast. The "sides" of the model, as well as the upgradient boundary, were specified as no-flow, which effectively represent flow lines. The downgradient boundary condition was a constant head set at 1,100 feet elevation, which is approximately the water table elevation in the alluvium in the Fenner Watershed (see Figure 12).

The model layer was simulated as unconfined, allowing for a water table surface to be simulated. The bottom elevation was set at 500 feet at the upgradient end of the model and -900 feet at the downgradient end of the model, with a uniform linear slope between the two ends. Bottom elevations were specified such that the saturated thickness is about 2,000 feet.

Simulated hydraulic conductivity values were adjusted until a reasonable representation of a potential water table was achieved; that is, produced the same hydraulic gradient as between the Bonanza Spring and water table in the adjacent alluvium. The hydraulic conductivity value used was 0.025 ft/day, which yielded a water table elevation at the upgradient end of the model of about 2,375 feet. This gradient is consistent with one that would result in the Bonanza Spring being in contact with the water table, at an elevation of 2,100 feet.

For transient simulations described below, a specific yield value was assumed to be two percent.

Model Results

Water Table Response to Drawdown In The Alluvial Aquifer

The model was used to simulate response of a bedrock water table to a 10-foot head decline in the downgradient alluvium (as simulated by GSSI (2011)[1]). This was accomplished by using a transient model with a constant head value in the alluvium set at 1,090 feet, and comparing change in groundwater levels to the simulated groundwater levels equilibrated to a constant head value in the alluvial aquifer of 1,100 feet. This simulation assumed that recharge to the water table is steady and does not change year to year.

Simulated water table elevations in the bedrock at select times are presented in Figure 15. It can be seen that there is little change in the water table elevation relative to the overall slope of the water table from the mountain ridge to the alluvial aquifer. However, a plot of

[1] GSSI presented groundwater modeling results in a draft technical memorandum dated June 16, 2011. The groundwater flow model simulations continue to be refined; however, the results of these refinements are not expected to differ materially from the initial results presented in the draft memorandum. Should the final groundwater flow model results differ from those used in this assessment of impacts to springs, then this memorandum will be updated to reflect those updated results.

simulated drawdown (Figure 16) suggests that bedrock groundwater levels could decline by about 5 to 10 feet in response to a 10-foot decline in alluvium groundwater levels. The timing of the response, however, is relatively slow. At the location of the spring (about 10,000 to 15,000 feet from the ridge), the model suggests there would be a fraction of a foot of water level decline after 10 years (note that this is 10 years after the groundwater in the alluvial aquifer declined to 10 feet), about three feet of decline after 50 years, and sometime after 500 years it would reach a new equilibrium state about six to seven feet lower than the current equilibrium state. As shown in Figure 11, groundwater levels in the alluvial aquifer are expected to recover over this long period, so impacts upgradient toward the spring will be significantly less than shown in Figure 16, which assumes that a 10-foot decline is maintained indefinitely.

A second model run was performed assuming an indefinite 30-foot decline in groundwater levels in the alluvial aquifer in response to pumping. The intent of this run was to evaluate how the magnitude of drawdown in the alluvial aquifer may affect the magnitude of water-table decline in the bedrock. Model simulation results suggest that the magnitude of water-table decline is about three times that of the 10-foot drawdown scenario, and the spatial distribution and timing of the decline is about the same. Accordingly, these simulation results can be scaled to any other amount of potential drawdown in the alluvial aquifer.

Figure 15: Change in water table elevation in response to a ten foot decline in water levels in adjacent alluvium

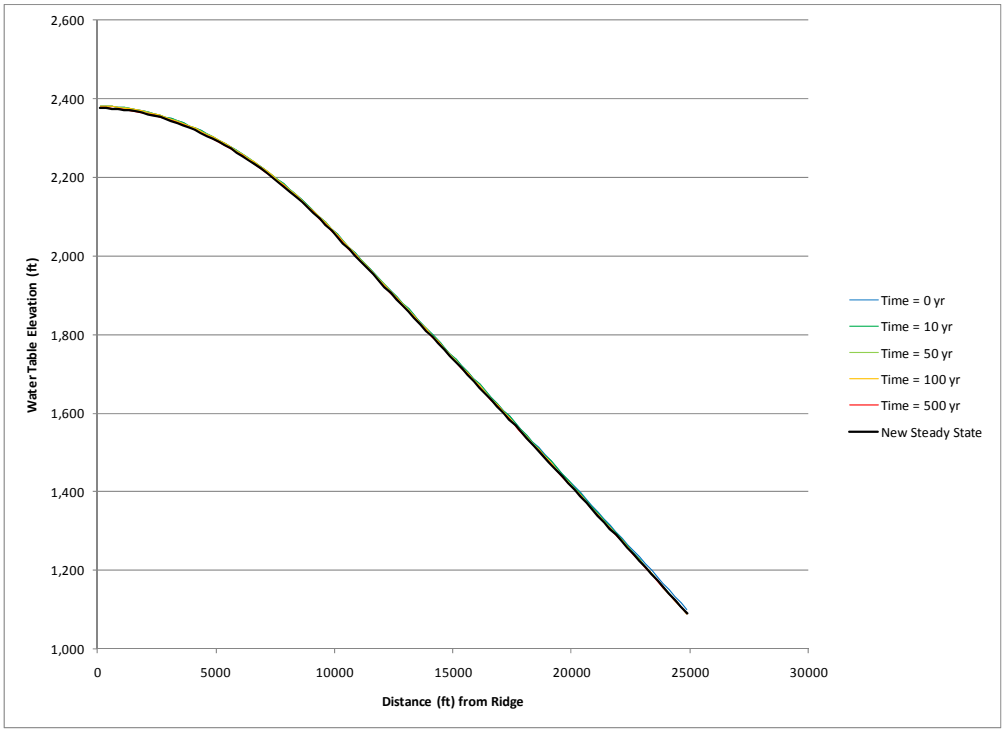
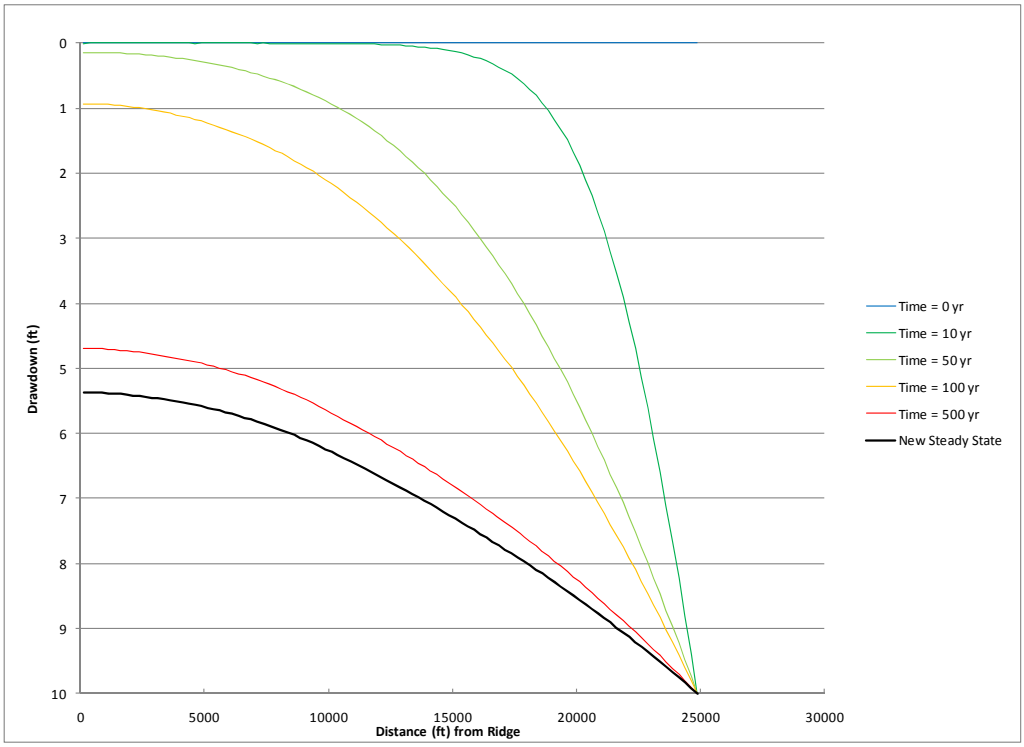


Figure 16: Drawdown in response to a ten foot decline in water levels in the alluvium

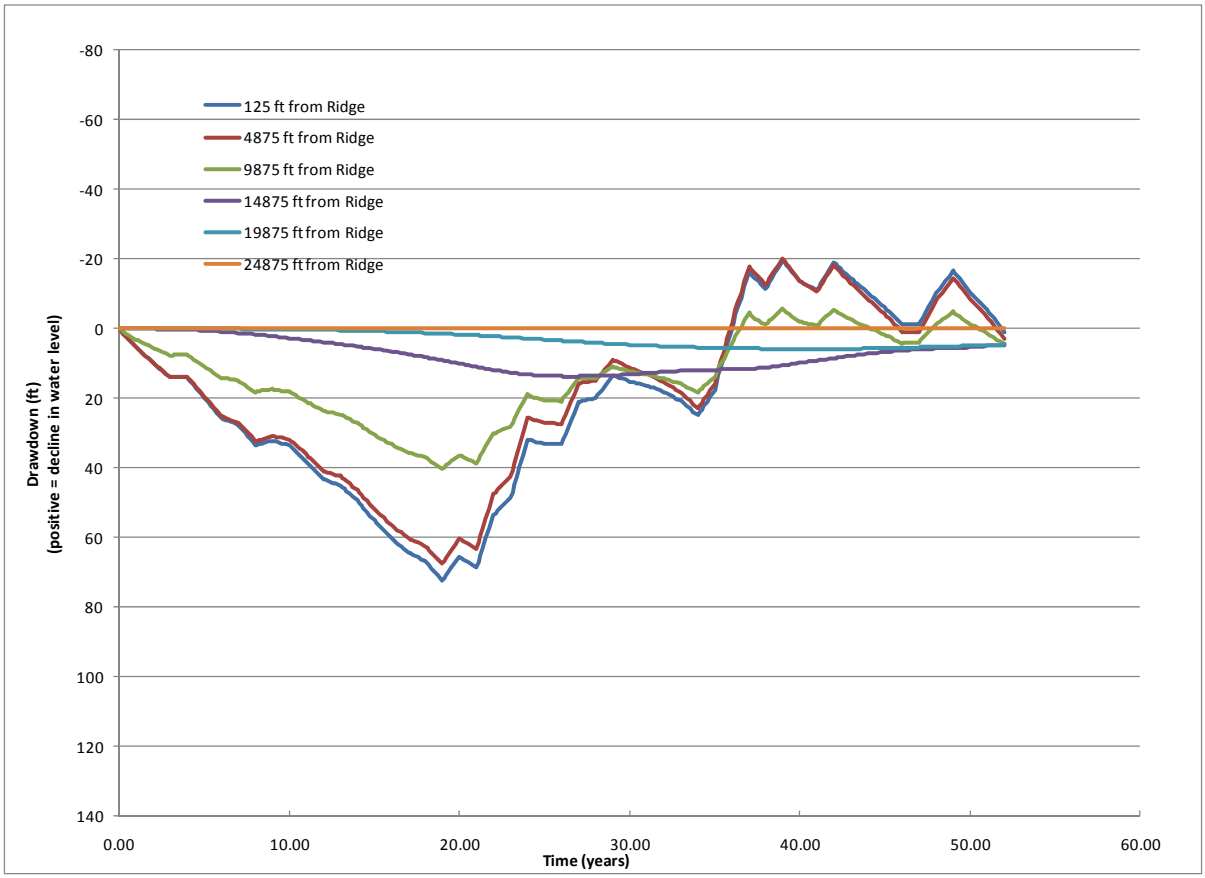


Response to Transient Recharge

A separate simulation was performed to evaluate changes in groundwater levels in the bedrock in response to transient recharge. In this case, a 50-year simulation was run in which recharge varied in proportion to the total estimated recharge based on the INFIL3.0 model for the Fenner Watershed. The minimum annual recharge rate was about one percent of the long-term average, and the maximum was nearly 400 percent of the long-term average (so from one percent to 400 percent of 250 AFY, varying annually based on INFIL3.0 percentages relatively to the long-term average in this watershed).

A plot of simulated drawdown (Figure 17) suggests that groundwater levels near the spring could fluctuate by as much as about 15 to 40 feet in response to climatic variations alone. It should be noted, however, that this is an "end-member" simulation, assuming the annual changes in recharge are applied to the water table in that same year. In reality, the percolating water would take some time to reach the water table, and the effect of year-to-year changes in percolation would likely be much more muted at the water table.

Figure 17: Drawdown in response to transient recharge



Sensitivity to Extent of Recharge

The above simulations assumed that recharge occurs at a uniform rate between the mountain ridge and a point 10,000 feet from the ridge. The effect of this assumption was evaluated by running the same simulations but changing the extent of recharge to the first 5,000 feet from the ridge. In this case, the recharge *rate* was doubled, but applied to half the area, so the resultant volume of recharge remains the same.

Results of the simulation of a 10-foot decline in alluvium water levels are presented in Figure 18. These results suggest that the recharge location has little effect on drawdown magnitude and timing in response to a decline in water levels in the alluvium.

Results of the transient simulation are presented in Figure 19. If recharge only occurred in the first 5,000 feet, model results suggest that groundwater level fluctuations at the upgradient end of the model would be nearly double the fluctuations if recharge occurred in the first 10,000 feet. However, near the spring, water table fluctuations would actually be less, on the order of 10 to 25 feet, so the impacts would vary depending on the location of the spring along the slope and actual recharge along the slope.

Figure 18: Drawdown in response to a ten foot decline in water levels in the alluvium, sensitivity case (recharge first 5,000 ft)

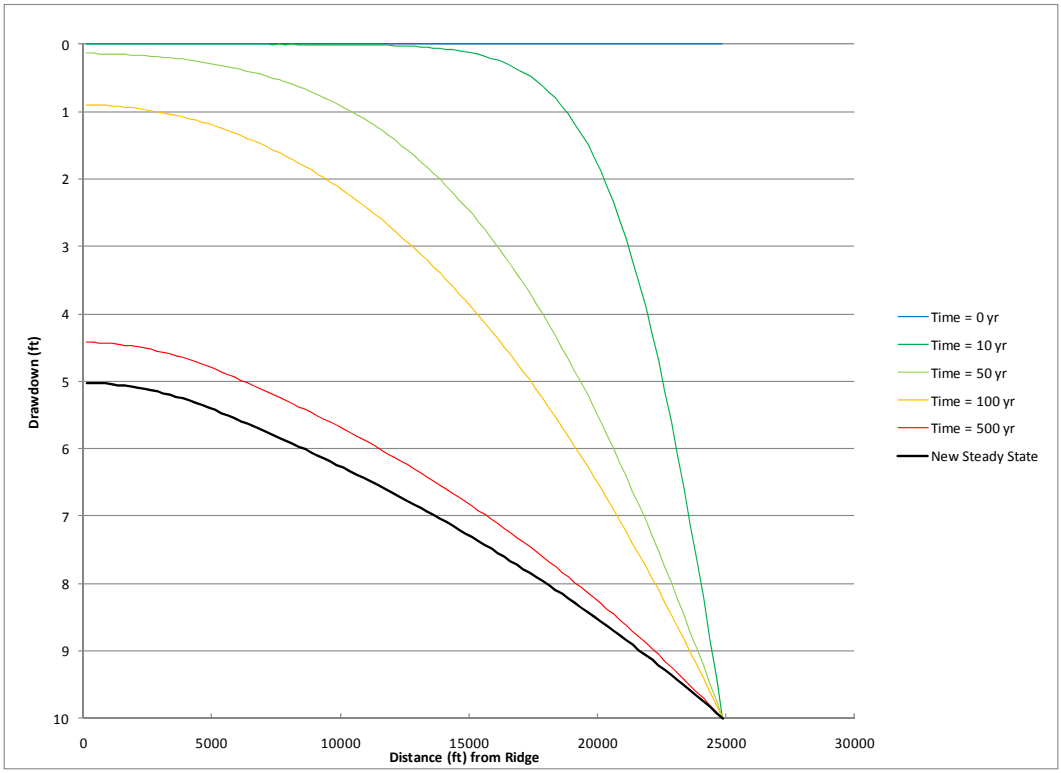
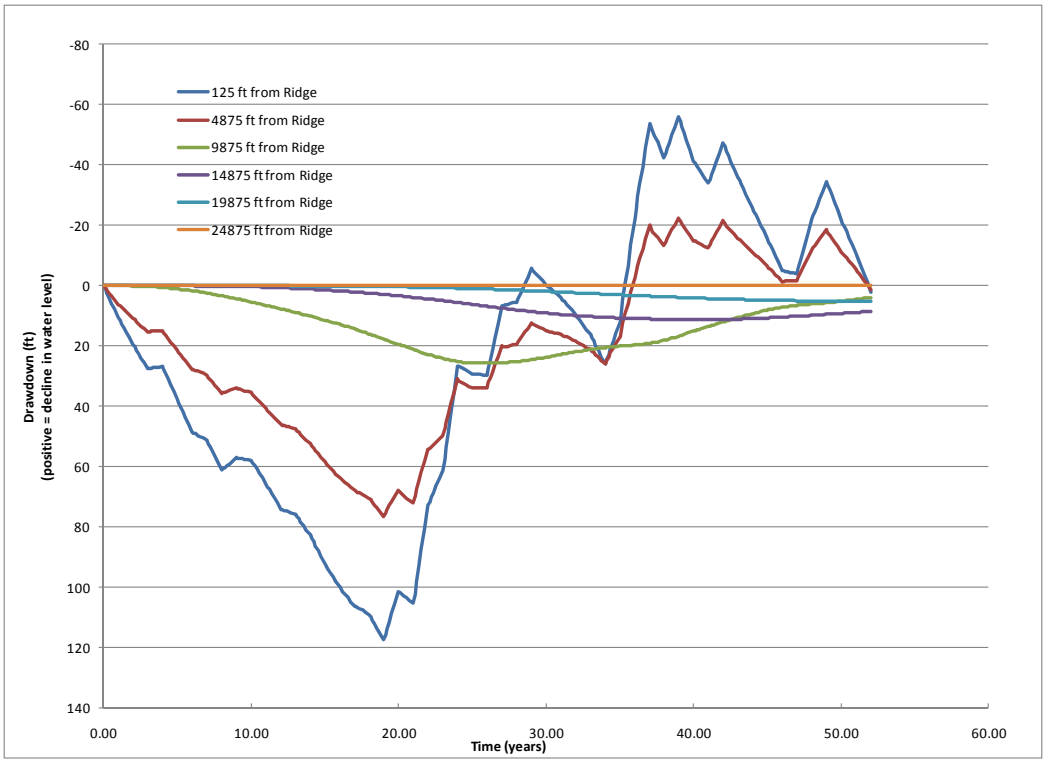


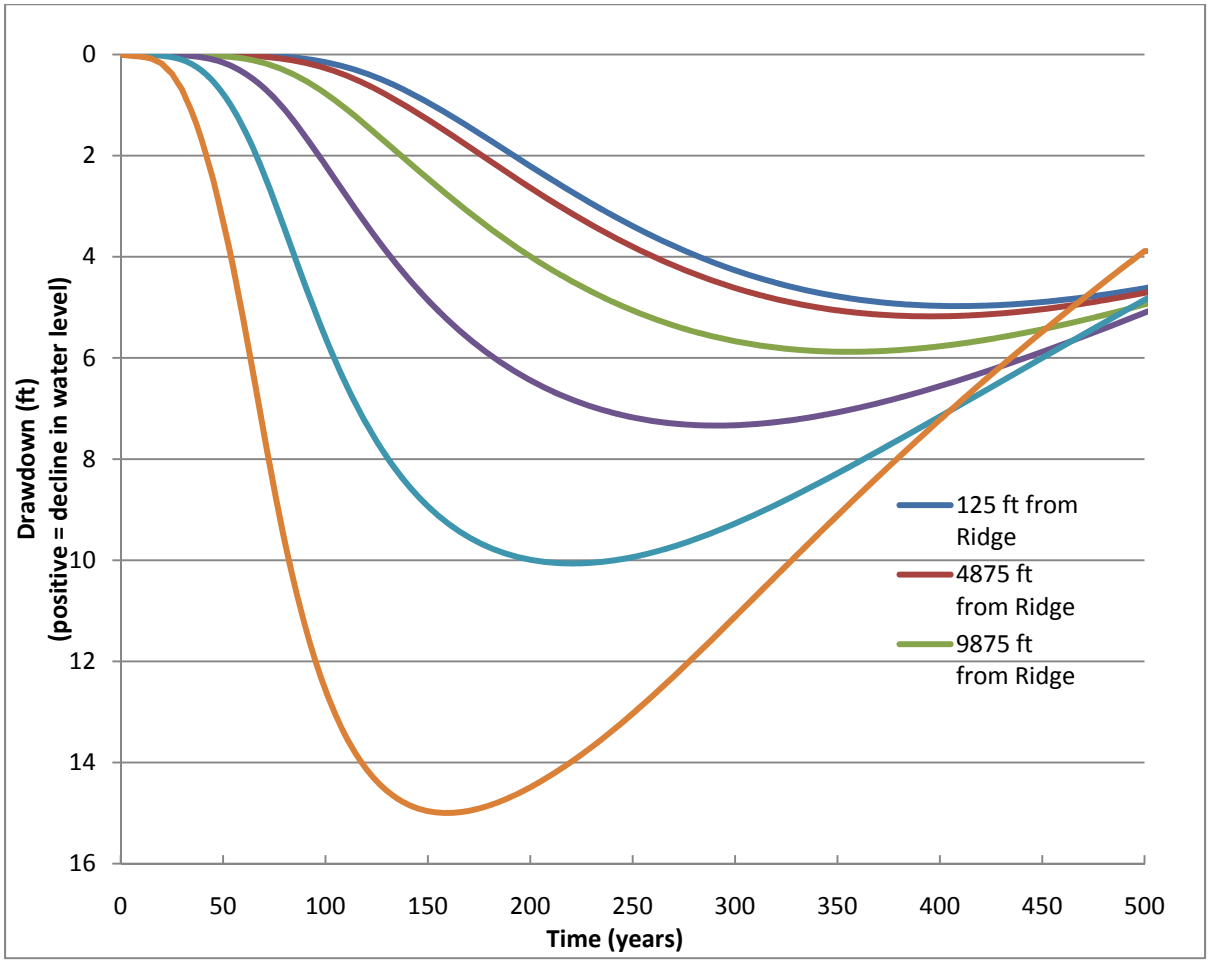
Figure 19: Drawdown in response to transient recharge, sensitivity case (recharge first 5,000 ft)



Sensitivity to Time-Varying Drawdown and Recovery in the Alluvial Aquifer

A separate model simulation was made to assess the effect of drawdown and recovery of groundwater levels in the alluvial aquifer on the water-table decline in the bedrock. As shown in Figures 10 and 11, groundwater levels in the alluvial aquifer equilibrate to changing conditions: first declining in response to pumping, then recovering followed by cessation of pumping. Figure 20 shows the response of groundwater levels in the bedrock as a result of declining then recovering groundwater levels in the alluvial aquifer for the 5,000 AFY recharge case, where the groundwater levels in the alluvial aquifer drawdown to 15 feet at the maximum and then recover after cessation of pumping. This simulation result demonstrates that the decline in the water table in the bedrock is arrested and never reaches the full extent of decline that would develop under a steady state condition, where groundwater levels in the alluvial aquifer are not assumed to recover. So, this simulation suggests that any potential impacts on the spring will be less than presented in the above simulation as a result of the recovery of groundwater levels in the alluvial aquifer.

Figure 20: Groundwater level responses in the bedrock due to drawdown and recovery in the alluvial aquifer (using the 5K AFY recharge scenario)



Summary and Discussion

There is no information demonstrating a physical connection of the springs to a regional groundwater table. If the springs are not connected to the regional water table, as illustrated in Concept-1, then no impacts to the springs are expected in response to the proposed project pumping operations.

Although there is no information that demonstrates a direct hydraulic connection between the springs and a regional groundwater table, Concept 2 assumes such as connection exists. Groundwater model results suggest that a bulk hydraulic conductivity of about 0.025 feet per day over a saturated thickness of 2,000 feet would be required to support a "mound" of groundwater below the Clipper Mountains such that the Bonanza Spring would be in contact with the regional water table (Concept-2).

Model results suggest that a ten foot decline in groundwater levels could result in about six to seven feet of drawdown at the springs after hundreds of years and assuming that the decline in the adjacent alluvial aquifer was maintained at ten feet of drawdown. For example, in the above simulations, after about 100 years, the drawdown would only be about 25 percent of the potential maximum drawdown in the alluvial aquifer. In addition, it is possible that, depending on how muted the water table response is to annual changes in precipitation, natural fluctuations of groundwater levels at the spring due to climate variability could be of a similar order of magnitude to potential project-induced drawdown at the springs. Such an impact is not considered to be material.

Under Concept 2, potential impacts to other springs in the southern part of Fenner Watershed are expected to be de minimus and even more remote than those potential impacts on the Bonanza Spring. Figures 21 through 23 show cross sections extending from the alluvial aquifer to Fenner, Barrel, and Honeymoon Springs, respectively. Plate 1 shows 1:1 (vertical to horizontal scales) cross sections for Barrel and Honeymoon Springs. These springs are at higher elevations and greater distances from the adjacent alluvial aquifer compared to Bonanza Spring. Groundwater-level drawdown in the alluvial aquifer is expected to be less in those areas adjacent to these springs compared to Bonanza Springs. Therefore, the impact to these springs is expected to be insignificant based on the assessment of the Bonanza Spring.

Potential Mitigation

The above analysis suggests that if there is no hydraulic connection between the springs and the regional groundwater table, there will be no impact on springs from the Project. If there is a hydraulic connection, the Project is not likely to have an impact, and if it does any impact would not be significant. It is anticipated that any effect on the water table would be small and it would take a long time for the spring to be affected such that recovery of groundwater levels may not have any effect whatsoever on the water table at the springs, and the effect may be subsumed with natural climatic background fluctuations in water table elevations in the bedrock. However, should the flow to the spring be affected, a mitigation measure could be to replace the flow to the spring by drilling a free-flowing well in the bedrock, which appears to be the origin of some springs in the area as described by the USGS' earlier studies in the area. Based on the estimated bedrock water table gradient of about 0.07 (ft/ft), a horizontal well would only need to be drilled laterally into the

bedrock a distance of about 150 feet to reach a point where the water table is 10 feet higher than it is at the spring. A well of about this "depth" should yield flow to the spring that would be similar to current pre-project flows. It would not be difficult to initiate such a measure, although it would be decades, if not centuries, before this would ever be required under the most conservative analysis.

References Cited

Bassett, A.M. and D.H. Kupfer. 1964. *A Geologic Reconnaissance in the Southeastern Mojave Desert, California*. California Division of Mines and Geology Special Report 83.

Bassett, A.M., D.H. Kupfer, and F.C. Barstow. 1959. *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California.* US Geological Survey Bulletin 1045-D. pp. 97-138.

Bedford, D.R., Miller, D.M., Phelps, G.A. 2006. *Preliminary Surficial Geologic Map Database of the Amboy 30x60 Minute Quadrangle, California.* U.S. Geological Survey Open-File Report 2006-1165.

Davisson, M.L. and Rose, T.P. 2000. *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*. Lawrence Livermore National Laboratory. UCRL-ID139027. p 15.

Dibblee, T.W., Jr. 1980a. *Pre-Cenozoic Rock Units of the Mojave Desert.* D.L. Fife and A.R. Brown, eds. Geology and Mineral Wealth of the California Desert. South Coast Geological Society. Santa Ana, CA.

Dibblee, T.W. 1980b. *Cenozoic Rock Units of the Mojave Desert*. D.L. Fife and A.R. Brown, eds. Geology and Mineral Wealth of the California Desert. South Coast Geological Society, Santa Ana, CA.

Dokka, R.K. and Travis, C.J. (Dokka). 1990. *Late Cenozoic Strike Slip Faulting in the Mojave Desert, California.* Tectonics, v. 9. No. 2. pp 311-340.

Freiwald, D.A. 1984. *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California.* US Geological Survey Water Resources Investigation Report 83-4082.

Gale, H.S. 1951. *Geology of the Saline Deposits, Bristol Dry Lake, San Bernardino County, California.* California Division of Mines and Geology Special Report 13.

GEOSCIENCE Support Services, Inc. (GSSI). 1995. *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins*. Prepared for Cadiz Land Company, Inc. (Cadiz Inc.) and Mojave Water District. September 6.

GEOSCIENCE Support Services, Inc. (GSSI). 1999. *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volumes I and II.* Prepared for the Metropolitan Water District of Southern California. November 1999.

GEOSCIENCE Support Services, Inc. (GSSI). 2011. Cadiz Groundwater Conservation and Storage Project, Phase 1 – Conservation Scenarios. Draft Technical Memorandum. Prepared for Brownstein Hyatt Farber Schreck, LLP. June 16, 2011.

Handford, C.R. 1982. *Sedimentology and Evaporite Genesis in a Holocene Continental Sabkha Playa Basin - Bristol Dry Lake, California.* Sedimentology, Volume 29.

Hazlett, R.W. 1992. "Some Thoughts on the Development of Amboy Crater." *Old Routes to the Colorado.* San Bernardino County Museum Association Special Publication 92-2.

Howard, K.A. and D.M. Miller. 1992. "Late Cenozoic Faulting at the Boundary between the Mojave and Sonoran Blocks: Bristol Lake Area, California." S.M. Richard, ed. *Deformation Associated with the Neogene Eastern California Shear Zone, Southwestern Arizona and Southeastern California: Redlands, California*. San Bernardino County Museums Special Publication 92-1. pp. 37-47.

Jachens, R.C., and Howard, K.A. 1992. "Bristol Lake Basin – A Deep Sedimentary Basin Along the Bristol-Danby Trough, Mojave Desert." *Old Routes to the Colorado*. San Bernardino County Museums Special Publication 92-2. Redlands, CA. pp 57·59.

Karlstrom. K.E., Miller, C.F., Kingsbury, J.A., and Wooden, J.L. 1993. *Pluton Emplacement Along an Active Ductile Thrust Zone. Piute Mountains. Southeastern California. Interaction Between Deformation and Solidification Processes.* Geological Society of America Bulletin. Vol. 105. p 213-230.

Kinney, Miles. Draft Geologic Structural Evaluation of the Fenner Gap Region located between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California. Prepared for Scott Slater, Brownstein Hyatt Farber Schreck, LLP. June 20, 2011.

Maas, J. 1994. *Depth to Basement Calculated from Gravity Data.* Proprietary report to Cadiz Land Company, Inc. (Cadiz Inc.)

Mendenhall, W.C. 1909. *Some Desert Water Places in Southern California and Southwestern Nevada.* US Geological Survey, Water-Supply Paper 224.

Metropolitan Water District of Southern California. 2001. *Cadiz Groundwater Storage and Dry-Year Supply Program: Final Environmental Impact Report / Final Environmental Impact Statement*. SCH No. 99021039, Report No. 1174 (in 4 volumes).

Moyle, W.R. 1967. *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*. California Department of Water Resources Bulletin 91-14.

NORCAL Geophysical Consultants, Inc. (NORCAL). 1997. *Seismic Reflection Survey Cadiz Valley, Cadiz, California.* Proprietary report to Cadiz, Inc.

Parker, R.B. 1963. *Recent Volcanism at Amboy Crater San Bernardino County*. California Division of Mines and Geology Special Report 76. p 22.

Rosen, M.R. 1989. *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate.* Ph.D. Dissertation, University of Texas, Austin, Texas. pp 266.

Simpson, R.W., R.C. Bracken, and D.J. Stierman. 1984. *Aeromagnetic, Bouguer Gravity, and Interpretation Maps, Sheep Hole-Cadiz Wildness Study Area, California.* U.S. Geological Survey MF 1615-B, 4 sheets, scale 1:62,500.

Thompson, D.G. 1929. *The Mohave Desert Region, California, A geographic, geologic, and hydrologic reconnaissance.* U.S. Geological Survey Water Supply Paper, 578. pp 795.

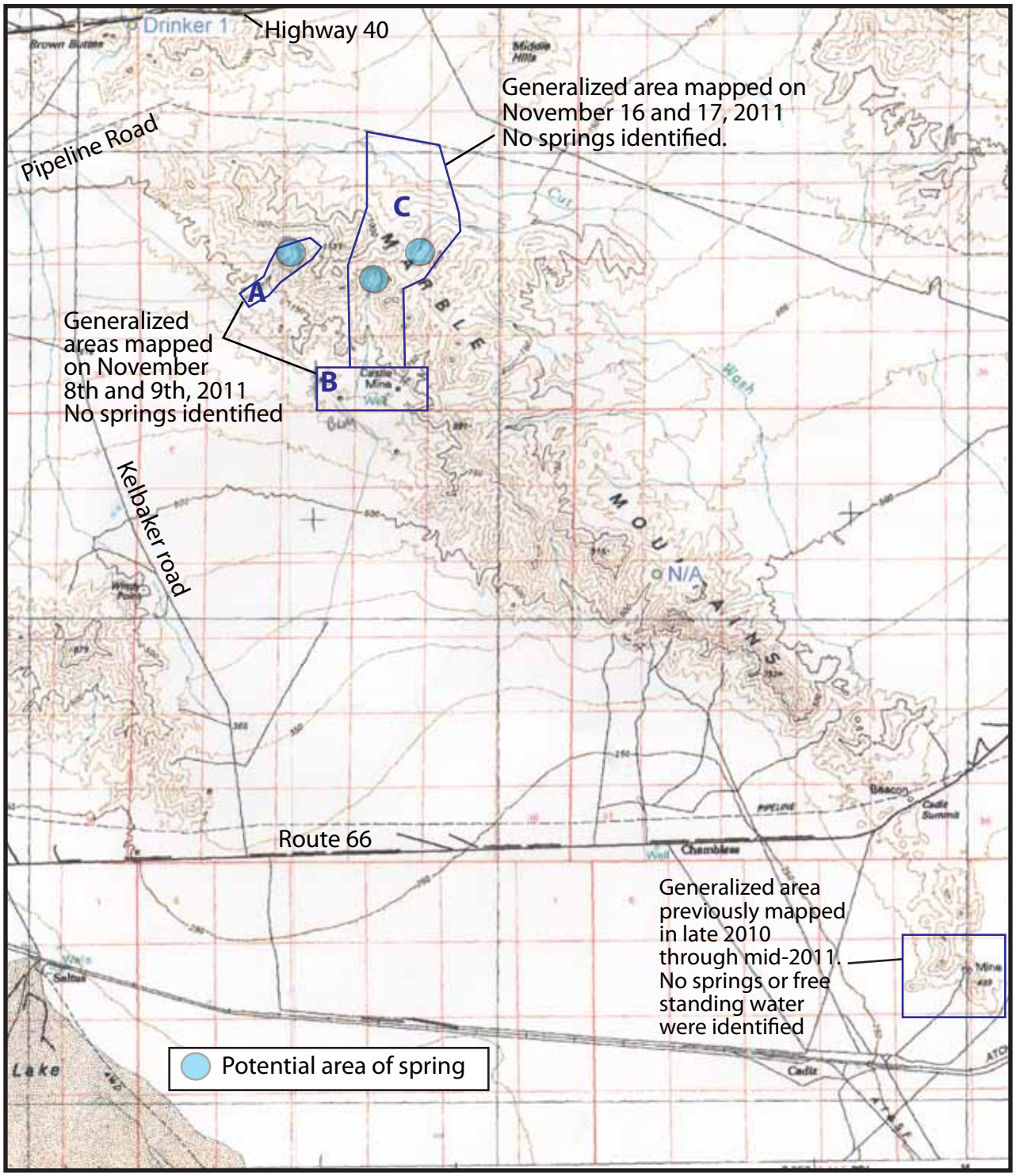
U.S. Geological Survey (USGS). 2000. *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources,*

Volumes I and II. Memorandum from James F. Devine to Molly S. Brady, Field Manager, Bureau of Land Management, Needles, California. February 23, 2000.

U.S. Geological Survey (USGS). 2006a. National Elevation Dataset. http://ned.usgs.gov/

U.S. Geological Survey (USGS). 2006b. *Geology and Mineral Resources of the East Mojave National Scenic Area, San Bernardino County, California.* U.S. Geological Survey Bulletin 2160.

U.S. Geological Survey (USGS). 2009. Online Well Database. http://waterdata.usgs.gov/ca/nwis/inventory and http://waterdata.usgs.gov/nwis/gwconstruction.

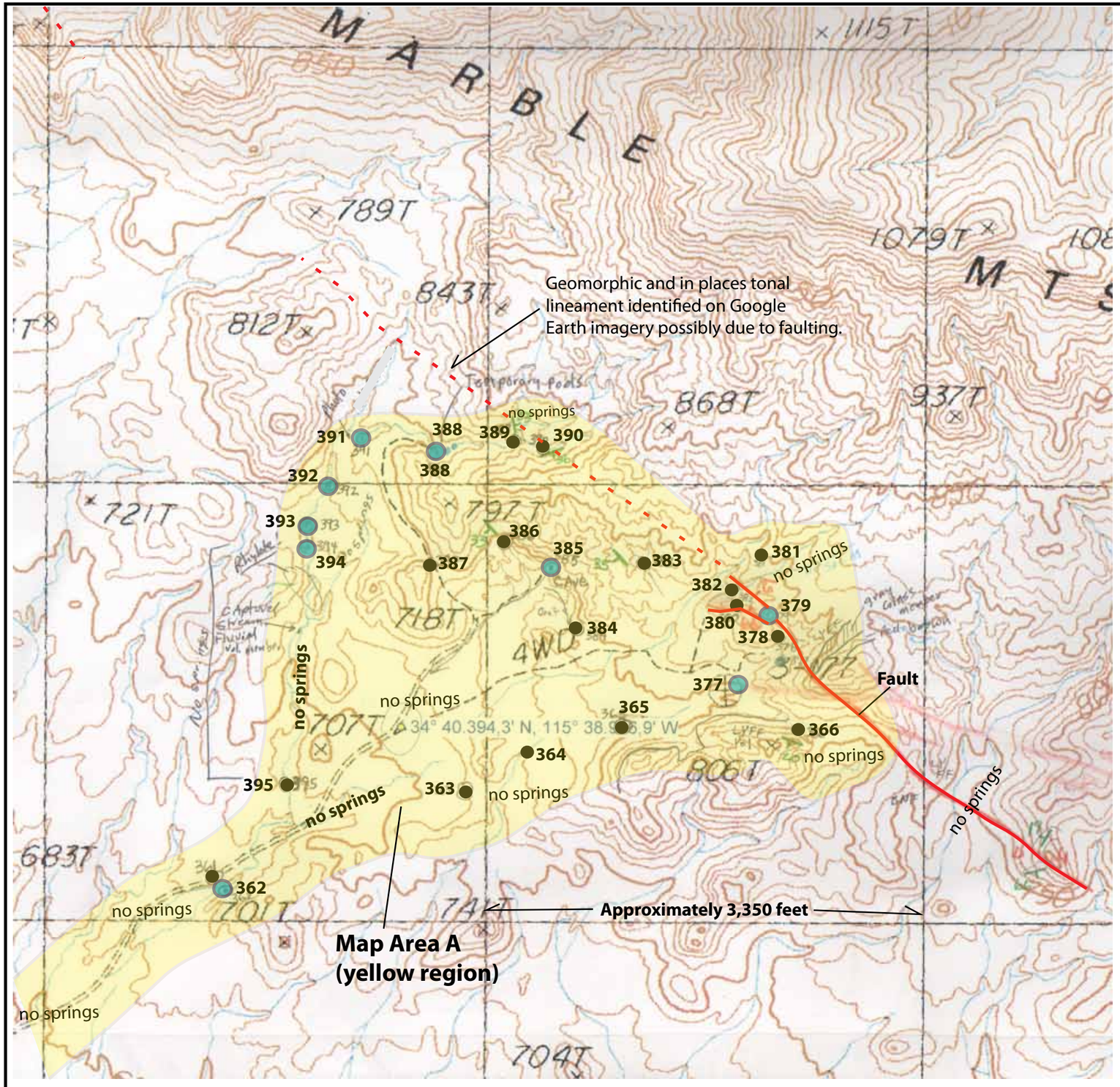


Base map source: USGS 250,000 scale topographic map.

0 2

Scale (miles) N

CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGIONS IN NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 8, 9, 16 and 17, 2011		MDK 11/2011
	Kenney GeoScience	Plate 1



Symbol Descriptions

362 Location of map site with water filled tinaja (a depression that can hold water cut into bedrock - locally volcanic rocks). Most tinajas were 6 to 8 inches wide and 4-inches deep. The largest was at site 392 which was ~3 feet wide and 2 feet deep. During mapping, the water was fresh, with no odor, no biotic life, and no vegetation grew near the tinaja's. Water is likely temporary and associated with local recent precipitation.

One exception is site 385 which was not a tinaja, but instead moisture observed at the top of an approximately 15 foot deep cave at the base of a tall stream cliff.

395 Location of map site where no water was observed. In addition, no springs were observed between consecutive mapped sites as these areas were evaluated.

Base map source: USGS 24,000 scale topographic map - enlarged.

N

CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGION "A" IN NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 9, 2011	Kenney GeoScience	MDK 11/2011
		Plate 2

Base map source: Google Earth Imagery.

0 ~1500

Scale (feet)

N

Symbol Descriptions

362 Location of map site with water filled tinaja (a depression that can hold water cut into bedrock - locally volcanic rocks). Most tinajas were 6 to 8 inches wide and 4-inches deep. The largest was at site 392 which was ~3 feet wide and 2 feet deep. During mapping, the water was fresh, with no odor, no biotic life, and no vegetation grew near the tinaja's.

One exception is site 385 which was not a tinaja, but instead moisture observed at the top of a 15 foot deep cave at the base of a tall stream cliff.

395 Location of map site where no water was observed. In addition, no springs were observed between consecutive mapped sites as these areas were evaluated.

CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGION "A" IN NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 9, 2011		MDK 11/2011
	Kenney GeoScience	Plate 3

Base map source: Google Earth Imagery.

Symbol Description

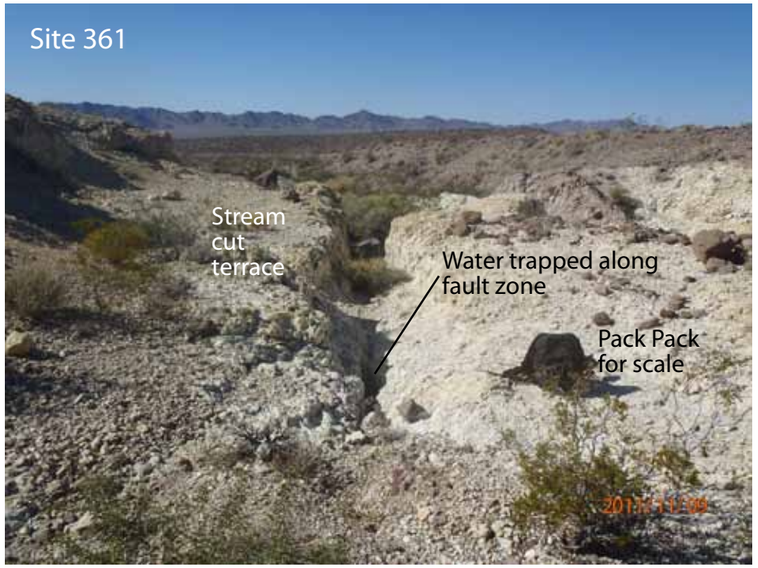
360 — Location of map site where no water was observed.

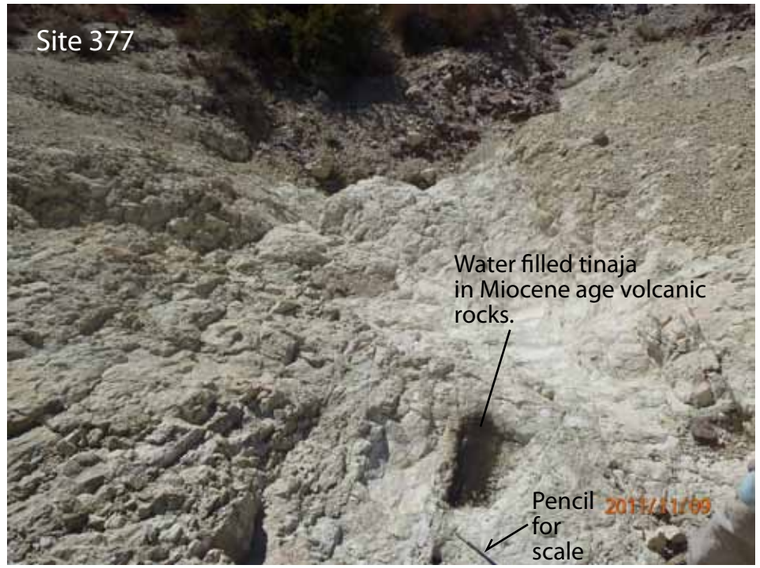
N

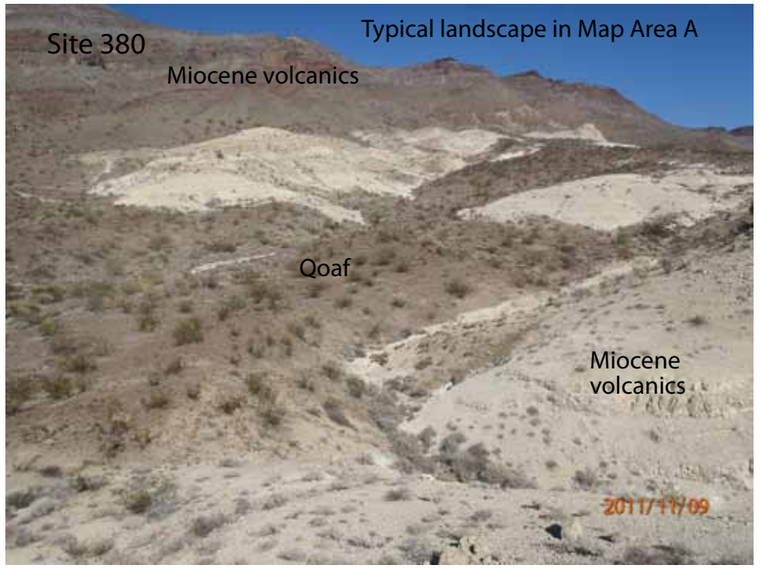
0 ~1000

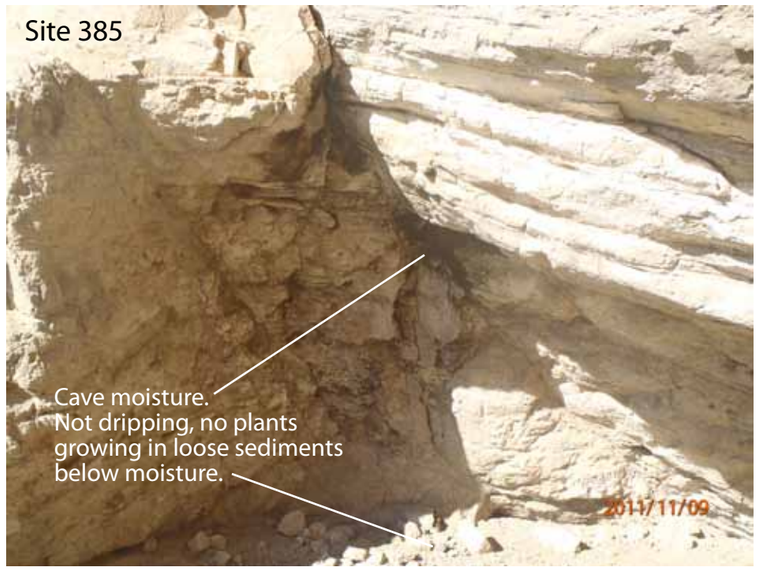
Scale (feet)

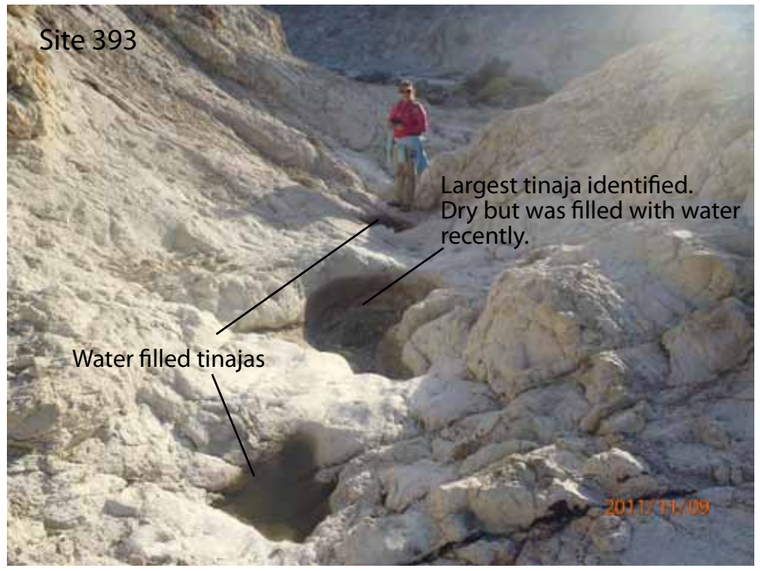
CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGION "B" IN NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 8, 2011	Kenney GeoScience	MDK 11/2011
		Plate 4



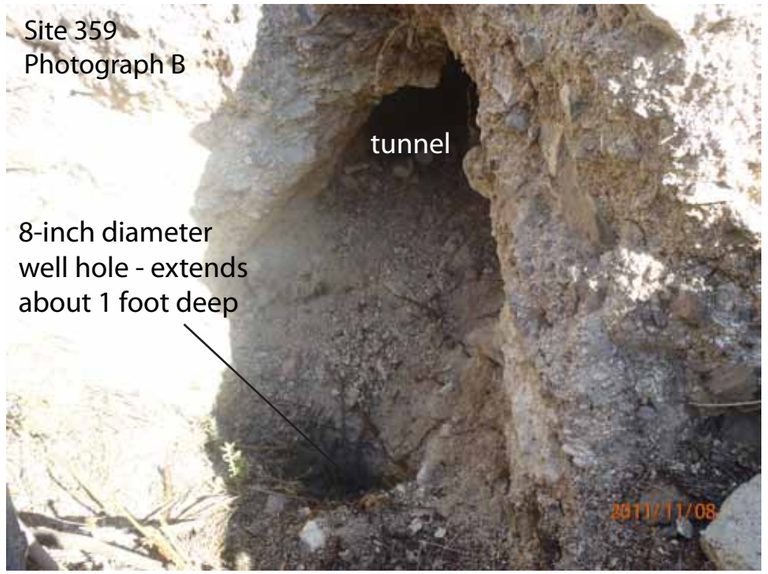


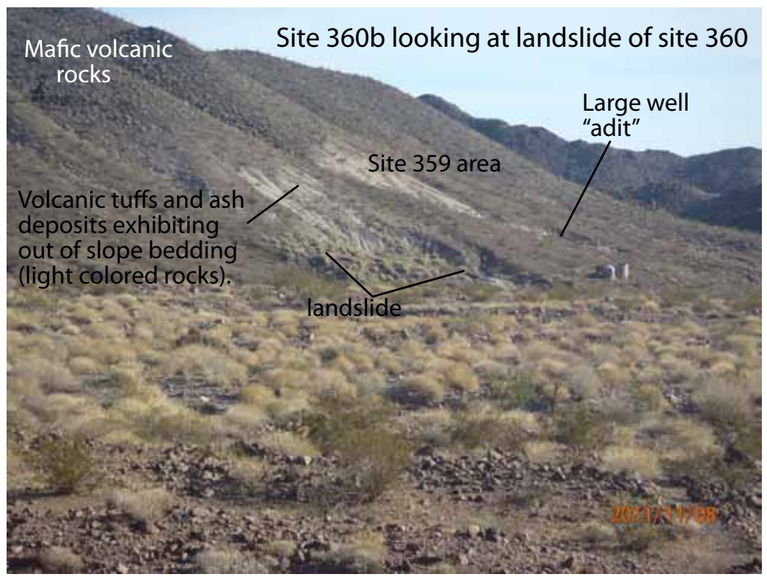






CADIZ GROUNDWATER PROJECT		JN 716-10
PHOTOGRAPHS IN MAP AREA "A" IN THE NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 9, 2011		MDK 11/2011
	Kenney GeoScience	Plate 5





CADIZ GROUNDWATER PROJECT

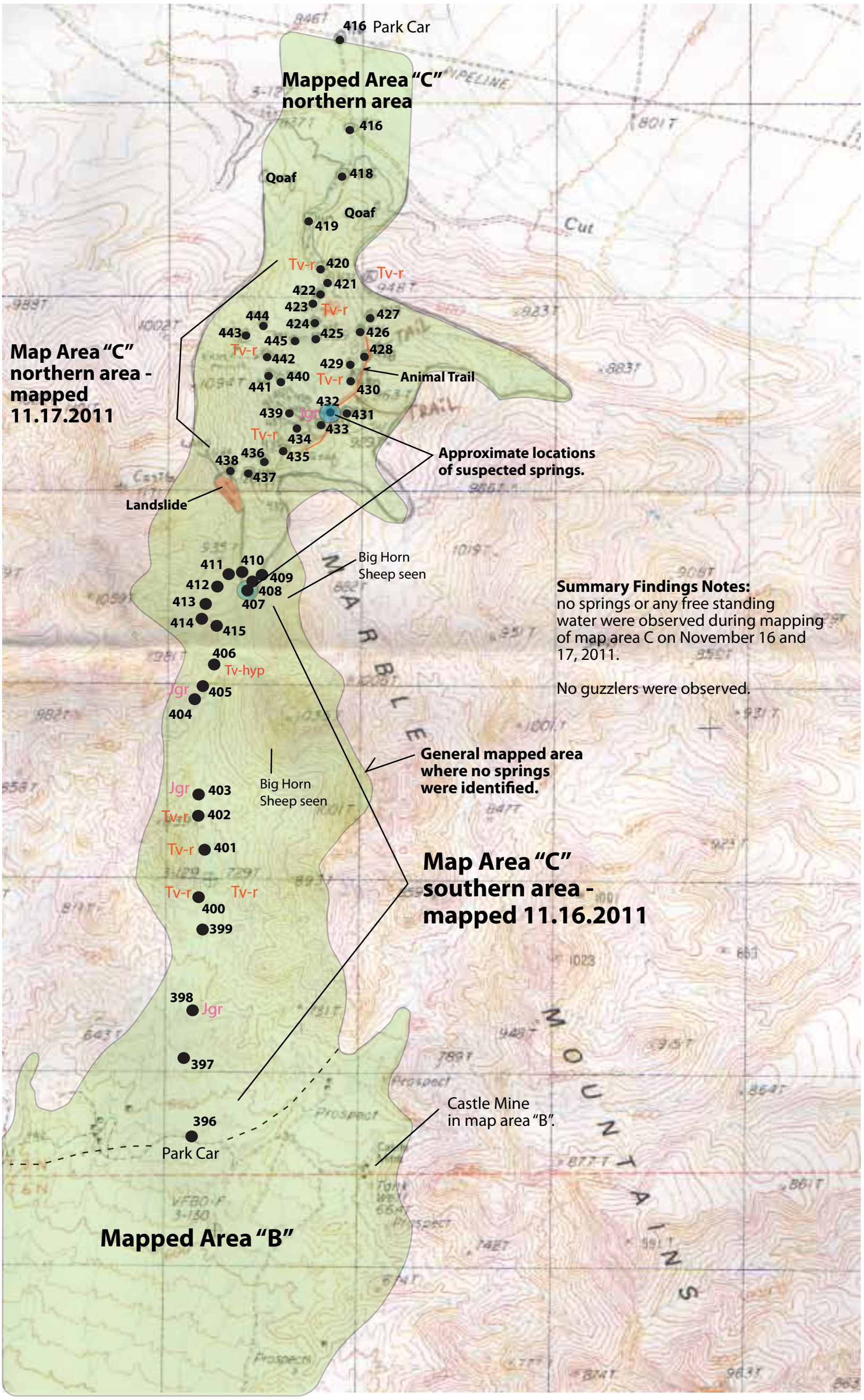
JN 716-10

PHOTOGRAPHS IN MAP AREA "B" IN THE
NORTHWESTERN MARBLE MOUNTAINS
IN SEARCH OF SPRINGS - NOVEMBER 8, 2011

MDK | 11/2011

Kenney GeoScience

Plate 6



USGS 7.5 minute Topographic Map

445 ● Location of map site where no water was observed. In addition, no springs were observed between consecutive mapped sites as these areas were evaluated during mapping (hiking).

0 ~1

Scale (miles)

N

CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGION "C" IN NORTHWESTERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 16 & 17, 2011	Kenney GeoScience	MDK 11/16&17/2011
		Plate 7

SYMBOLS

415 — Approximate field site location where no springs or free standing water were observed. In addition, no surface water was observed during mapping between site locations. Visual observations up various canyons did not exhibit any vegetation "clusters" suggesting the presence of a spring as indicated by "no springs".

Generalized Rock Types

Qoaf Quaternary Older Alluvium

Tv-r Tertiary (Miocene) volcanic rocks dominately siliceous (rhyolitic).

Tv-hyp Tertiary (Miocene) igneous rocks that cooled close to the surface (hypabyssal).

Jgr Jurassic igneous plutonic rocks.

Summary Findings Notes:
no springs or any free standing water were observed during mapping in the southern region of map area C on November 16, 2011.

No guzzlers were observed.

Base map source: Google Earth Imagery.

0 ~1300

Scale (feet)

N

CADIZ GROUNDWATER PROJECT

MAPPED REGION "C-Southern" IN THE NORTHERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 16, 2011

JN 716-10

MDK 11/2011

Kenney GeoScience

Plate 8

SYMBOLS

415 ○ Approximate field site location where no springs or free standing water were observed. In addition, no surface water was observed during mapping between site locations. Visual observations up various canyons did not exhibit any vegetation "clusters" suggesting the presence of a spring as indicated by "no springs".

Qoaf Quarternary Older Alluvial fan

Tv-r Tertiary (Miocene) volcanic rocks, dominately siliceous (rhyolitic).

Jgr Jurassic igneous plutonic rocks.

Summary Findings Notes:
no springs or any free standing water were observed during mapping in the northern region of map area C on November 17, 2011.

No guzzlers were observed.

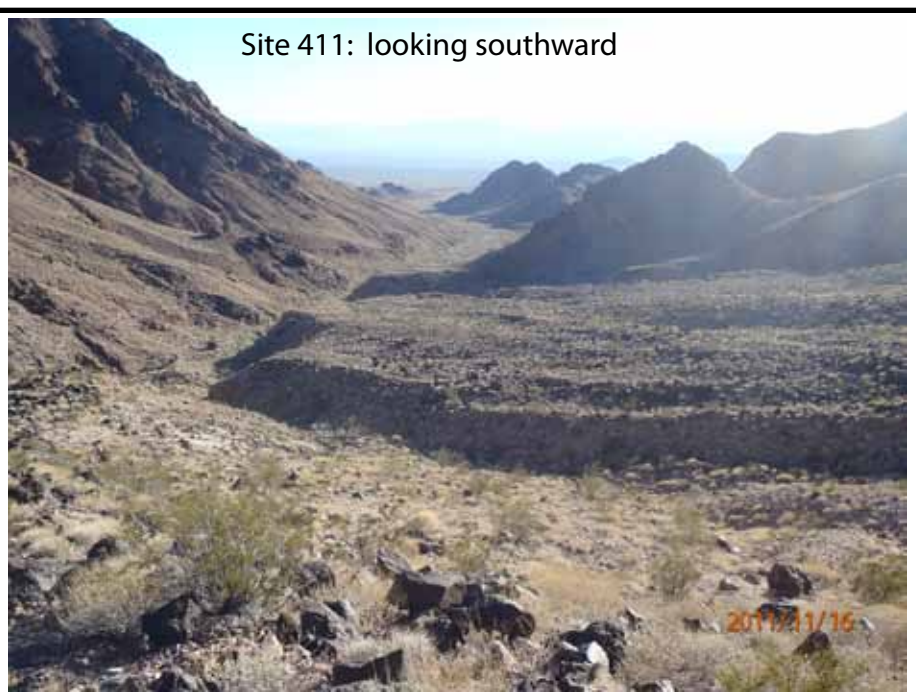
Site 438 is approximately 500' west of site 437 standing above the landslide - no springs observed at toe of slide (see Plate 7)

0 ~900
Scale (feet)

N

Base map source: Google Earth Imagery.

CADIZ GROUNDWATER PROJECT		JN 716-10
MAPPED REGION "C-Northern" IN THE NORTHERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 17, 2011		MDK 11/2011
	Kenney GeoScience	Plate 9



CADIZ GROUNDWATER PROJECT

JN 716-10

PHOTOGRAPHS OF MAPPED REGION "C-Southern" IN THE NORTHERN MARBLE MOUNTAINS IN SEARCH OF SPRINGS - NOVEMBER 16, 2011

MDK | 11/2011

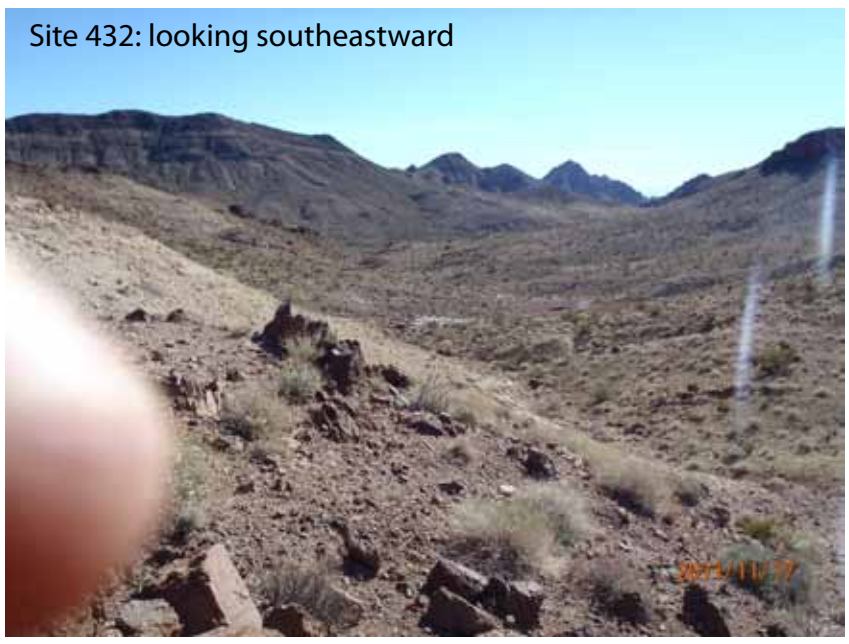
Kenney GeoScience

Plate 10

Site 427: looking east

Site 437: view to the south into southern map area C.

Site 432: looking southeastward



VSite 437: view to the east

Site 433: area of previously mapped spring;
dry watering hole dug out by animals in alluvium.

Site 437: view to the south in the southern region of map area C. Landslide is just to the right of this photograph.

Site 435: Tinaja in Tv-r; dry.

Site 438: Landslide in Tv

CADIZ GROUNDWATER PROJECT

JN 716-10

PHOTOGRAPHS OF MAPPED REGION "C-Northern" IN THE NORTHERN MARBLE MOUNTAINS IN EARCH OF SPRINGS - NOVEMBER 17, 2011

MDK 11/2011

Kenney GeoScience

Plate 11

Technical Memorandum

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

From:	Dennis E. Williams, Ph.D. President GEOSCIENCE Support Services, Inc.
Date:	November 14, 2011
Subject:	**Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis (Geoscience)**

This Technical Memorandum provides a supplemental assessment of historical geohydrologic conditions at the Cadiz Agricultural Wellfield and additional information with regards to the selected groundwater extraction scenarios and wellfield configuration.

1.0 Discussion of Change in Water Levels in Cadiz Agricultural Wellfield Area

The Cadiz Agricultural Wellfield extracts groundwater from aquifers that are for the most part semi-confined or leaky. A semi-confined aquifer is an aquifer that has lower permeability sedimentary units above the main aquifer system as well as in the main aquifer system. The result is that when the wellfield is operated, an immediate drop in the water level occurs in association with the recharge to the well field. This cone of depression expands in a logarithmic form from each of the wells, overlapping when interference occurs. The cone of depression continues to expand outward away from the wellfield until the recharge is sufficient to meet the wellfield demands. During this time, the cone of depression behaves like a confined aquifer system until the vertical hydraulic gradient is established to allow leakage from the upper saturated materials through the aquitards to the main aquifer system. As such, there is a time lag associated with the pumping of a semi-confined system such as the Cadiz Agricultural Wellfield before stabilization occurs. The time lag may occur over decades as in the Cadiz Agricultural Wellfield case. This phenomenon is very similar to the phenomenon of delayed yield in unconfined aquifers. That is, in the early stages of operations, the aquifer system behaves as a confined system until the delayed yield of the vertical gravity drainage “catches up” and allows stabilization of

ground water levels. The fact that this is a semi-confined system is supported by: (1) static (non-pumping) water levels rising above the top of the well screens; (2) aquifer parameters calculated from pumping test data; and (3) the stratigraphy of the aquifer as assessed from the lithologic logs of the wells.

Therefore, the stresses caused by Cadiz agricultural pumping have not created sufficient recharge (from vertical leakage or other induced recharge) to sufficiently stabilize water levels.

2.0 Selection of 50,000 acre-ft/yr for Proposed Conservation Pumping

The Project intends to conserve groundwater from evaporation to dry lakes by retrieving groundwater presently down gradient from the well-field in addition to capturing natural recharge. Previous analysis (GEOSCIENCE Technical Memorandum dated September 20, 2011) has shown that pumping in excess of the natural recharge is necessary to reduce the evaporative losses to the dry lakes. Project pumping of 50,000 acre-ft/yr and 75,000 acre-ft/yr was used for determining the volumes of conservation using the ground water model. The analysis showed that conservation of evaporative losses increases with increased Project pumping by retrieving water that was moving down-gradient towards the dry lakes. That is to say Project pumping of 50,000 acre-ft/yr will result in increased conservation of evaporative losses above the natural recharge (32,000 acre-ft/yr) and Project pumping of 75,000 acre-ft/yr will further increase conservation by reducing outflows to the dry lakes. However, due to Project uncertainties with natural recharge, a pumping rate of 50,000 acre-ft/yr was selected for the Project to balance the objective of retrieving water before it can evaporate with the intent to minimize impacts. Pumping of less than the proposed 50,000 acre-ft/yr will result in an increase of loss to the dry lakes relative to Project pumping of 50,000 acre-ft/yr.

The aquifer storage created from the 50-year period of operation will allow natural recharge to fill the area of vacated storage resulting in continued minimal losses to the dry lakes during the early part of the recovery phase. Losses to evaporation will increase as ground water levels rise to pre-project conditions.

3.0 Discussion of Wellfield Configuration

Two wellfield configurations were used to address the potential range in recharge rates and thus transmissivity variations of the aquifer. The wellfield construction will be “Phased”. That is, a group of wells will be constructed initially in the Fenner Gap area. Long-term pumping tests on these wells will be used to validate regional aquifer characteristics. Based on these data, the model will be recalibrated

and subsequent well locations will be based on the optimum locations from the regional aquifer tests. The wellfield installation is adaptable to the findings from the field data.

4.0 Additional Model Runs and Relationship to Wellfield Configuration

Two wellfield configurations were used in the September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis to address the potential range in recharge rates and thus transmissivity variations of the aquifer. Wellfield configuration A focuses pumping in the Fenner Gap, including the use of high capacity wells in the carbonate aquifer, in the case of 32,000 acre-ft/yr of recharge. If, while installing the production wells, it is determined that the aquifer it not as transmissive as estimated from the 32,000 acre-ft/yr recharge, the lateral distance between each pumping well will be increased as shown in configuration B. So, the installation of the wellfield is adaptive to findings in the field.

Three additional groundwater flow model runs were made including (See Attached Tables):

- Natural Recharge of 32,000 acre-ft/yr with Wellfield configuration B,
- Natural Recharge of 16,000 acre-ft/yr with Wellfield configuration A, and
- Natural Recharge of 5,000 acre-ft/yr with Wellfield configuration A.

The following table summarizes the predicted drawdown at the end of 50 years (i.e., end of Project pumping) under each wellfield configuration and natural recharge conditions.

Natural Recharge	Wellfield Configuration A		Wellfield Configuration B	
	Drawdown at Wellfield [ft]	Drawdown at Bristol Dry Lake [ft]	Drawdown at Wellfield [ft]	Drawdown at Bristol Dry Lake [ft]
32,000 acre-ft/yr	70 – 80	10 – 30	60 – 70	10 - 40
16,000 acre-ft/yr	170 – 180	10 – 50	120 – 130	10 – 60
5,000 acre-ft/yr	380 – 390	0 – 70	260 - 270	0 – 80

As shown, under natural recharge of 5,000 acre-ft/yr conditions, an additional 120 ft of drawdown would occur with wellfield configuration A as compared to wellfield configuration B. As can be seen in the above table, when assumed recharge rates are low, drawdowns are increased for the centralized wellfield configuration A. The increased drawdowns occur in these low recharge scenarios as in order to calibrate, the transmissive characteristics of the aquifer were also made very low. What this is saying is that for low recharge rates the wellfield needs to be "spread out" and not centralized as in Wellfield Configuration A. As a result, the wellfield construction will be "Phased" as described above in section 3.0. That is, a group of wells will be constructed initially and long-term pumping tests run on these wells to validate regional aquifer characteristics. Based on these data, the model will be recalibrated and subsequent well locations based on the optimum locations from regional aquifer tests. This illustrates the importance of installation of a wellfield that is adaptable to the findings from the field data.

5.0 Explanation of Depth to Groundwater and Additional Table

In the Cadiz Groundwater Modeling and Impact Analysis, existing depth to water was based on the model-generated depth to water at five selected locations (see Figure 71 of the report) at the end of transient model calibration (i.e., December 2009). These locations were selected for the purpose of evaluation of groundwater water impacts and are not actual wells. In general, the water levels at these locations are consistent with the groundwater level contours shown in Figure 2 of the report and our interpretation of depth to water control point data by Moyle (1967) and Shafer (1964) (see Figure 2 of GEOSCIENCE, 2000[1]). For example, the model-calculated depth to water of 33 ft and 18 ft and the edge and center of Bristol Dry Lake, respectively, is consistent with our interpreted depths of 39 ft and 16 ft.

The table shown in page 52 of the report is revised to the following:

Location	Model-Calculated Depth to Groundwater (December 2009) [ft]	Time	Depth to Groundwater [ft]		
			Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	354	End of 50 Years	435	486	627
		End of 100 Years	351	371	412

[1] Cadiz Groundwater Storage and Dry-Year Supply Program Dry Lake Evapotranspiration Estimates. Prepared for the Metropolitan Water District of Southern California. June 19, 2000.

Existing Cadiz Wells	156	End of 50 Years	197	241	315
		End of 100 Years	154	181	219
Edge of Bristol Dry Lake	33	End of 50 Years	68	95	118
		End of 100 Years	42	74	108
Center of Bristol Dry	18	End of 50 Years	50	63	54
		End of 100 Years	33	62	79
Edge of Cadiz Dry Lake	7	End of 50 Years	21	59	72
		End of 100 Years	10	17	68

The depth to water of 18 feet shown in the table above represents only one model cell (an area of 500 ft by 500 ft) in the Bristol Dry Lake. The model-calculated average evaporation during the period from 1986 to 2009 was 30,300 acre-ft/yr, 15,000 acre-ft/yr and 4,800 acre-ft/yr for natural recharge of 32,000 acre-ft/yr, 16,000 acre-ft/yr and 5,000 acre-ft/yr, respectively.

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
1	**1986**	32,422	32,384	2,970	-2,932	-2,932
2	**1987**	32,422	32,244	3,366	-3,188	-6,120
3	**1988**	32,422	32,041	4,059	-3,678	-9,798
4	**1989**	32,422	31,793	5,940	-5,311	-15,109
5	**1990**	32,422	31,472	6,689	-5,738	-20,847
6	**Jan-91**	2,700	2,608	48	45	-20,802
7	**Feb-91**	2,700	2,606	109	-14	-20,817
8	**Mar-91**	2,700	2,604	120	-23	-20,840
9	**Apr-91**	2,700	2,602	321	-222	-21,062
10	**May-91**	2,700	2,600	484	-383	-21,446
11	**Jun-91**	2,700	2,598	625	-522	-21,968
12	**Jul-91**	2,700	2,596	653	-549	-22,517
13	**Aug-91**	2,700	2,594	457	-351	-22,867
14	**Sep-91**	2,700	2,592	279	-171	-23,038
15	**Oct-91**	2,700	2,591	203	-93	-23,132
16	**Nov-91**	2,700	2,589	151	-40	-23,172
17	**Dec-91**	2,700	2,588	136	-23	-23,195
18	**Jan-92**	2,700	2,586	13	101	-23,094
19	**Feb-92**	2,700	2,585	143	-27	-23,121
20	**Mar-92**	2,700	2,583	287	-170	-23,291
21	**Apr-92**	2,700	2,582	479	-360	-23,651
22	**May-92**	2,700	2,580	592	-472	-24,123
23	**Jun-92**	2,700	2,579	594	-472	-24,595
24	**Jul-92**	2,700	2,577	797	-674	-25,269
25	**Aug-92**	2,700	2,576	395	-271	-25,540
26	**Sep-92**	2,700	2,575	285	-160	-25,700
27	**Oct-92**	2,700	2,574	56	71	-25,629
28	**Nov-92**	2,700	2,573	46	82	-25,548
29	**Dec-92**	2,700	2,571	77	52	-25,496
30	**Jan-93**	2,700	2,570	127	3	-25,492
31	**Feb-93**	2,700	2,569	157	-25	-25,518
32	**Mar-93**	2,700	2,568	228	-96	-25,613
33	**Apr-93**	2,700	2,567	319	-185	-25,798
34	**May-93**	2,700	2,565	622	-487	-26,285
35	**Jun-93**	2,700	2,565	747	-611	-26,896
36	**Jul-93**	2,700	2,564	781	-644	-27,541
37	**Aug-93**	2,700	2,562	479	-341	-27,882
38	**Sep-93**	2,700	2,562	349	-210	-28,092
39	**Oct-93**	2,700	2,561	295	-155	-28,247
40	**Nov-93**	2,700	2,559	125	16	-28,231
41	**Dec-93**	2,700	2,559	46	95	-28,136
42	**Jan-94**	2,700	2,557	88	55	-28,081
43	**Feb-94**	2,700	2,556	155	-11	-28,092
44	**Mar-94**	2,700	2,555	331	-186	-28,278
45	**Apr-94**	2,700	2,554	619	-473	-28,751

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
46	**May-94**	2,700	2,553	796	-648	-29,399
47	**Jun-94**	2,700	2,552	895	-747	-30,146
48	**Jul-94**	2,700	2,551	858	-708	-30,854
49	**Aug-94**	2,700	2,549	475	-323	-31,177
50	**Sep-94**	2,700	2,548	235	-83	-31,260
51	**Oct-94**	2,700	2,547	83	70	-31,191
52	**Nov-94**	2,700	2,546	47	108	-31,082
53	**Dec-94**	2,700	2,545	154	2	-31,081
54	**Jan-95**	2,700	2,543	35	122	-30,959
55	**Feb-95**	2,700	2,542	249	-91	-31,050
56	**Mar-95**	2,700	2,541	382	-223	-31,272
57	**Apr-95**	2,700	2,540	577	-416	-31,689
58	**May-95**	2,700	2,539	960	-798	-32,487
59	**Jun-95**	2,700	2,538	1,233	-1,071	-33,558
60	**Jul-95**	2,700	2,537	605	-441	-33,999
61	**Aug-95**	2,700	2,536	624	-459	-34,459
62	**Sep-95**	2,700	2,535	589	-423	-34,882
63	**Oct-95**	2,700	2,533	417	-249	-35,131
64	**Nov-95**	2,700	2,532	171	-3	-35,134
65	**Dec-95**	2,700	2,531	128	42	-35,092
66	**Jan-96**	2,700	2,530	156	15	-35,078
67	**Feb-96**	2,700	2,528	275	-103	-35,181
68	**Mar-96**	2,700	2,527	612	-439	-35,619
69	**Apr-96**	2,700	2,526	770	-596	-36,215
70	**May-96**	2,700	2,524	919	-742	-36,957
71	**Jun-96**	2,700	2,523	951	-774	-37,731
72	**Jul-96**	2,700	2,522	855	-676	-38,407
73	**Aug-96**	2,700	2,520	418	-238	-38,645
74	**Sep-96**	2,700	2,519	428	-246	-38,891
75	**Oct-96**	2,700	2,517	217	-34	-38,925
76	**Nov-96**	2,700	2,516	57	128	-38,797
77	**Dec-96**	2,700	2,514	62	124	-38,673
78	**Jan-97**	2,700	2,513	114	74	-38,599
79	**Feb-97**	2,700	2,512	194	-6	-38,605
80	**Mar-97**	2,700	2,510	433	-242	-38,848
81	**Apr-97**	2,700	2,509	659	-467	-39,315
82	**May-97**	2,700	2,508	814	-621	-39,936
83	**Jun-97**	2,700	2,506	969	-775	-40,711
84	**Jul-97**	2,700	2,506	862	-668	-41,378
85	**Aug-97**	2,700	2,504	593	-397	-41,775
86	**Sep-97**	2,700	2,503	387	-190	-41,965
87	**Oct-97**	2,700	2,502	262	-63	-42,028
88	**Nov-97**	2,700	2,501	76	123	-41,905
89	**Dec-97**	2,700	2,500	100	100	-41,804
90	**Jan-98**	2,700	2,498	120	82	-41,722

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
91	**Feb-98**	2,700	2,497	88	115	-41,607
92	**Mar-98**	2,700	2,497	257	-54	-41,661
93	**Apr-98**	2,700	2,495	442	-237	-41,898
94	**May-98**	2,700	2,494	758	-552	-42,450
95	**Jun-98**	2,700	2,494	810	-603	-43,053
96	**Jul-98**	2,700	2,493	909	-701	-43,754
97	**Aug-98**	2,700	2,492	776	-568	-44,322
98	**Sep-98**	2,700	2,491	393	-183	-44,506
99	**Oct-98**	2,700	2,490	290	-79	-44,585
100	**Nov-98**	2,700	2,489	114	97	-44,488
101	**Dec-98**	2,700	2,489	130	82	-44,406
102	**Jan-99**	2,700	2,488	95	117	-44,288
103	**Feb-99**	2,700	2,487	145	69	-44,220
104	**Mar-99**	2,883	2,486	461	-64	-44,284
105	**Apr-99**	2,801	2,485	779	-462	-44,747
106	**May-99**	2,745	2,484	954	-693	-45,440
107	**Jun-99**	2,852	2,483	1,151	-783	-46,223
108	**Jul-99**	2,948	2,483	1,228	-763	-46,985
109	**Aug-99**	2,918	2,482	1,046	-609	-47,595
110	**Sep-99**	2,817	2,480	696	-360	-47,954
111	**Oct-99**	2,700	2,480	344	-123	-48,078
112	**Nov-99**	2,700	2,479	179	43	-48,035
113	**Dec-99**	2,700	2,478	116	107	-47,928
114	**Jan-00**	2,700	2,477	106	117	-47,811
115	**Feb-00**	2,700	2,475	192	33	-47,778
116	**Mar-00**	2,700	2,475	351	-125	-47,904
117	**Apr-00**	2,700	2,473	550	-323	-48,226
118	**May-00**	2,700	2,472	799	-571	-48,798
119	**Jun-00**	2,700	2,472	1,053	-824	-49,622
120	**Jul-00**	2,700	2,470	900	-670	-50,291
121	**Aug-00**	2,700	2,469	823	-592	-50,883
122	**Sep-00**	2,700	2,468	655	-423	-51,305
123	**Oct-00**	2,700	2,467	401	-168	-51,473
124	**Nov-00**	2,700	2,466	152	82	-51,391
125	**Dec-00**	2,700	2,465	109	126	-51,265
126	**Jan-01**	2,700	2,464	159	77	-51,188
127	**Feb-01**	2,700	2,463	335	-98	-51,286
128	**Mar-01**	2,700	2,462	378	-139	-51,425
129	**Apr-01**	2,700	2,461	482	-242	-51,667
130	**May-01**	2,700	2,460	771	-530	-52,197
131	**Jun-01**	2,700	2,459	949	-708	-52,905
132	**Jul-01**	2,700	2,457	809	-566	-53,471
133	**Aug-01**	2,700	2,457	452	-208	-53,679
134	**Sep-01**	2,700	2,455	374	-129	-53,808
135	**Oct-01**	2,700	2,455	294	-48	-53,857

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
136	**Nov-01**	2,700	2,454	151	95	-53,761
137	**Dec-01**	2,700	2,453	82	165	-53,596
138	**Jan-02**	2,700	2,452	89	160	-53,437
139	**Feb-02**	2,700	2,451	164	85	-53,351
140	**Mar-02**	2,700	2,451	231	18	-53,333
141	**Apr-02**	2,700	2,450	343	-93	-53,426
142	**May-02**	2,700	2,449	1,380	-1,129	-54,554
143	**Jun-02**	2,700	2,448	872	-620	-55,174
144	**Jul-02**	2,700	2,447	882	-629	-55,804
145	**Aug-02**	2,700	2,446	684	-430	-56,234
146	**Sep-02**	2,700	2,446	456	-201	-56,435
147	**Oct-02**	2,700	2,445	300	-45	-56,480
148	**Nov-02**	2,700	2,444	116	141	-56,340
149	**Dec-02**	2,700	2,444	82	174	-56,165
150	**Jan-03**	2,700	2,443	73	185	-55,980
151	**Feb-03**	2,700	2,442	97	161	-55,820
152	**Mar-03**	2,700	2,441	213	46	-55,773
153	**Apr-03**	2,700	2,441	411	-151	-55,925
154	**May-03**	2,700	2,440	896	-635	-56,560
155	**Jun-03**	2,700	2,439	950	-689	-57,249
156	**Jul-03**	2,700	2,439	975	-713	-57,962
157	**Aug-03**	2,700	2,438	666	-404	-58,366
158	**Sep-03**	2,700	2,437	442	-179	-58,544
159	**Oct-03**	2,700	2,436	229	35	-58,509
160	**Nov-03**	2,700	2,436	63	202	-58,307
161	**Dec-03**	2,700	2,435	82	184	-58,123
162	**Jan-04**	2,700	2,434	103	164	-57,960
163	**Feb-04**	2,700	2,433	75	191	-57,768
164	**Mar-04**	2,700	2,433	270	-2	-57,771
165	**Apr-04**	2,700	2,432	396	-128	-57,899
166	**May-04**	2,700	2,431	498	-229	-58,127
167	**Jun-04**	2,700	2,431	584	-315	-58,442
168	**Jul-04**	2,700	2,430	652	-382	-58,824
169	**Aug-04**	2,700	2,430	687	-416	-59,240
170	**Sep-04**	2,700	2,429	558	-287	-59,527
171	**Oct-04**	2,700	2,429	231	41	-59,486
172	**Nov-04**	2,700	2,429	115	157	-59,330
173	**Dec-04**	2,700	2,429	61	211	-59,119
174	**Jan-05**	2,700	2,428	37	235	-58,883
175	**Feb-05**	2,700	2,428	33	239	-58,644
176	**Mar-05**	2,700	2,428	181	91	-58,553
177	**Apr-05**	2,700	2,427	252	21	-58,531
178	**May-05**	2,700	2,427	490	-216	-58,748
179	**Jun-05**	2,700	2,427	889	-615	-59,363
180	**Jul-05**	2,700	2,427	905	-631	-59,994

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
181	**Aug-05**	2,700	2,426	760	-486	-60,479
182	**Sep-05**	2,700	2,426	504	-230	-60,709
183	**Oct-05**	2,700	2,425	299	-24	-60,733
184	**Nov-05**	2,700	2,425	208	67	-60,666
185	**Dec-05**	2,700	2,425	61	214	-60,452
186	**Jan-06**	2,700	2,424	75	201	-60,251
187	**Feb-06**	2,700	2,424	109	167	-60,084
188	**Mar-06**	2,700	2,424	188	89	-59,995
189	**Apr-06**	2,700	2,423	252	25	-59,971
190	**May-06**	2,700	2,423	504	-227	-60,197
191	**Jun-06**	2,700	2,423	748	-471	-60,668
192	**Jul-06**	2,700	2,422	690	-412	-61,079
193	**Aug-06**	2,700	2,422	666	-387	-61,466
194	**Sep-06**	2,700	2,421	567	-288	-61,755
195	**Oct-06**	2,700	2,421	291	-12	-61,766
196	**Nov-06**	2,700	2,421	282	-3	-61,769
197	**Dec-06**	2,700	2,421	64	215	-61,554
198	**Jan-07**	2,700	2,421	88	192	-61,362
199	**Feb-07**	2,700	2,421	86	193	-61,169
200	**Mar-07**	2,700	2,421	130	149	-61,020
201	**Apr-07**	2,700	2,421	472	-192	-61,212
202	**May-07**	2,700	2,421	512	-232	-61,444
203	**Jun-07**	2,700	2,420	629	-348	-61,792
204	**Jul-07**	2,700	2,420	493	-213	-62,005
205	**Aug-07**	2,700	2,420	428	-147	-62,152
206	**Sep-07**	2,700	2,419	317	-36	-62,188
207	**Oct-07**	2,700	2,419	193	88	-62,100
208	**Nov-07**	2,700	2,419	153	128	-61,972
209	**Dec-07**	2,700	2,419	86	195	-61,777
210	**Jan-08**	2,700	2,419	58	223	-61,554
211	**Feb-08**	2,700	2,419	54	227	-61,328
212	**Mar-08**	2,700	2,419	109	172	-61,156
213	**Apr-08**	2,700	2,419	169	112	-61,044
214	**May-08**	2,700	2,419	200	81	-60,963
215	**Jun-08**	2,700	2,420	346	-65	-61,028
216	**Jul-08**	2,700	2,419	344	-63	-61,091
217	**Aug-08**	2,700	2,420	194	86	-61,005
218	**Sep-08**	2,700	2,420	187	94	-60,911
219	**Oct-08**	2,700	2,420	174	106	-60,805
220	**Nov-08**	2,700	2,421	89	191	-60,614
221	**Dec-08**	2,700	2,421	45	234	-60,380
222	**Jan-09**	2,700	2,421	38	241	-60,139
223	**Feb-09**	2,700	2,422	48	231	-59,909
224	**Mar-09**	2,700	2,422	144	135	-59,774
225	**Apr-09**	2,700	2,423	216	62	-59,712

Table 1

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 32,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
226	**May-09**	2,700	2,423	226	51	-59,661
227	**Jun-09**	2,700	2,424	230	47	-59,614
228	**Jul-09**	2,700	2,424	397	-121	-59,735
229	**Aug-09**	2,700	2,425	236	40	-59,695
230	**Sep-09**	2,700	2,425	152	123	-59,572
231	**Oct-09**	2,700	2,426	115	160	-59,412
232	**Nov-09**	2,700	2,427	55	219	-59,193
233	**Dec-09**	2,700	2,427	26	247	-58,946
Annual Average from 1986 to 2009		**32,453**	**30,260**	**4,649**	**-2,456**	

[1] Model input data including natural recharge of 32,422 acre-ft/yr and artificial recharge for pilot infiltration testing conducted between Mar-99 and Sep-99

[2] Model-calculated

[3] Model input data

[4] = [1] - [2] - [3]

[5] cumulative values based on [4]

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
1	**1986**	16,211	16,207	2,970	-2,966	-2,966
2	**1987**	16,211	16,169	3,366	-3,324	-6,290
3	**1988**	16,211	16,096	4,059	-3,944	-10,234
4	**1989**	16,211	15,994	5,940	-5,723	-15,957
5	**1990**	16,211	15,855	6,689	-6,333	-22,290
6	**Jan-91**	1,350	1,315	48	-12	-22,303
7	**Feb-91**	1,350	1,313	109	-72	-22,375
8	**Mar-91**	1,350	1,312	120	-82	-22,457
9	**Apr-91**	1,350	1,311	321	-282	-22,739
10	**May-91**	1,350	1,310	484	-444	-23,183
11	**Jun-91**	1,350	1,309	625	-584	-23,767
12	**Jul-91**	1,350	1,308	653	-611	-24,378
13	**Aug-91**	1,350	1,307	457	-414	-24,791
14	**Sep-91**	1,350	1,306	279	-235	-25,026
15	**Oct-91**	1,350	1,305	203	-157	-25,183
16	**Nov-91**	1,350	1,304	151	-105	-25,288
17	**Dec-91**	1,350	1,303	136	-89	-25,376
18	**Jan-92**	1,350	1,302	13	35	-25,341
19	**Feb-92**	1,350	1,301	143	-94	-25,434
20	**Mar-92**	1,350	1,300	287	-237	-25,671
21	**Apr-92**	1,350	1,299	479	-428	-26,098
22	**May-92**	1,350	1,298	592	-540	-26,638
23	**Jun-92**	1,350	1,297	594	-541	-27,179
24	**Jul-92**	1,350	1,296	797	-743	-27,921
25	**Aug-92**	1,350	1,295	395	-340	-28,261
26	**Sep-92**	1,350	1,294	285	-229	-28,490
27	**Oct-92**	1,350	1,293	56	1	-28,489
28	**Nov-92**	1,350	1,292	46	12	-28,477
29	**Dec-92**	1,350	1,291	77	-18	-28,495
30	**Jan-93**	1,350	1,291	127	-67	-28,562
31	**Feb-93**	1,350	1,290	157	-96	-28,659
32	**Mar-93**	1,350	1,289	228	-167	-28,826
33	**Apr-93**	1,350	1,288	319	-257	-29,082
34	**May-93**	1,350	1,287	622	-559	-29,641
35	**Jun-93**	1,350	1,286	747	-683	-30,324
36	**Jul-93**	1,350	1,285	781	-716	-31,040
37	**Aug-93**	1,350	1,284	479	-413	-31,453
38	**Sep-93**	1,350	1,284	349	-282	-31,736
39	**Oct-93**	1,350	1,283	295	-228	-31,963
40	**Nov-93**	1,350	1,282	125	-57	-32,020
41	**Dec-93**	1,350	1,281	46	23	-31,997
42	**Jan-94**	1,350	1,280	88	-19	-32,016
43	**Feb-94**	1,350	1,280	155	-84	-32,100
44	**Mar-94**	1,350	1,279	331	-260	-32,360
45	**Apr-94**	1,350	1,278	619	-547	-32,907

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
46	**May-94**	1,350	1,277	796	-723	-33,630
47	**Jun-94**	1,350	1,276	895	-821	-34,451
48	**Jul-94**	1,350	1,275	858	-783	-35,234
49	**Aug-94**	1,350	1,275	475	-399	-35,633
50	**Sep-94**	1,350	1,274	235	-158	-35,792
51	**Oct-94**	1,350	1,273	83	-6	-35,798
52	**Nov-94**	1,350	1,272	47	31	-35,767
53	**Dec-94**	1,350	1,272	154	-76	-35,843
54	**Jan-95**	1,350	1,271	35	44	-35,798
55	**Feb-95**	1,350	1,270	249	-169	-35,967
56	**Mar-95**	1,350	1,269	382	-301	-36,267
57	**Apr-95**	1,350	1,268	577	-495	-36,762
58	**May-95**	1,350	1,267	960	-877	-37,640
59	**Jun-95**	1,350	1,266	1,233	-1,149	-38,789
60	**Jul-95**	1,350	1,266	605	-520	-39,309
61	**Aug-95**	1,350	1,265	624	-539	-39,848
62	**Sep-95**	1,350	1,264	589	-503	-40,350
63	**Oct-95**	1,350	1,263	417	-330	-40,680
64	**Nov-95**	1,350	1,262	171	-84	-40,764
65	**Dec-95**	1,350	1,262	128	-39	-40,803
66	**Jan-96**	1,350	1,261	156	-67	-40,870
67	**Feb-96**	1,350	1,260	275	-185	-41,055
68	**Mar-96**	1,350	1,259	612	-521	-41,576
69	**Apr-96**	1,350	1,258	770	-678	-42,254
70	**May-96**	1,350	1,257	919	-826	-43,080
71	**Jun-96**	1,350	1,256	951	-858	-43,938
72	**Jul-96**	1,350	1,256	855	-760	-44,698
73	**Aug-96**	1,350	1,255	418	-322	-45,020
74	**Sep-96**	1,350	1,254	428	-331	-45,352
75	**Oct-96**	1,350	1,253	217	-120	-45,471
76	**Nov-96**	1,350	1,252	57	41	-45,431
77	**Dec-96**	1,350	1,251	62	37	-45,394
78	**Jan-97**	1,350	1,250	114	-14	-45,407
79	**Feb-97**	1,350	1,250	194	-94	-45,501
80	**Mar-97**	1,350	1,249	433	-331	-45,832
81	**Apr-97**	1,350	1,248	659	-556	-46,389
82	**May-97**	1,350	1,247	814	-710	-47,099
83	**Jun-97**	1,350	1,246	969	-865	-47,963
84	**Jul-97**	1,350	1,245	862	-757	-48,721
85	**Aug-97**	1,350	1,244	593	-487	-49,207
86	**Sep-97**	1,350	1,243	387	-280	-49,487
87	**Oct-97**	1,350	1,242	262	-154	-49,641
88	**Nov-97**	1,350	1,242	76	33	-49,609
89	**Dec-97**	1,350	1,241	100	9	-49,600
90	**Jan-98**	1,350	1,240	120	-10	-49,609

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
91	**Feb-98**	1,350	1,239	88	23	-49,587
92	**Mar-98**	1,350	1,238	257	-146	-49,732
93	**Apr-98**	1,350	1,238	442	-329	-50,062
94	**May-98**	1,350	1,237	758	-645	-50,707
95	**Jun-98**	1,350	1,236	810	-695	-51,402
96	**Jul-98**	1,350	1,235	909	-794	-52,195
97	**Aug-98**	1,350	1,234	776	-660	-52,856
98	**Sep-98**	1,350	1,233	393	-276	-53,132
99	**Oct-98**	1,350	1,233	290	-172	-53,304
100	**Nov-98**	1,350	1,232	114	4	-53,300
101	**Dec-98**	1,350	1,231	130	-11	-53,310
102	**Jan-99**	1,350	1,231	95	24	-53,286
103	**Feb-99**	1,350	1,230	145	-25	-53,311
104	**Mar-99**	1,533	1,229	461	-158	-53,468
105	**Apr-99**	1,451	1,228	779	-556	-54,024
106	**May-99**	1,395	1,228	954	-787	-54,811
107	**Jun-99**	1,502	1,227	1,151	-877	-55,687
108	**Jul-99**	1,598	1,226	1,228	-856	-56,544
109	**Aug-99**	1,568	1,225	1,046	-703	-57,247
110	**Sep-99**	1,467	1,225	696	-454	-57,701
111	**Oct-99**	1,350	1,224	344	-218	-57,919
112	**Nov-99**	1,350	1,223	179	-52	-57,971
113	**Dec-99**	1,350	1,223	116	12	-57,959
114	**Jan-00**	1,350	1,222	106	22	-57,937
115	**Feb-00**	1,350	1,221	192	-64	-58,001
116	**Mar-00**	1,350	1,221	351	-221	-58,222
117	**Apr-00**	1,350	1,220	550	-419	-58,642
118	**May-00**	1,350	1,219	799	-668	-59,310
119	**Jun-00**	1,350	1,218	1,053	-921	-60,231
120	**Jul-00**	1,350	1,217	900	-767	-60,997
121	**Aug-00**	1,350	1,217	823	-689	-61,687
122	**Sep-00**	1,350	1,216	655	-520	-62,207
123	**Oct-00**	1,350	1,215	401	-266	-62,473
124	**Nov-00**	1,350	1,214	152	-17	-62,490
125	**Dec-00**	1,350	1,214	109	28	-62,462
126	**Jan-01**	1,350	1,213	159	-22	-62,484
127	**Feb-01**	1,350	1,212	335	-197	-62,682
128	**Mar-01**	1,350	1,212	378	-239	-62,921
129	**Apr-01**	1,350	1,211	482	-342	-63,263
130	**May-01**	1,350	1,210	771	-631	-63,894
131	**Jun-01**	1,350	1,209	949	-808	-64,702
132	**Jul-01**	1,350	1,208	809	-668	-65,370
133	**Aug-01**	1,350	1,208	452	-309	-65,679
134	**Sep-01**	1,350	1,207	374	-231	-65,909
135	**Oct-01**	1,350	1,206	294	-150	-66,059

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
136	**Nov-01**	1,350	1,205	151	-7	-66,066
137	**Dec-01**	1,350	1,205	82	63	-66,003
138	**Jan-02**	1,350	1,204	89	57	-65,945
139	**Feb-02**	1,350	1,203	164	-17	-65,962
140	**Mar-02**	1,350	1,202	231	-83	-66,046
141	**Apr-02**	1,350	1,202	343	-195	-66,241
142	**May-02**	1,350	1,201	1,380	-1,231	-67,472
143	**Jun-02**	1,350	1,200	872	-722	-68,194
144	**Jul-02**	1,350	1,199	882	-732	-68,926
145	**Aug-02**	1,350	1,199	684	-533	-69,459
146	**Sep-02**	1,350	1,198	456	-304	-69,762
147	**Oct-02**	1,350	1,197	300	-148	-69,910
148	**Nov-02**	1,350	1,197	116	37	-69,873
149	**Dec-02**	1,350	1,196	82	72	-69,801
150	**Jan-03**	1,350	1,196	73	82	-69,719
151	**Feb-03**	1,350	1,195	97	58	-69,661
152	**Mar-03**	1,350	1,194	213	-56	-69,717
153	**Apr-03**	1,350	1,194	411	-254	-69,972
154	**May-03**	1,350	1,193	896	-738	-70,710
155	**Jun-03**	1,350	1,192	950	-792	-71,502
156	**Jul-03**	1,350	1,191	975	-816	-72,318
157	**Aug-03**	1,350	1,191	666	-506	-72,825
158	**Sep-03**	1,350	1,190	442	-282	-73,106
159	**Oct-03**	1,350	1,189	229	-68	-73,174
160	**Nov-03**	1,350	1,189	63	99	-73,076
161	**Dec-03**	1,350	1,188	82	80	-72,996
162	**Jan-04**	1,350	1,188	103	60	-72,936
163	**Feb-04**	1,350	1,187	75	88	-72,848
164	**Mar-04**	1,350	1,186	270	-106	-72,954
165	**Apr-04**	1,350	1,186	396	-232	-73,186
166	**May-04**	1,350	1,185	498	-332	-73,518
167	**Jun-04**	1,350	1,184	584	-418	-73,937
168	**Jul-04**	1,350	1,184	652	-485	-74,422
169	**Aug-04**	1,350	1,183	687	-519	-74,942
170	**Sep-04**	1,350	1,183	558	-391	-75,332
171	**Oct-04**	1,350	1,182	231	-63	-75,395
172	**Nov-04**	1,350	1,181	115	54	-75,341
173	**Dec-04**	1,350	1,181	61	108	-75,233
174	**Jan-05**	1,350	1,180	37	133	-75,100
175	**Feb-05**	1,350	1,180	33	137	-74,963
176	**Mar-05**	1,350	1,180	181	-11	-74,973
177	**Apr-05**	1,350	1,179	252	-80	-75,054
178	**May-05**	1,350	1,178	490	-318	-75,371
179	**Jun-05**	1,350	1,178	889	-717	-76,088
180	**Jul-05**	1,350	1,177	905	-732	-76,820

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
181	**Aug-05**	1,350	1,177	760	-586	-77,406
182	**Sep-05**	1,350	1,177	504	-331	-77,737
183	**Oct-05**	1,350	1,176	299	-125	-77,861
184	**Nov-05**	1,350	1,176	208	-34	-77,895
185	**Dec-05**	1,350	1,175	61	114	-77,781
186	**Jan-06**	1,350	1,175	75	100	-77,681
187	**Feb-06**	1,350	1,174	109	67	-77,614
188	**Mar-06**	1,350	1,174	188	-12	-77,626
189	**Apr-06**	1,350	1,173	252	-75	-77,702
190	**May-06**	1,350	1,173	504	-327	-78,029
191	**Jun-06**	1,350	1,172	748	-570	-78,599
192	**Jul-06**	1,350	1,172	690	-512	-79,111
193	**Aug-06**	1,350	1,171	666	-487	-79,598
194	**Sep-06**	1,350	1,171	567	-388	-79,986
195	**Oct-06**	1,350	1,171	291	-111	-80,097
196	**Nov-06**	1,350	1,170	282	-102	-80,199
197	**Dec-06**	1,350	1,170	64	116	-80,082
198	**Jan-07**	1,350	1,169	88	93	-79,989
199	**Feb-07**	1,350	1,169	86	95	-79,895
200	**Mar-07**	1,350	1,169	130	51	-79,843
201	**Apr-07**	1,350	1,168	472	-290	-80,133
202	**May-07**	1,350	1,168	512	-330	-80,464
203	**Jun-07**	1,350	1,168	629	-446	-80,910
204	**Jul-07**	1,350	1,167	493	-310	-81,220
205	**Aug-07**	1,350	1,167	428	-245	-81,464
206	**Sep-07**	1,350	1,166	317	-133	-81,597
207	**Oct-07**	1,350	1,166	193	-9	-81,606
208	**Nov-07**	1,350	1,166	153	31	-81,576
209	**Dec-07**	1,350	1,166	86	98	-81,477
210	**Jan-08**	1,350	1,165	58	127	-81,350
211	**Feb-08**	1,350	1,165	54	131	-81,220
212	**Mar-08**	1,350	1,165	109	76	-81,144
213	**Apr-08**	1,350	1,164	169	17	-81,127
214	**May-08**	1,350	1,164	200	-14	-81,140
215	**Jun-08**	1,350	1,164	346	-160	-81,300
216	**Jul-08**	1,350	1,164	344	-157	-81,457
217	**Aug-08**	1,350	1,163	194	-7	-81,464
218	**Sep-08**	1,350	1,163	187	0	-81,464
219	**Oct-08**	1,350	1,163	174	14	-81,450
220	**Nov-08**	1,350	1,163	89	99	-81,352
221	**Dec-08**	1,350	1,162	45	143	-81,209
222	**Jan-09**	1,350	1,162	38	150	-81,059
223	**Feb-09**	1,350	1,162	48	140	-80,919
224	**Mar-09**	1,350	1,162	144	45	-80,874
225	**Apr-09**	1,350	1,162	216	-27	-80,902

Table 2

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 16,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
226	**May-09**	1,350	1,162	226	-37	-80,939
227	**Jun-09**	1,350	1,161	230	-41	-80,980
228	**Jul-09**	1,350	1,161	397	-208	-81,189
229	**Aug-09**	1,350	1,161	236	-47	-81,236
230	**Sep-09**	1,350	1,161	152	37	-81,199
231	**Oct-09**	1,350	1,161	115	74	-81,124
232	**Nov-09**	1,350	1,161	55	135	-80,990
233	**Dec-09**	1,350	1,161	26	163	-80,826

Annual Average from 1986 to 2009	**16,248**	**14,967**	**4,649**	**-3,368**

[1] Model input data including natural recharge of 16,211 acre-ft/yr and artificial recharge for pilot infiltration testing conducted between Mar-99 and Sep-99

[2] Model-calculated

[3] Model input data

[4] = [1] - [2] - [3]

[5] cumulative values based on [4]

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
1	**1986**	5,058	5,055	2,970	-2,967	-2,967
2	**1987**	5,058	5,047	3,366	-3,355	-6,322
3	**1988**	5,058	5,036	4,059	-4,037	-10,359
4	**1989**	5,058	5,025	5,940	-5,907	-16,267
5	**1990**	5,058	5,012	6,689	-6,643	-22,910
6	**Jan-91**	421	417	48	-43	-22,953
7	**Feb-91**	421	417	109	-104	-23,057
8	**Mar-91**	421	416	120	-115	-23,173
9	**Apr-91**	421	416	321	-316	-23,489
10	**May-91**	421	416	484	-479	-23,968
11	**Jun-91**	421	416	625	-620	-24,587
12	**Jul-91**	421	416	653	-648	-25,235
13	**Aug-91**	421	416	457	-451	-25,686
14	**Sep-91**	421	416	279	-273	-25,960
15	**Oct-91**	421	415	203	-197	-26,157
16	**Nov-91**	421	415	151	-145	-26,302
17	**Dec-91**	421	415	136	-130	-26,432
18	**Jan-92**	421	415	13	-7	-26,438
19	**Feb-92**	421	415	143	-136	-26,575
20	**Mar-92**	421	415	287	-280	-26,855
21	**Apr-92**	421	414	479	-472	-27,327
22	**May-92**	421	414	592	-585	-27,912
23	**Jun-92**	421	414	594	-587	-28,499
24	**Jul-92**	421	414	797	-790	-29,288
25	**Aug-92**	421	414	395	-387	-29,676
26	**Sep-92**	421	413	285	-277	-29,953
27	**Oct-92**	421	413	56	-48	-30,001
28	**Nov-92**	421	413	46	-38	-30,038
29	**Dec-92**	421	413	77	-69	-30,107
30	**Jan-93**	421	413	127	-118	-30,225
31	**Feb-93**	421	412	157	-148	-30,374
32	**Mar-93**	421	412	228	-219	-30,592
33	**Apr-93**	421	412	319	-310	-30,902
34	**May-93**	421	412	622	-613	-31,515
35	**Jun-93**	421	412	747	-737	-32,252
36	**Jul-93**	421	411	781	-771	-33,023
37	**Aug-93**	421	411	479	-469	-33,492
38	**Sep-93**	421	411	349	-339	-33,831
39	**Oct-93**	421	411	295	-284	-34,115
40	**Nov-93**	421	411	125	-114	-34,230
41	**Dec-93**	421	410	46	-35	-34,265
42	**Jan-94**	421	410	88	-77	-34,342
43	**Feb-94**	421	410	155	-143	-34,486
44	**Mar-94**	421	410	331	-319	-34,805
45	**Apr-94**	421	409	619	-608	-35,413

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
46	**May-94**	421	409	796	-784	-36,196
47	**Jun-94**	421	409	895	-883	-37,079
48	**Jul-94**	421	409	858	-846	-37,924
49	**Aug-94**	421	409	475	-462	-38,386
50	**Sep-94**	421	408	235	-222	-38,608
51	**Oct-94**	421	408	83	-70	-38,678
52	**Nov-94**	421	408	47	-33	-38,712
53	**Dec-94**	421	408	154	-141	-38,852
54	**Jan-95**	421	407	35	-21	-38,873
55	**Feb-95**	421	407	249	-235	-39,108
56	**Mar-95**	421	407	382	-367	-39,476
57	**Apr-95**	421	407	577	-562	-40,038
58	**May-95**	421	407	960	-945	-40,983
59	**Jun-95**	421	406	1,233	-1,218	-42,202
60	**Jul-95**	421	406	605	-590	-42,791
61	**Aug-95**	421	406	624	-608	-43,400
62	**Sep-95**	421	406	589	-573	-43,973
63	**Oct-95**	421	405	417	-401	-44,374
64	**Nov-95**	421	405	171	-155	-44,529
65	**Dec-95**	421	405	128	-111	-44,640
66	**Jan-96**	421	405	156	-140	-44,780
67	**Feb-96**	421	404	275	-258	-45,038
68	**Mar-96**	421	404	612	-595	-45,633
69	**Apr-96**	421	404	770	-753	-46,386
70	**May-96**	421	404	919	-901	-47,287
71	**Jun-96**	421	403	951	-934	-48,220
72	**Jul-96**	421	403	855	-837	-49,057
73	**Aug-96**	421	403	418	-400	-49,457
74	**Sep-96**	421	403	428	-409	-49,866
75	**Oct-96**	421	402	217	-198	-50,064
76	**Nov-96**	421	402	57	-38	-50,102
77	**Dec-96**	421	402	62	-43	-50,145
78	**Jan-97**	421	402	114	-94	-50,239
79	**Feb-97**	421	401	194	-175	-50,414
80	**Mar-97**	421	401	433	-413	-50,826
81	**Apr-97**	421	401	659	-639	-51,465
82	**May-97**	421	401	814	-793	-52,258
83	**Jun-97**	421	400	969	-948	-53,206
84	**Jul-97**	421	400	862	-841	-54,047
85	**Aug-97**	421	400	593	-571	-54,619
86	**Sep-97**	421	400	387	-365	-54,984
87	**Oct-97**	421	399	262	-240	-55,224
88	**Nov-97**	421	399	76	-54	-55,278
89	**Dec-97**	421	399	100	-78	-55,356
90	**Jan-98**	421	399	120	-97	-55,453

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
91	**Feb-98**	421	398	88	-65	-55,519
92	**Mar-98**	421	398	257	-234	-55,753
93	**Apr-98**	421	398	442	-419	-56,172
94	**May-98**	421	398	758	-734	-56,906
95	**Jun-98**	421	397	810	-786	-57,691
96	**Jul-98**	421	397	909	-885	-58,576
97	**Aug-98**	421	397	776	-752	-59,328
98	**Sep-98**	421	396	393	-368	-59,696
99	**Oct-98**	421	396	290	-265	-59,960
100	**Nov-98**	421	396	114	-88	-60,049
101	**Dec-98**	421	396	130	-104	-60,153
102	**Jan-99**	421	395	95	-69	-60,222
103	**Feb-99**	421	395	145	-119	-60,341
104	**Mar-99**	604	395	461	-252	-60,593
105	**Apr-99**	522	395	779	-651	-61,244
106	**May-99**	466	394	954	-882	-62,126
107	**Jun-99**	573	394	1,151	-973	-63,099
108	**Jul-99**	669	394	1,228	-953	-64,052
109	**Aug-99**	639	393	1,046	-800	-64,851
110	**Sep-99**	538	393	696	-551	-65,403
111	**Oct-99**	421	393	344	-316	-65,719
112	**Nov-99**	421	393	179	-150	-65,869
113	**Dec-99**	421	392	116	-87	-65,956
114	**Jan-00**	421	392	106	-77	-66,033
115	**Feb-00**	421	392	192	-163	-66,196
116	**Mar-00**	421	391	351	-321	-66,517
117	**Apr-00**	421	391	550	-520	-67,037
118	**May-00**	421	391	799	-769	-67,806
119	**Jun-00**	421	391	1,053	-1,022	-68,828
120	**Jul-00**	421	390	900	-869	-69,696
121	**Aug-00**	421	390	823	-792	-70,488
122	**Sep-00**	421	390	655	-623	-71,111
123	**Oct-00**	421	389	401	-370	-71,481
124	**Nov-00**	421	389	152	-120	-71,601
125	**Dec-00**	421	389	109	-77	-71,678
126	**Jan-01**	421	389	159	-127	-71,804
127	**Feb-01**	421	388	335	-302	-72,106
128	**Mar-01**	421	388	378	-345	-72,451
129	**Apr-01**	421	388	482	-448	-72,899
130	**May-01**	421	388	771	-737	-73,636
131	**Jun-01**	421	387	949	-915	-74,552
132	**Jul-01**	421	387	809	-775	-75,327
133	**Aug-01**	421	387	452	-417	-75,744
134	**Sep-01**	421	386	374	-339	-76,083
135	**Oct-01**	421	386	294	-258	-76,342

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
136	**Nov-01**	421	386	151	-116	-76,457
137	**Dec-01**	421	386	82	-47	-76,504
138	**Jan-02**	421	385	89	-53	-76,557
139	**Feb-02**	421	385	164	-127	-76,684
140	**Mar-02**	421	385	231	-195	-76,879
141	**Apr-02**	421	384	343	-307	-77,186
142	**May-02**	421	384	1,380	-1,343	-78,528
143	**Jun-02**	421	384	872	-835	-79,363
144	**Jul-02**	421	383	882	-844	-80,208
145	**Aug-02**	421	383	684	-646	-80,854
146	**Sep-02**	421	383	456	-418	-81,272
147	**Oct-02**	421	383	300	-262	-81,534
148	**Nov-02**	421	382	116	-77	-81,610
149	**Dec-02**	421	382	82	-43	-81,654
150	**Jan-03**	421	382	73	-33	-81,687
151	**Feb-03**	421	381	97	-58	-81,744
152	**Mar-03**	421	381	213	-173	-81,917
153	**Apr-03**	421	381	411	-370	-82,287
154	**May-03**	421	381	896	-855	-83,142
155	**Jun-03**	421	380	950	-909	-84,052
156	**Jul-03**	421	380	975	-934	-84,985
157	**Aug-03**	421	380	666	-625	-85,610
158	**Sep-03**	421	379	442	-400	-86,010
159	**Oct-03**	421	379	229	-187	-86,196
160	**Nov-03**	421	379	63	-21	-86,217
161	**Dec-03**	421	379	82	-39	-86,256
162	**Jan-04**	421	378	103	-60	-86,316
163	**Feb-04**	421	378	75	-32	-86,348
164	**Mar-04**	421	378	270	-226	-86,574
165	**Apr-04**	421	377	396	-353	-86,926
166	**May-04**	421	377	498	-454	-87,380
167	**Jun-04**	421	377	584	-540	-87,920
168	**Jul-04**	421	377	652	-607	-88,527
169	**Aug-04**	421	376	687	-642	-89,169
170	**Sep-04**	421	376	558	-513	-89,682
171	**Oct-04**	421	376	231	-185	-89,867
172	**Nov-04**	421	375	115	-69	-89,936
173	**Dec-04**	421	375	61	-15	-89,951
174	**Jan-05**	421	375	37	9	-89,941
175	**Feb-05**	421	375	33	13	-89,928
176	**Mar-05**	421	374	181	-134	-90,062
177	**Apr-05**	421	374	252	-204	-90,267
178	**May-05**	421	374	490	-442	-90,709
179	**Jun-05**	421	374	889	-841	-91,550
180	**Jul-05**	421	373	905	-857	-92,407

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
181	**Aug-05**	421	373	760	-711	-93,118
182	**Sep-05**	421	373	504	-456	-93,574
183	**Oct-05**	421	372	299	-250	-93,824
184	**Nov-05**	421	372	208	-159	-93,983
185	**Dec-05**	421	372	61	-12	-93,995
186	**Jan-06**	421	372	75	-26	-94,020
187	**Feb-06**	421	371	109	-59	-94,080
188	**Mar-06**	421	371	188	-138	-94,218
189	**Apr-06**	421	371	252	-202	-94,420
190	**May-06**	421	371	504	-454	-94,873
191	**Jun-06**	421	370	748	-697	-95,571
192	**Jul-06**	421	370	690	-639	-96,210
193	**Aug-06**	421	370	666	-614	-96,824
194	**Sep-06**	421	369	567	-516	-97,339
195	**Oct-06**	421	369	291	-239	-97,578
196	**Nov-06**	421	369	282	-230	-97,807
197	**Dec-06**	421	369	64	-12	-97,819
198	**Jan-07**	421	369	88	-35	-97,854
199	**Feb-07**	421	368	86	-33	-97,887
200	**Mar-07**	421	368	130	-77	-97,964
201	**Apr-07**	421	368	472	-419	-98,383
202	**May-07**	421	367	512	-458	-98,841
203	**Jun-07**	421	367	629	-575	-99,416
204	**Jul-07**	421	367	493	-439	-99,855
205	**Aug-07**	421	367	428	-373	-100,228
206	**Sep-07**	421	366	317	-262	-100,490
207	**Oct-07**	421	366	193	-138	-100,628
208	**Nov-07**	421	366	153	-98	-100,726
209	**Dec-07**	421	366	86	-31	-100,757
210	**Jan-08**	421	365	58	-2	-100,759
211	**Feb-08**	421	365	54	2	-100,757
212	**Mar-08**	421	365	109	-53	-100,811
213	**Apr-08**	421	365	169	-112	-100,923
214	**May-08**	421	365	200	-143	-101,066
215	**Jun-08**	421	364	346	-289	-101,355
216	**Jul-08**	421	364	344	-287	-101,642
217	**Aug-08**	421	364	194	-137	-101,778
218	**Sep-08**	421	364	187	-129	-101,908
219	**Oct-08**	421	363	174	-116	-102,023
220	**Nov-08**	421	363	89	-31	-102,054
221	**Dec-08**	421	363	45	13	-102,041
222	**Jan-09**	421	363	38	21	-102,020
223	**Feb-09**	421	362	48	11	-102,010
224	**Mar-09**	421	362	144	-84	-102,094
225	**Apr-09**	421	362	216	-157	-102,251

Table 3

Groundwater Budget for Transient Model Calibration 1986 through 2009
Natural Recharge of 5,000 acre-ft/yr

		[1]	[2]	[3]	[4]	[5]
Stress Period	**Time**	**Inflow**	**Outflow**		**Changes in Groundwater Storage**	**Cumulative Changes in Groundwater**
		Recharge	**ET**	**Cadiz Pumping**		
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
226	**May-09**	421	362	226	-166	-102,417
227	**Jun-09**	421	361	230	-171	-102,587
228	**Jul-09**	421	361	397	-337	-102,924
229	**Aug-09**	421	361	236	-175	-103,100
230	**Sep-09**	421	361	152	-92	-103,192
231	**Oct-09**	421	361	115	-54	-103,246
232	**Nov-09**	421	360	55	6	-103,239
233	**Dec-09**	421	360	26	35	-103,204

Annual Average from 1986 to 2009	**5,100**	**4,752**	**4,649**	**-4,300**	

[1] Model input data including natural recharge of 5,058 acre-ft/yr and artificial recharge for pilot infiltration testing conducted between Mar-99 and Sep-99

[2] Model-calculated

[3] Model input data

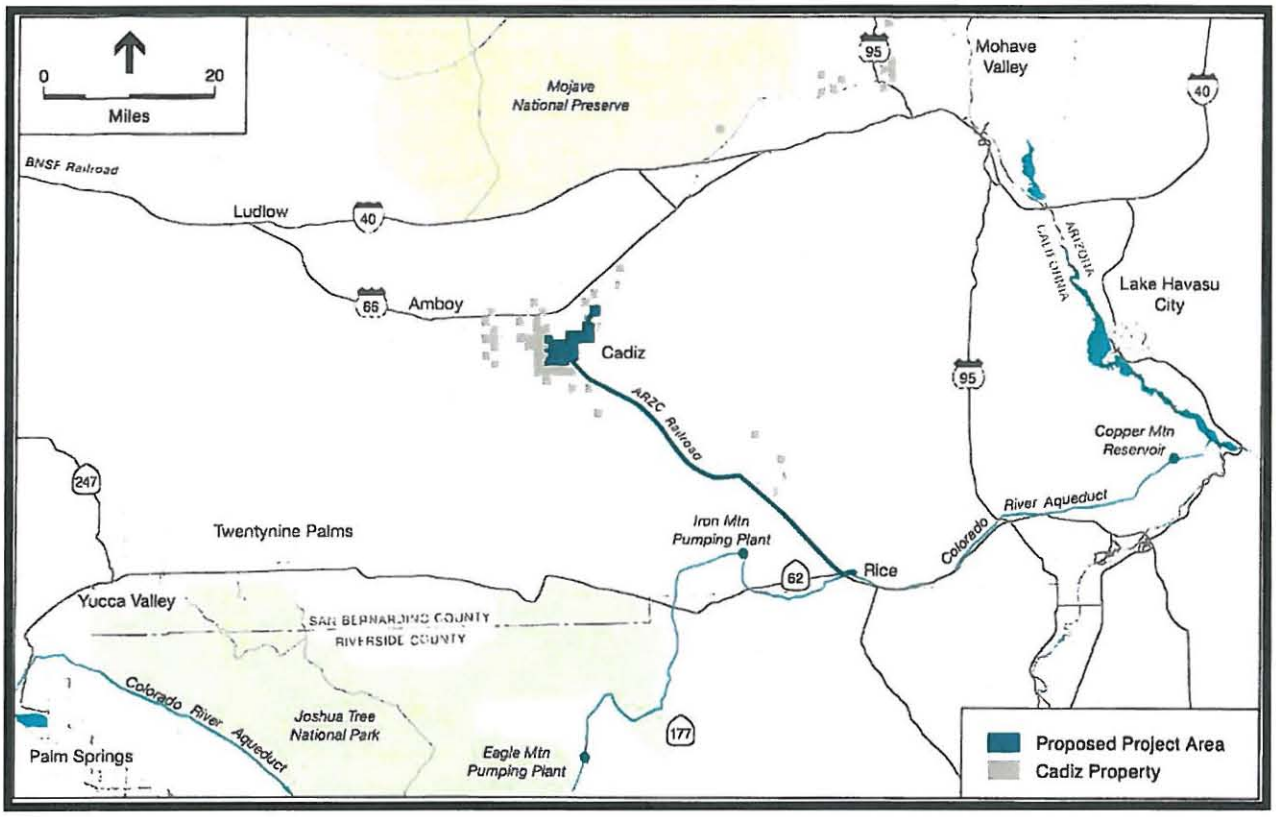
[4] = [1] - [2] - [3]

[5] cumulative values based on [4]

Economic Impact of the Proposed

Cadiz Valley

Groundwater Conservation, Recovery, and Imported Water Storage Project



Final Report

April 18, 2011

John E. Husing, Ph.D.

Economics & Politics, Inc.
961 Creek View Lane
Redlands, CA 92373
(909) 307-9444 Phone
(909) 748-0620 FAX
john@johnhusing.com
www.johnhusing.com

Executive Summary

Looking at the year by year results, the economic impact of the full Cadiz Groundwater Conservation, Recovery, and Imported Water Storage Project yields the following results over its four year period of design and construction:

Summary of Economic Impacts of Construction Activity, Cadiz Water Project						
Type of Impact	**Phase 1 Year 1**	**Phase 1 Year 2**	**Phase 2 Year 1**	**Phase 2 Year 2**	**4-Year Total**	**Annual Avg.**
Job Creation (*man-years*)	1,011	2,090	940	1,945	5,986	1,497
Labor & Proprietorship Income	$53,416,010	$115,788,200	$49,713,909	$107,763,274	$326,681,393	$81,670,348
Economic Activity Generated	$138,561,306	$316,207,131	$128,958,046	$294,291,784	$878,018,267	$219,504,567
State & Local Taxes Generated	$6,113,696	$13,537,310	$5,689,975	$12,599,082	$37,940,063	$9,485,016

Longer term, assuming that the increase in the property valuation equals the construction cost of the Cadiz Water Project's facilities, the increase would be $536,250,000. This property is inside the Needles Unified School District where the tax rate is $1.00 per $100 of valuation for San Bernardino County's government and $0.1143 for the Needles Unified School District. If the assessed valuation is not increased by an inflation factor, the annual property tax revenue generated in San Bernardino County would total $6.0 million, including $5,362,500 to San Bernardino County's government and $612,934 to the Needles Unified School District.

Permanent Property Tax Revenue Increase			
	San Bdno Co.	**Needles Unified**	**Total**
Assumed Property Valuation	$536,250,000	$536,250,000	$536,250,000
$100 of Assessed Valuation	$5,362,500	$5,362,500	$5,362,500
Tax Rates Per $100 of AV	$1.000	$0.1143	$1.1143
Annual Tax Revenue	**$5,362,500**	**$612,934**	**$5,975,434**

Economics & Politics, Inc.

961 Creek View Lane
Redlands, CA 92373
(909) 307-9444 Phone
(909) 748-0620 FAX
john@johnhusing.com
www.johnhusing.com

Economic Impact of the Proposed Cadiz Valley Groundwater Conservation, Recovery, and Imported Water Storage Project

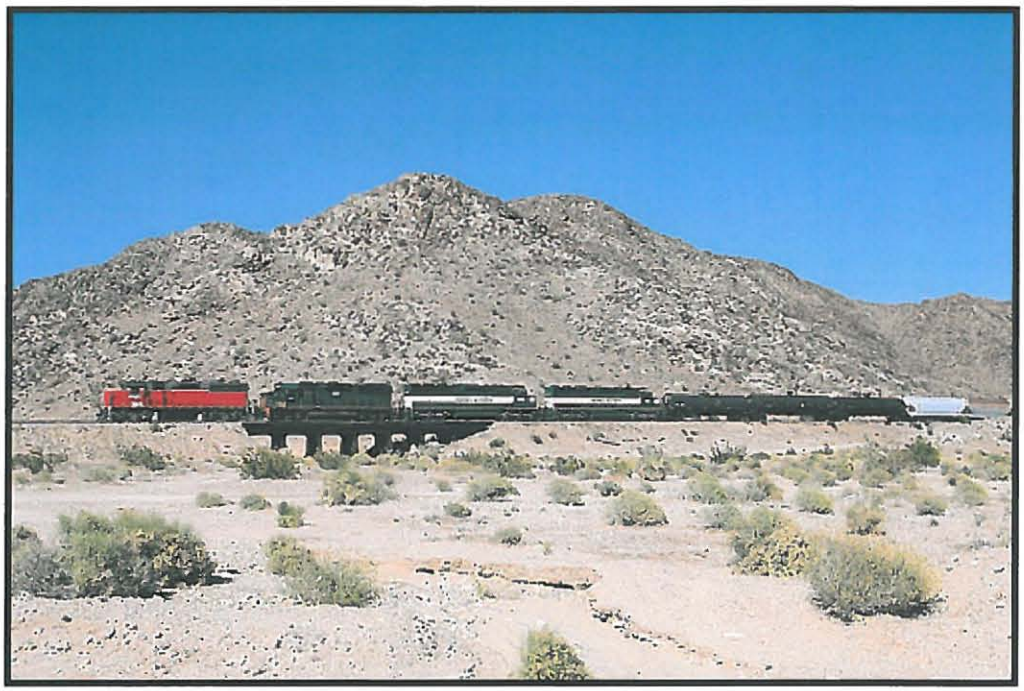
John E. Husing, Ph.D.

Project. The project's northern end is located at Cadiz, California, just south of the SR-66 in northeastern San Bernardino County. Its southern end is at Rice, California located along the SR-62 next to the Colorado River Aqueduct. Underlying Cadiz is an aquifer system that lies at the base of the Fenner Valley and Orange Blossom watersheds. This underground "lake" is naturally recharged by rain and snow in the nearby mountains that over time flows underground into it. The aquifer is roughly equivalent in capacity to Lake Mead, the nation's largest surface reservoir. Ultimately, a good deal of water that reaches the aquifer ends up just below ground at Cadiz Dry Lake and Bristol Dry Lake (*below*) where it converges with saline water and evaporates through the surface.

Phase I. <u>Conservation and Recovery</u>. In Phase I of the project, facilities would be built near Cadiz to capture and conserve the average annual natural recharge into the aquifer that would otherwise reach the Cadiz Dry Lake and the Bristol Dry Lake and evaporate. Phase I would include the construction of extraction wells that would be used to extract the amount of water that would otherwise flow to the Dry Lakes plus the amount needed to maintain hydraulic control in the well field area.

Phase I would also include the building of a 42-mile underground water pipeline that would transmit water southeast to the Colorado River Aqueduct near Rice. The pipeline would be

buried along the already disturbed railroad right-of-way along which the Arizona-California Railroad (*ARZC*) currently operates (*see photograph*). It would be sized to allow the conveyance of an annual average of 50,000 acre-feet of water. Once the water reaches the Colorado River Aqueduct, it would be conveyed down it into Southern California where it would be made available to the Santa Margarita Water District and other participating water districts.



Phase I: Timing & Budget. Once environmental approvals are finalized, Phase I of the project is slated to begin. Planning, design and engineering will occur over a six month period. Construction of the well field, pipeline and power facility is anticipated to take an additional 18 months. The construction budget is estimated as:

• Well Field (*20-32 wells*)	$23,500,000
• Pipeline	$211,500,000
• Power Facilities	$17,500,000
• Planning, engineering, other overhead	$25,250,000
• Total Phase I Budget	**$277,750,000**

Phase I: Economic Impact. The primary impact of a project like the Cadiz Valley Groundwater Conservation & Recovery effort would occur during its construction, not its operational phase. As the project will be built in San Bernardino County, this will be the location of all of the activity. In part, this is because the county has an extensive blue collar labor supply that can build the project. It is also because San Bernardino County is home to production facilities like Ameron International Water Transmission Group and Northwest Pipe Company, leading manufacturers of the materials used in construction wells, pipelines and power plants.

- It is therefore assumed that 100% of the construction expenditures will be made to workers and suppliers located within San Bernardino County.

Phase I, Year 1. In Year 1 of the project, it is assumed that 80% of the planning, engineering and management work on Phase I of the project is completed. Also in Year 1, 25% of construction and the purchase of materials required for it occurs. In addition, it is assumed that 75% of the construction budget for each activity represents construction, while 25% represents materials and supplies. Combined, this places $83,325,000 of activity into Year 1 (*Exhibit 1*).

Exhibit 1.-Assumptions, Phase I Year 1			
	Period	**Share**	**Year 1**
Engineering & Related	80.0%		$20,200,000
Pipeline Construction	25.0%	75.0%	$39,656,250
Pipeline Supplies	25.0%	25.0%	$13,218,750
Power Plant	25.0%	75.0%	$3,281,250
Power Plant Supplies	25.0%	25.0%	$1,093,750
Well Field	25.0%	75.0%	$4,406,250
Well Field Supplies	25.0%	25.0%	$1,468,750
Total Expenditures			**$83,325,000**
Impact Sectors			
Construction			$47,343,750
Materials & Supplies			$15,781,250
Engineering & Related			$20,200,000
Total Expenditures			**$83,325,000**

These expenditures are recombined into three broad sectors used by the IMPLAN model to estimate the economic impact on San Bernardino County's economy of these Year 1 expenditures. The IMPLAN model is the standard one used by economists in determining the economic impact of funds coming from the outside world, in this case, the nation's money markets and hitting the local economy through specific types of activities.[1] The model assumes the economy is not operating at full capacity, a realistic assumption given the February 2011 unemployment rate of 13.7% in the county. Those sectors include:

- Construction of other non-residential structures (*Implan Sector #36*)
- Fabricated pipe and pipe fitting manufacturing (*Implan Sector #201*)
- Management, scientific and technical consulting (*Implan Sector #374*)

[1] Minnesota IMPLAN Group, Inc, IMpacts For PLANning, model version 3. 0. 5. 2

Essentially, what the IMPLAN model does is provide analysts with three types of estimates:

- **Direct.** This is an estimate of the direct effect impact on the local economy of the activity being studied that brings money to the market from the outside world. To use an analogy, this is akin to the money coming to gold miners in the old west who find gold, send it away and bring money to an area that heretofore had no economy.
- **Indirect.** This is made up of activities in local sectors that receive expenditures from the activity being studied in support of it. In the analogy, this would be the general store which sells supplies to the miners. Without the miners, it would not exist. With them, it becomes a viable business.
- **Induced.** This is made up of activities in the local economy that occur simply because money is flowing through it. These activities are not directly or indirectly related to the initial cause of the money coming to the local economy. In the analogy, this would be the saloon that exists because money is being re-spent in the local area by miners and general store workers. The beneficiaries of the induced effects may not even be aware that their success is being caused by the activity being studied.

  Note: During and after World War II, the navy let local tradesman understand how much sailors meant to them by paying them in $2.00 bills. As these bills changed hands through the local economy, merchants became aware of the induced effect that occurred because a fleet had showed up.

In Year 1, the activities associated with planning and starting construction on the Conservation and Recovery phase of the Cadiz project will have the impacts shown in Exhibit 2:

Exhibit 2.-Economic Impact of Construction Activity, Phase I, Year 1

Impact Type	Employment	Labor Income	Output
Direct Effect	593	$34,328,422	$83,325,000
Indirect Effect	152	$7,654,712	$21,284,424
Induced Effect	266	$11,432,875	$33,951,882
Total Effect	**1,011**	**$53,416,010**	**$138,561,306**

Source: Output from IMPLAN model for San Bernardino County, 2011

- 1,011 full time equivalent jobs would be created in San Bernardino County. Of those, 593 would be working directly on the project either in construction, construction material production or planning and engineering. Another 152 jobs would be created in firms assisting those operations. Firms having essentially no ties to the project would add 266 jobs due to monies flowing generally through the economy.
- $53.4 million in wages and salaries to workers as well as income to proprietorships in San Bernardino County. $34.3 million would be to workers or proprietorships working directly on some phase of the project; $7.7 million would go to workers in firms assisting

these operations. $11.4 million would go to workers in unrelated firms benefiting from the general increase in economic activity in the county.

- $138.6 million in economic activity would be added into San Bernardino County's economy.

In addition, in Year 1 of the project, $6.1 million in tax revenues that currently do not exist would be created for the state of California and local governments in San Bernardino County (*Exhibit 3*).

Exhibit 3.-California & Local Taxes Generated, Phase I, Year 1

Type of Tax	Amount
Dividends	$ 573,600
Social Ins Tax- Employee Contribution	$ 75,645
Social Ins Tax- Employer Contribution	$ 187,893
Indirect Bus Tax: Sales Tax	$ 1,360,016
Indirect Bus Tax: Property Tax	$ 1,524,190
Indirect Bus Tax: Motor Vehicle Licenses	$ 31,206
Indirect Bus Tax: Severance Tax	$ 524
Indirect Bus Tax: Other Taxes	$ 267,511
Indirect Bus Tax: State & Local Non-Taxes	$ 143,364
Corporate Profits Tax	$ 285,191
Personal Tax: Income Tax	$ 1,206,212
Personal Tax: Non-Taxes (Fines- Fees)	$ 363,468
Personal Tax: Motor Vehicle License	$ 55,826
Personal Tax: Property Taxes	$ 28,388
Personal Tax: Other Tax	$ 10,662
Total State and Local Tax	**$ 6,113,696**

Source: Output from IMPLAN model for San Bernardino County, 2011

Phase I, Year 2. In Year 2 of the project, it is assumed that 20% of the planning, engineering and management work on Phase I of the project is completed. Also in Year 2, 75% of construction and the purchase of materials required for it occurs. In addition, it is again assumed that 75% of the construction budget for each activity represents construction, while 25% represents materials and supplies. Combined, this places $194,425,000 of activity into Year 2 (*Exhibit 4*).

Exhibit 4.-Assumptions, Phase I, Year 2			
	Period	**Share**	**Year 2**
Engineering & Related	80.0%		$5,050,000
Pipeline Construction	25.0%	75.0%	$118,968,750
Pipeline Supplies	25.0%	25.0%	$39,656,250
Power Plant	25.0%	75.0%	$9,843,750
Power Plant Supplies	25.0%	25.0%	$3,281,250
Well Field	25.0%	75.0%	$13,218,750
Well Field Supplies	25.0%	25.0%	$4,406,250
Total Expenditures			**$194,425,000**
Impact Sectors			
Construction			$142,031,250
Materials & Supplies			$47,343,750
Engineering & Related			$5,050,000
Total Expenditures			**$194,425,000**

As before, these expenditures are recombined into three broad sectors used by the IMPLAN model to estimate the economic impact on San Bernardino County's economy of these Year 2 expenditures. It is further assumed that the county's economy will not have fully overcome its 13.7% unemployment rate by Year 2 and be will still be operating at below full capacity:

- Construction of other non-residential structures (*Implan Sector #36*)
- Fabricated pipe and pipe fitting manufacturing (*Implan Sector #201*)
- Management, scientific and technical consulting (*Implan Sector #374*)

Using the IMPLAN model to calculate the direct, indirect and induced impacts of these expenditure yields the following estimates for Year 2 (*Exhibit 5*):

Exhibit 5.-Economic Impact of Phase I, Year 2 ,Construction Activity			
Impact Type	**Employment**	**Labor Income**	**Output**
Direct Effect	1,197	$73,830,338	$194,425,000
Indirect Effect	316	$17,164,297	$48,151,836
Induced Effect	577	$24,793,566	$73,630,295
Total Effect	**2,090**	**$115,788,200**	**$316,207,131**

Source: Output from IMPLAN model for San Bernardino County, 2011

- 2,090 full time equivalent jobs would be created in San Bernardino County. Of those, 1,197 would be working directly on the project either in construction, construction material production or planning and engineering. Another 316 jobs would be created in firms assisting those operations. Firms having essentially no ties to the project would add 577 jobs due to monies flowing generally through the economy.
- $115.8 million in wages and salaries to workers, as well as income to proprietorships in San Bernardino County. $73.8 million would be to workers or proprietorships working directly on some phase of the project; $17.2 million would go to workers in firms assisting these operations. $24.8 million would go to workers in unrelated firms benefiting from the general increase in economic activity in the county.
- $316.2 million in economic activity would be added into San Bernardino County's economy.

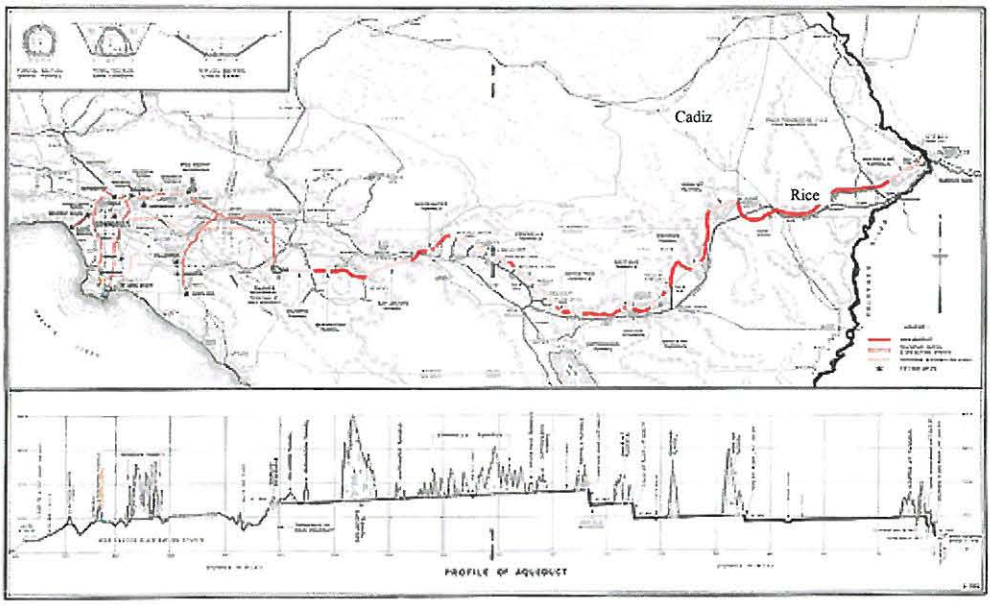
In addition, the project would create $13.5 million in tax revenues that currently do not exist for California and San Bernardino County's local governments (*Exhibit 6*):

Exhibit 6.-California & Local Taxes Generated, Phase I, Year 2

Type of Tax	Amount
CA Dividend Taxes	$ 1,331,795
Social Ins Tax- Employee Contribution	$ 162,113
Social Ins Tax- Employer Contribution	$ 402,667
Indirect Bus Tax: Sales Tax	$ 3,012,145
Indirect Bus Tax: Property Tax	$ 3,375,756
Indirect Bus Tax: Motor Vehicle Licenses	$ 69,114
Indirect Bus Tax: Severance Tax	$ 1,161
Indirect Bus Tax: Other Taxes	$ 592,481
Indirect Bus Tax: State & Local Non-Taxes	$ 317,520
Corporate Profits Tax	$ 662,162
Personal Tax: Income Tax	$ 2,616,256
Personal Tax: Non-Taxes (Fines- Fees)	$ 788,356
Personal Tax: Motor Vehicle License	$ 121,086
Personal Tax: Property Taxes	$ 61,573
Personal Tax: Other Tax	$ 23,125
Total State and Local Tax	**$ 13,537,310**

Source: Output from IMPLAN model for San Bernardino County, 2011

Phase II. <u>Imported Water Storage</u>. In Phase II of the project, imported water from the Colorado River would be sent down the Colorado River Aqueduct (*see map*) to its junction with the Arizona-California Railroad near Rice. There the water would be pump up through a 44 mile pipeline parallel to the pipeline built in Phase I, terminating in recharge basins in the Fenner Valley above Cadiz. There, the water would then be allowed to percolate into the ground and be stored in the underground aquifer until it is needed as a dry-year supply. The total capacity of the storage system is anticipated to be one million acre feet of ground water storage.



Phase II would also include the building of a 42-mile underground water pipeline that would transmit water southeast to the Colorado River Aqueduct near Rice. The pipeline would be buried along the already disturbed railroad right-of-way along which the Arizona-California Railroad (*ARZC*) currently operates (*see photograph*). It would be sized to allow the conveyance of an annual average of 50,000 acre-feet of water. Once the water reaches the Colorado River Aqueduct, it would be conveyed down it into Southern California where it would be made available to the parties responsible for storing it.

<u>Phase II: Timing & Budget</u>. Once environmental approvals are finalized, Phase II of the project is slated to begin. Planning, design and engineering will occur over a six month period. Construction of the second well field and pipeline is anticipated to take an additional 18 months. The power plant needed to raise the water will be the same one constructed in Phase I. The construction budget is estimated as:

• Well Field	$23,500,000
• Pipeline	$211,500,000
• Planning, engineering, other overhead	<u>$25,250,000</u>
• Total Phase II Budget	**$258,500,000**

Phase II: Economic Impact. Again, the primary impact of a project like the Cadiz Valley Imported Water Storage effort would occur during its construction, not its operational phase. As the project will be built in San Bernardino County, this will be the location of all of its activity. Again, this is because the county has an extensive blue collar labor supply that can build the project. It is also because San Bernardino County is home to the production facilities of leading manufacturers of the materials used in construction wells and pipelines.

- It is therefore assumed that 100% of the construction expenditures will be made to workers and suppliers located within San Bernardino County.

Phase II Year 1. In Year 1 of Phase II of the project, it is assumed that 80% of the planning, engineering and management work on Phase II of the project is completed. Also in Year 1 of Phase II, 25% of construction and the purchase of materials required for it occurs. In addition, it is assumed that 75% of the construction budget for each activity represents construction, while 25% represents materials and supplies. Combined, this places $77,550,000 of activity into Phase II Year 1 (*Exhibit 7*).

Exhibit 7.-Assumptions, Phase II, Year 1

	Period	Share	Phase II Year 2
Engineering & Related	80.0%		$18,800,000
Pipeline Construction	25.0%	75.0%	$39,656,250
Pipeline Supplies	25.0%	25.0%	$13,218,750
Well Field	25.0%	75.0%	$4,406,250
Well Field Supplies	25.0%	25.0%	$1,468,750
Total Expenditures			**$77,550,000**
Impact Sectors			
Construction			$44,062,500
Materials & Supplies			$14,687,500
Engineering & Related			$18,800,000
Total Expenditures			**$77,550,000**

These expenditures are recombined into three broad sectors used by the IMPLAN model to estimate the economic impact on San Bernardino County's economy of these Phase II Year 1 expenditures. Again, the model assumes the economy continues to not be operating at full capacity given the deep hole from which it must recover, due to the county's February 2011 unemployment rate of 13.7%. Those sectors include:

- Construction of other non-residential structures (*Implan Sector #36*)
- Fabricated pipe and pipe fitting manufacturing (*Implan Sector #201*)
- Management, scientific and technical consulting (*Implan Sector #374*)

In Phase II Year 1, the activities associated with planning and starting construction on the Imported Water Storage phase of the Cadiz project with have the impacts shown in Exhibit 8:

Exhibit 8.-Economic Impact of Construction Activity, Phase II, Year 1			
Impact Type	**Employment**	**Labor Income**	**Output**
Direct Effect	552	$31,949,224	$77,550,000
Indirect Effect	141	$7,124,188	$19,809,266
Induced Effect	248	$10,640,497	$31,598,780
Total Effect	**940**	**$49,713,909**	**$128,958,046**

Source: Output from IMPLAN model for San Bernardino County, 2011

- 940 full time equivalent jobs would be created in San Bernardino County. Of those, 552 would be working directly on the project either in construction, construction material production or planning and engineering. Another 141 jobs would be created in firms assisting those operations. Firms having essentially no ties to the project would add 248 jobs due to monies flowing generally through the economy.
- $49.7 million in wages and salaries to workers, as well as income to proprietorships in San Bernardino County. $31.9 million would be to workers or proprietorships working directly on some phase of the project; $7.1 million would go to workers in firms assisting these operations. $10.6 million would go to workers in unrelated firms benefiting from the general increase in economic activity in the county.
- $129.0 million in economic activity would be added into San Bernardino County's economy.

In addition, in Phase II Year 1 of the project, $5.7 million in tax revenues that currently do not exist would be created for the state of California and local governments in San Bernardino County (*Exhibit 9*).

Exhibit 9.-California & Local Taxes Generated, Phase II, Year 1	
Type of Tax	**Amount**
Dividends	$ 533,845
Social Ins Tax- Employee Contribution	$ 70,403
Social Ins Tax- Employer Contribution	$ 174,871
Indirect Bus Tax: Sales Tax	$1,265,757
Indirect Bus Tax: Property Tax	$1,418,553
Indirect Bus Tax: Motor Vehicle Lic	$ 29,043
Indirect Bus Tax: Severance Tax	$ 488
Indirect Bus Tax: Other Taxes	$ 248,971
Indirect Bus Tax: State & Local NonTaxes	$ 133,428

Corporate Profits Tax	$ 265,425
Personal Tax: Income Tax	$1,122,613
Personal Tax: Non-Taxes (Fines- Fees)	$ 338,277
Personal Tax: Motor Vehicle License	$ 51,957
Personal Tax: Property Taxes	$ 26,421
Personal Tax: Other Tax	$ 9,923
Total State and Local Tax	**$5,689,975**

Source: Output from IMPLAN model for San Bernardino County, 2011

Phase II, Year 2. In Year 2 of Phase II of the project, it is assumed that 20% of the planning, engineering and management work on Phase II of the project is completed. Also in Year 2, 75% of construction and the purchase of materials required for it occurs. In addition, it is again assumed that 75% of the construction budget for each activity represents construction, while 25% represents materials and supplies. Combined, this places $180,950,000 of activity into Phase II Year 2 (*Exhibit 10*).

Exhibit 10.-Assumptions, Phase II, Year 2

	Period	Share	Phase II Year 2
Engineering & Related	80.0%		$4,700,000
Pipeline Construction	25.0%	75.0%	$118,968,750
Pipeline Supplies	25.0%	25.0%	$39,656,250
Well Field	25.0%	75.0%	$13,218,750
Well Field Supplies	25.0%	25.0%	$4,406,250
Total Expenditures			**$180,950,000**
Impact Sectors			
Construction			$132,187,500
Materials & Supplies			$44,062,500
Engineering & Related			$4,700,000
Total Expenditures			**$180,950,000**

As before, these expenditures are recombined into three broad sectors used by the IMPLAN model to estimate the economic impact on San Bernardino County's economy of these Phase II Year 2 expenditures. It is further assumed that the county's economy will still not have fully overcome its 13.7% unemployment rate by this time and will be operating at below full capacity:

- Construction of other non-residential structures (*Implan Sector #36*)
- Fabricated pipe and pipe fitting manufacturing (*Implan Sector #201*)

- Management, scientific and technical consulting (*Implan Sector #374*)

Using the IMPLAN model to calculate the direct, indirect and induced impacts of these expenditure yields the following estimates for Phase II, Year 2 (*Exhibit 11*):

Exhibit 11.-Economic Impact of Phase II Year 2 Construction Activity

Impact Type	Employment	Labor Income	Output
Direct Effect	1,114	$68,713,383	$180,950,000
Indirect Effect	294	$15,974,692	$44,814,580
Induced Effect	537	$23,075,199	$68,527,204
Total Effect	**1,945**	**$107,763,274**	**$294,291,784**

Source: Output from IMPLAN model for San Bernardino County, 2011

- 1,945 full time equivalent jobs would be created in San Bernardino County. Of those, 1,114 would be working directly on the project either in construction, construction material production or planning and engineering. Another 294 jobs would be created in firms assisting those operations. Firms having essentially no ties to the project would add 537 jobs due to monies flowing generally through the economy.
- $107.8 million in wages and salaries to workers, as well as income to proprietorships in San Bernardino County. $68.7 million would be to workers or proprietorships working directly on some phase of the project; $16.0 million would go to workers in firms assisting these operations. $23.1 million would go to workers in unrelated firms benefiting from the general increase in economic activity in the county.
- $294.3 million in economic activity would be added into San Bernardino County's economy.

In addition, the project would create $12.6 million in tax revenues that currently do not exist for California and San Bernardino County's local governments (*Exhibit 12*):

Exhibit 12.-California & Local Taxes Generated, Phase II, Year 2

Type of Tax	Amount
Dividends	$ 1,239,492
Social Ins Tax- Employee Contribution	$ 150,877
Social Ins Tax- Employer Contribution	$ 374,759
Indirect Bus Tax: Sales Tax	$ 2,803,383
Indirect Bus Tax: Property Tax	$ 3,141,793
Indirect Bus Tax: Motor Vehicle Lic	$ 64,324
Indirect Bus Tax: Severance Tax	$ 1,080
Indirect Bus Tax: Other Taxes	$ 551,418
Indirect Bus Tax: S/L NonTaxes	$ 295,514
Corporate Profits Tax	$ 616,270
Personal Tax: Income Tax	$ 2,434,931
Personal Tax: Non-Taxes (Fines- Fees)	$ 733,718
Personal Tax: Motor Vehicle License	$ 112,694

Personal Tax: Property Taxes	$ 57,306
Personal Tax: Other Tax (like Fish/Hunt)	$ 21,523
Total State and Local Tax	**$12,599,082**

Source: Output from IMPLAN model for San Bernardino County, 2011

Summary. Looking at the year by year results, the economic impact of the full Cadiz Groundwater Conservation, Recovery, and Imported Water Storage Project yields the following results over its four year period:

Exhibit 13.-Summary of Economic Impacts of Construction Activity, Cadiz Water Project

Type of Impact	Phase I, Year 1	Phase I, Year 2	Phase II, Year 1	Phase II, Year 2	4-Year Total	Annual Avg.
Job Creation (*man-years*)	1,011	2,090	940	1,945	5,986	1,497
Labor & Proprietorship Income	$53,416,010	$115,788,200	$49,713,909	$107,763,274	$326,681,393	$81,670,348
Economic Activity Generated	$138,561,306	$316,207,131	$128,958,046	$294,291,784	$878,018,267	$219,504,567
State & Local Taxes Generated	$6,113,696	$13,537,310	$5,689,975	$12,599,082	$37,940,063	$9,485,016

Note that the annual average employment over this period would be 1,497 full time equivalent jobs. Altogether, the project would generate $326.7 million in income to workers and single proprietors, an average of $81.7 million per year. The economic activity added into San Bernardino County's economy over the four years would total $878.0 million, or $219.5 million per year. State and local taxes generated would total $37.9 million, or $9.5 million per year.

Looking longer term, the result of construction of the full Cadiz Water Project would be to increase the assessed valuation of property in the Cadiz area, as well as along the Arizona-California Railroad right of way and in the area where the pipelines would interact with the Colorado River Aqueduct near Rice. If it is assumed that the increase in the property valuation would be equal to the construction cost of the facilities, the increase would be $536,250,000. All of this property is in unincorporated areas of the Needles Unified School District, where the tax rate is $1.00 per $100 of valuation for San Bernardino County's government and $0.1143 for the Needles Unified School District.

If assessed valuation is not increased by an inflation factor, the annual property tax revenue generated by the Cadiz Water Project within San Bernardino County would total $6.0 million. This would include $5,362,000 to San Bernardino County and $612,934 to Needles Unified School District (*Exhibit 14*).

Exhibit 14.-Permanent Property Tax Increase, San Bernardino County

	San Bernardino Co.	Needles Unified	Total
Assumed Property Valuation	$536,250,000	$536,250,000	$536,250,000
$100 of Assessed Valuation	$5,362,500	$5,362,500	$5,362,500
Tax Rates Per $100 of AV	$1	$0.1143	$1.1143
Annual Tax Revenue	**$5,362,500**	**$612,934**	**$5,975,434**

Source: San Bernardino County Auditor Controllers Office, Tax Rates June 30, 2010

APPENDIX J

Significant and Unavoidable Impacts Identified in General Plan EIRs for Counties and Cities within the Water Area of Use

	Counties					Cities							
Resource Area/ Impact	**Los Angeles County[a]**	**San Bernardino County[b]**	**Riverside County[c]**	**San Diego County[d]**	**Orange County[e]**	**City of Los Angeles[f]**	**City of Ontario[g]**	**City of Anaheim[h]**	**City of Riverside[i]**	**City of San Diego[j]**	**City of Rancho Santa Margarita[k]**	**City of Palmdale[l]**	**City of Irvine[m]**
Aesthetics													
Impacts													
• **Degradation of visual character.**				●						●			
• **Introduction of new sources of light or glare.**		●		●									
• **Impacts to scenic highways.**		●								●			
• **Impacts to designated scenic resources in open space areas.**		●								●			
Mitigation Measures													
• Develop a Scenic Resources Overlay District.		●											
• Direct urban development and revitalization efforts to protect natural areas and areas with significant natural resource values (significant ecological areas, prime agricultural areas, scenic vistas).				●									

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Promote park development; develop and conserve open space easement, natural features, and watershed areas. Concentrate growth in urban centers to limit urban expansion into scenic open spaces.		●		●									
• Implement hillslope and ridgelines development guidelines and grading restrictions.		●		●									
• Require compliance with lighting standards to preserve dark sky conditions.		●		●									
• Require compliance with community design standards, which may include landscaping guidelines, building height restrictions, etc.				●									
• Provide road and right-of-way development standards,				●									
• Require project level review and incorporation of mitigation as a condition of approval.													
• Require undergrounding of utilities.				●									
• Establish and enforce regulations to abate abandonment of vehicles, trash, equipment, or deteriorated structures.													
Agricultural Resources													
Impacts													
• **Conversion of Important Farmland.**	●	●	●	●			●		●	●			
• **Conflict with agricultural zoning or Williamson Act contract.**			●				●		●	●			
Mitigation Measures													
• Require project level review and appropriate mitigation.													
• Create buffers between new uses and existing adjacent agricultural uses.			●	●						●			
• Consider acquisition of replacement acreage.													

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Consider relocation of prime topsoil.													
• Preserve, conserve, or create easements for important agricultural land.	●	●	●							●			
• Avoid development on prime soils and avoid agricultural development on unsuitable soils.	●	●											
• Allow development of prime agricultural land only after supplies of non-productive areas have been exhausted.		●											
• Enter into Williamson Act contracts or develop zoning designations to protect agricultural land.	●	●	●										
• Provide incentives, such as property tax relief for long-term farming operations or compensation for voluntarily limiting future development on agricultural land.		●	●										
• Implement policies in the Conservation Element.			●										
• Develop and implement programs and regulations that identify and protect agricultural lands.				●									
Air Quality													
Impacts													
• **Conflict with air quality management plan.**							●		●				
• **Violation of air quality standards.**		●		●		●	●		●	●	●	●	
• **Cumulatively considerable net increase of criteria pollutants in non-attainment areas.**				●		●	●	●		●	●		
• **Cumulative considerable net increase in greenhouse gas emissions.**							●		●	●			
• **Increased exposure of sensitive receptors to pollutants.**				●		●				●			
• **Increased objectionable odors, including diesel fumes.**		●					●						

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• **Long-term air emissions will occur from stationary sources.**			●							●		●	
• **Increased emissions from operations and vehicle miles traveled**.			●							●	●	●	
• **Short-term construction-related impacts, including fugitive dust and PM 10.**		●	●							●		●	
Mitigation Measures													
• Conform to the Transportation Improvement and Mitigation Plan.						●						●	
• Conform to the applicable local Air Quality Management Plan.		●				●							
• Develop alternative transportation options.			●								●	●	
• Coordination with local AQMD and councils of government to develop and achieve air quality improvement goals.				●							●		
• Promote energy conservation and design to reduce transportation demand.													
• Require new development to implement dust control measures (i.e. watering active sites, covering hauling trucks) during construction, including grading restrictions.		●	●	●			●		●				
• Evaluate projects based on proximity to public transit.		●		●			●						
• Evaluate projects using methods sanctioned by the South Coast Air Quality Management District and identify measure to mitigate impacts.							●		●				
• Evaluate Project compatibility with California Air Resources Board Air Quality and Land Use Handbook.			●				●						
• Implement policies established in the Environmental Resources Element and Circulation Element.												●	
• Develop and improve transit systems and vehicle trip reduction methods.		●	●				●				●	●	

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Implement transportation management programs.												●	
• Encourage participation of major employers in transportation management associations.								●					
• Consider diverting commercial truck traffic to off-peak periods.								●					
• Implementation of best available control measures for projects that would exceed daily construction emissions.				●					●	●			
• Require specified construction practices to reduce emissions and construction-related traffic and parking impacts.							●	●					
• Condition Project approval on mitigation plans.													
• Require buffers (i.e. trees, open space, sound walls) between sources and sensitive receptors.										●			
• Provide preferential parking for alternative fuel vehicles.		●		●									
• Implement fueling standards to improve number of alternative fuel vehicles.				●									
• Provide incentives for siting or use of clean air technologies, such as renewable energy sources.				●									
• Promote energy saving techniques in development design.							●	●	●				
• Prevent permitting for major sources.				●									
• Implement regional air quality standards to attain State standards.				●									
• Require use of temporary electrical power sources as alternatives to diesel at construction sites.									●				
• Implement Good Neighbor Guidelines measures to minimize exposure to and generation of diesel emissions.									●				

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Join the GHG Climate Action Registry and comply with California Air Resources Board regulations.							●		●				
• Develop, enhance, and/or implement programs to reduce energy consumption.									●				
• Require new residential projects near freeways to provide disclosure of potential increased cancer risk on all rental, lease, and sale documents.									●				
• Require truck terminals and other shipping facilities to provide electrical hookups to reduce idling. Improvements for refrigeration storage facilities shall include electrical hookups for refrigerated units.									●				
• Integrate air quality planning with land use, economic development and transportation planning.											●		
• Encourage retention and expansion of local retail business to reduce vehicle miles traveled.											●		
Biological Resources													
Impacts													
• **Sensitive species impacted via habitat modification, removal or riparian vegetation, or disruption of sensitive natural communities.**		●	●	●						●			
• **Impacts to protected wetlands.**		●								●			
• **Habitat fragmentation and interference with migratory corridors.**			●	●						●		●	
Mitigation Measures													
• Coordinate with local interest groups, and State and federal agencies prior to land use conversion to ensure protection of habitat.		●		●									
• Develop and update a biological resources inventory.		●										●	
• Improve downstream water quality and habitat.		●											

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Require site specific, project-level mitigation.		●											
• Improve solid waste management to reduce litter that attracts predator species.													
• Implement policies that preserve significant ecological areas, upland areas, open space, and natural biological communities.		●		●						●		●	
• Implement mining standards.												●	
• Establish conservation plans.		●		●									
• Develop Significant Ecological Area/ Biological Resources Overlay.		●		●									
• Protect wetland areas, vernal pools, drainages, and significant vegetation, such as Joshua tree.				●						●		●	
• Develop and protect wildlife corridors and open space networks.		●	●							●			
• Provide buffers between sensitive habitats and land use.				●						●			
• Establish native vegetation for landscaping requirements.				●									
• Require development to obtain necessary CWA 401/404 permits from RWQCB or USACE.				●									
• Implement watershed protection, stormwater management, and discharge control ordinances to protect wetlands.				●									
• Implement policies in the Conservation Element.				●									
• Require compliance with the Biological Report Guidelines, which requires field surveys, literature review, anticipated impacts and mitigation, preservation and replacement of disturbed habitat at a minimum of 1:1 ratio, and compliance with applicable HCPs.			●										

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
Cultural Resources													
Impacts													
• **Impacts to historical, archaeological, cultural, paleontological resources.**							●			●			
• **Impacts to unique geologic features.**													
Mitigation Measures													
• Conduct field studies prior to development approvals.							●						
• Require detailed mitigation plans to be incorporated into the Project.													
• Require contractors to retain a qualified archaeologist to be present onsite during ground disturbing activities and cease operations if a resource is discovered.													
• Communicate with local tribes.													
• Require site specific mitigation at a project-level as part of the discretionary review process.										●			
• Provide incentives through the Mill Act to encourage restoration, renovation, or adaptive use of historic resources.													
• Require inventory, monitoring, recovery and curation of found resources.													
• Ensure landmarking and historical listing of sites.										●			
• Develop management and restoration plans for identified and acquired properties with cultural resources.													
• Coordinate with Native American Heritage Commission, local tribal governments, and conduct SB 18 review.													

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
Geology													
Impacts													
• **Increased risk from strong seismic ground shaking and other geologic and soil hazards including poor or erosion susceptible soil conditions, landslides, soil liquefaction, unconsolidated granular soils, and soil erosion when grading occurs on slopes and ridgelines.**	●					●				●			
• **Increased risk from earthquake fault rupture.**	●					●				●		●	
• **Increased risk from seismic groundshaking.**	●					●				●		●	
• **Increased risk from liquefaction.**						●				●			
• **Increased exposure of people and structures to landslides.**						●				●			
• **Soil erosion and loss of topsoil.**										●			
• **Risk from unstable soils.**						●				●			
• **Construction impacts associated with shallow groundwater.**						●							
• **Risk to structures from subsidence and settlement of soils.**						●							
Mitigation Measures													
• Require soils engineering and soils performance review related to excavation activities.	●					●				●			
• Implement hillside management guidelines which may include grading restrictions.	●									●		●	
• Use of appropriate building materials.	●											●	
• Require Project specific mitigation related to liquefaction and landslide.													

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Implement guidelines and programs defined in the Safety Element.						●							
• Conduct a hazardous building inventory.												●	
• Require geologic investigation for new development.						●						●	
• Develop and/or comply with an emergency preparedness plan.						●						●	
• Require compliance with State and local building, structural, and seismic codes.	●					●				●		●	
Hazards and Hazardous Materials													
Impacts													
• **Exposure of people and structures to wildland fire hazards.**		●		●						●			
Mitigation Measures													
• Require proper siting of projects in high fire hazard areas to minimize fire vulnerability.		●		●						●			
• Require pre-approval analysis of land use compatibility to ensure that incompatible uses are not located adjacent to or proximate to sensitive receptors.		●								●			
• Development in fire hazard areas must have most current and fire-safe building techniques and comply with building codes.		●		●									
• Monitor post-fire debris flow hazard evaluation and prediction methods.		●											
• Monitor population growth and evaluate road capacities and hazard conditions along evacuation corridors to prepare contingency plans to correspond to the location, direction, and spread rate of wildfires.		●											
• Implement policies in the Safety Element.				●									
• Require brush removal and defensible space techniques.				●									

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
Hydrology and Water Quality													
Impacts													
• **Violation of water quality standards or impacts to surface or groundwater quality.**				●					●	●			
• **Groundwater depletion.**			●	●									
• **Alteration of drainage patterns or increased impervious surfaces resulting in erosion, siltation, flooding, and overland runoff.**										●			
• **Impacts to stormwater drainage.**													
• **Risk to habitable structures and people located in dam inundation areas or due to dam/levee failure.**						●			●				
• **Inundation by seiche, tsunami, or mudflow.**	●					●							
Mitigation Measures													
• Provide incentives to maintain ground permeability, create flood control, preserve floodplains and open space, develop stormwater facilities, and comply with NPDES permits.				●		●							
• Implement policies in the Conservation and Safety Elements.				●		●							
• Implement groundwater monitoring, recharge, and recycling programs.			●	●									
• Develop landscaping guidelines and require water conservation techniques.										●			
• Conduct water quality monitoring.													
• Require compliance with Regional Water Quality Control Board standards.				●						●			
• Require site specific mitigation at the project level.										●			

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Require future projects to be sited and designed to minimize impacts to absorption rates, drainage patterns, or rates of runoff.				●						●			
• Require onsite infiltration, preserve natural drainage systems, direct concentrate flows into sedimentation basins, grassy swales, reduce impervious surfaces, and increase vegetation coverage.				●						●			
• Implement a jurisdiction-wide urban runoff management plan.				●									
• Implement a watershed protection ordinance.				●									
• Encourage development that allows for maximum groundwater infiltration.				●									
• Restrict development in flood plains.	●												
Land Use													
Impacts													
• **Disruption or division of community.**										●			
• **Conflict with plans and policies.**										●			
• **Conversion of open space and rural land.**			●			●							
• **Conflict with existing land uses, land use patterns, and intensification of development in undeveloped areas.**						●				●			
Mitigation Measures													
• Develop open space and parkland preservation programs and consider open space and parkland dedication.													
• Encourage cluster development to reduce encroachment into open space.													
• Use policies in the Land Use Element to address compatibility issues and ensure zoning consistency.						●							

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Update Community Plans to ensure consistency with the General Plan, environmental policies, and the Airport Land Use Plan.										●			
• Develop and adopt standards to reduce land use incompatibilities.										●			
• Consider land use compatibility, parking availability, truck delivery routes, noise limitations, open space, fire protection, and visual privacy for residential units in consideration of approval of mixed uses, land use conversion, and intensification of densities.						●				●			
Mineral Resources													
Impacts													
• **Loss of regionally, locally, and statewide important mineral resource availability.**				●						●			
• **Loss of locally important mineral resource recovery sites.**				●									
Mitigation Measures													
• Require site specific mitigation at the project level.				●									
• Revise and comply with updated County ordinance regarding mineral resource areas with potential mining operations.				●									
Noise													
Impacts													
• **Exposure of sensitive receptors to vehicular traffic noise.**									●				
• **Exposure of sensitive receptors to noise levels in excess of accepted standards.**										●			
• **Exposure of sensitive receptors to ground-borne vibration.**									●				

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• **Stationary noise sources.**						●							
• **Periodic temporary or permanent increase in ambient noise levels.**				●					●	●			●
• **Exposure of sensitive receptors to excess noise levels from airports.**										●		●	
• **Exposure of sensitive receptors to railroad noise.**									●			●	
Mitigation Measures													
• Implement policies in the Noise Element.				●						●			●
• Require acoustical analysis reports to determine land use compatibility.				●					●	●			
• Require review by the Airport Land Use Commission.										●		●	
• Require future projects to incorporate architectural features to reduce indoor noise levels.										●			
• Require all non-emergency construction and land uses to comply with State and local limits.				●		●				●			
• Require compliance with State and local building codes						●			●				
• Vibration sensitive land uses adjacent to railroads must comply with Federal Transportation Administration standards.													
• Require development to comply with Caltrans noise abatement policies and construct sound walls in residential areas adjacent to city freeways.				●		●							
• Require Project design considerations to promote traffic calming, traffic control measures, and measures to minimize vehicular traffic.				●									
• Require buffer zones between incompatible land uses.				●									

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Make a fair-share contribution to a City-designated fund for the development of noise attenuation measures. All projects within the City shall be subject to an in-lieu fee for the development of noise attenuation measures in areas where noise levels are unacceptable to existing uses, particularly residential uses.													●
Population and Housing													
Impacts													
• **Deficiencies in the jobs/ housing balance.**												●	
• **Displacement of housing and need for replacement housing.**										●			
• **Increased rate of increase for the number of persons per dwelling, alteration of housing mix, and lack of affordable housing.**						●							
• **Directly or indirectly induce substantial population growth**									●				
Mitigation Measures													
• Develop strategies to address the jobs/ housing balance, such as approving future annexations or encouraging residential and non-residential development to occur at a similar rate.												●	
• Develop new housing development ordinance, condominium conversion standards, first time homebuyer incentives, mortgage revenue bonds, mobile home rent control, neighborhood quality improvement programs, senior housing programs, and habitability standards.						●							
• Require project level review to develop appropriate mitigation.													
• Implement policies to meet existing and future needs and distribute housing according to demand.						●							
• Encourage rehabilitation, revitalization, and restoration of deteriorated buildings and neighborhoods.						●							
• Develop housing types for all levels of income.						●							

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
Public Services													
Impacts													
• **Increased physical impacts associated with the provision of new or physically altered governmental facilities or need for new or physical altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for public services, including fire protection, police protection, schools, libraries, and medical facilities.**				●						●			
Mitigation Measures													
• Determine the need and potential funding sources for additional facilities and services.													
• Mitigate for physical impacts associated with new or expanded facilities, as listed by resource section.										●			
• Review plans for new or expanded school facilities.				●									
• Plan and site schools that are context specific according to the location and need.				●						●			
• Coordinate with school districts to encourage siting new facilities in accordance with General Plan and include feasible mitigation to reduce physical impacts.				●									
• Require discretionary Project applications to include commitments from available school districts.				●						●			
Recreation													
Impacts													
• **Impacts from expanded or new recreational facilities.**													

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
Mitigation Measures													
• Apply mitigation identified for resource specific impacts.													
Traffic and Transportation													
Impacts													
• **Increased traffic load, vehicle trips, congestion, and volume to capacity ratio.**				●			●	●	●	●		●	
• **Exceedance of roadway level of service.**			●	●			●		●			●	
• **Contribution to traffic congestion in surrounding areas.**		●		●									
• **Altered air traffic patterns.**													
• **Increased hazards from design features or incompatible land use.**				●									
• **Inadequate parking capacity.**										●			
• **Increased demand and use/ deterioration of public transit, commercial air service, bicycle routes, equestrian trails, and truck routes.**												●	
Mitigation Measures													
• Strive to achieve LOS D on roadways within the jurisdiction.		●										●	
• Implement policies in the Circulation Elements and implement transportation management programs.		●	●	●						●		●	
• Provide alternative transportation.		●	●										
• Work with adjacent jurisdictions to maximize roadway capacity across jurisdictional boundaries.		●		●								●	

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Coordinate with Caltrans, and local councils of government to define fair share mitigation for impacts.		●		●				●					
• Install signalized street lights.												●	
• Implement roadway improvements.								●				●	
• Implement the Walkable Communities Program.													
• Develop programs to address street and freeway systems, bicycling and pedestrian networks, parking, and transportation demand.		●								●			
• Extend public transportation to major land uses, such as airports.		●											
• Promote land use patterns that center around public transit facilities.		●											
• Install synchronized signalization.		●											
• Limit truck traffic and/or obtain additional right-of-way to accommodate right and left turn lanes at major intersections.		●											
• Require large projects to mitigate impacts to traffic networks.			●	●				●	●				
• Require large projects to pay for traffic model updates required by the project, traffic signal assessment and traffic impact fees.								●					
• Require large employers to participate in the transportation network/transportation management association.								●					
• Require large motel and hotel developers to implement transportation demand measures to limit trip generation consistent with the traffic analysis model.								●					
Public Services and Utilities													
Impacts													
• **Inadequate water supplies.**			●	●									

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• **Exceedance of landfill capacity resulting from increased solid waste.**				●									
• **Violation of AB 32 standards.**													
• **Increased risk from climate change.**	●			●									
Mitigation Measures													
• Require discretionary approval applications to include commitments from available water and sanitation districts.				●									
• Require new development that meets certain size or occupancy parameters to prepare a water supply assessment that consists of information regarding Project water demand, supply alternatives, evaluation of compliance with the UWMP, and conservation techniques.			●										
• Utilize alternative waters sources.													
• Estimate future water demands and study the feasibility of reclaiming water.													
• Require compliance with applicable urban water management plans.			●										
• Condition approval on consistency with General Plan policies and approval of land use that is consistent with long-term sustainability of groundwater supplies.				●									
• Coordinate land use planning with local water supply agencies.				●									
• Require innovative design, construction, and operation to reduce storm water pollution, energy use, and waste generation.										●			
• Offer incentives (i.e. expedited permit review) for projects that achieve LEED silver certification.				●									
• Implement water and energy conservation measures beyond those required by the State through review of Project siting, land use, and design that could reduce vehicle miles traveled.				●						●			
• Encourage development to use passive cooling techniques (i.e. Tree shading).										●			

Resource Area/ Impact	Counties					Cities							
	Los Angeles County[a]	San Bernardino County[b]	Riverside County[c]	San Diego County[d]	Orange County[e]	City of Los Angeles[f]	City of Ontario[g]	City of Anaheim[h]	City of Riverside[i]	City of San Diego[j]	City of Rancho Santa Margarita[k]	City of Palmdale[l]	City of Irvine[m]
• Prepare a Climate Action Plan which will include a greenhouse gas inventory, quantification of an emission reduction target, and a list of local emission reduction measures (i.e. requiring municipal fleets to be fuel efficient, installing LED traffic lights, conducting energy efficiency audits for municipal buildings).				●									
• Develop a Sustainable Communities Strategies Plan and participate in the County of San Bernardino Green Valley Initiative.													
• Update the local Green Building Program to provide incentives and education.				●									
• Work with local councils of government to reduce greenhouse gas emissions associated with land use and transportation.				●									
• Require commercial and industrial recycling and expand recycling and composting programs for residences.													
• Monitor landfill capacity and if capacity is limited increase efforts to divert waste and increase recycling.									●				
• Coordinate with energy providers to consider and develop a mitigation credit program.				●									

[a] County of Los Angeles, Department of Regional Planning, *County of Los Angeles General Plan Final Environmental Impact Report*, November 1980.
[b] County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006; County of San Bernardino, *San Bernardino County 2007 General Plan Program Final Program Environmental Impact Report and Appendices,* February 2007.
[c] County of Riverside, *2002 Riverside County General Plan Draft Program Environmental Impact Report*, August 2002; County of Riverside, *2003 Riverside County General Plan Final Program Environmental Impact Report*, *Volumes I and II*, October 2003.
[d] County of San Diego, San *Diego County General Plan Update Draft Program Environmental Impact Report*, July 2009; County of San Diego, *San Diego County General Plan Update Final Program Environmental Impact Report*, August 2011.
[e] County of Orange, *Environmental Determination for Orange County General Plan Technical Update*, 2005. Orange County concluded that no significant unavoidable impacts would result from implementation of their General Plan Update. Thus, Orange County's General Plan was updated by a Technical Memorandum for which an environmental impact report was not prepared.
[f] City of Los Angeles, *City of Los Angeles Citywide General Plan Framework Draft Environmental Impact Report*, January 1995; City of Los Angeles, *Los Angeles Citywide General Plan Framework Final Environmental Impact Report*, June 1996.
[g] City of Ontario, *The Ontario Plan Draft Environmental Report Volume I*, April 2009; City of Ontario, *The Ontario Plan Final Environmental Impact Report*, July 2009.
[h] City of Anaheim, *City of Anaheim Final General Plan and Zoning Code Update Environmental Impact Report No. 330*, May 2004.
[i] City of Riverside, *City of Riverside General Plan and Supporting Documents Final Program Environmental Impact Report*, November 2007.
[j] City of San Diego*, Final Program Environmental Impact Report*, March 2008.
[k] City of Rancho Santa Margarita*, Rancho Santa Margarita General Plan Final Program Environmental Impact Report*, August 2002 (SCH# 2002021113); and, *Addendum to the Rancho Santa Margarita General Plan Final Program Environmental Impact Report*, June 2006.
[l] City of Palmdale, *City of Palmdale Draft General Plan Draft Environmental Impact Report*, August 1992.
[m] City if Irvine, *City of Irvine Comprehensive General Plan Update (Phase 2) Master EIR,* April 1995; City of Irvine, City *of Irvine Comprehensive General Plan Update (Phase 3) Master EIR*, February 1997.

APPENDIX A

Soil Boring Log – TW-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Bucket Auger	Grab			None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, sand is subangular, includes <10% fines to 1/2 gravel, angular to subangular	Grab samples from Bucket Auger Rig crew
10					None		**SILTY SAND WITH GRAVEL (SM)** as above, except gravel fraction is up to 20%	
20					None		**SILTY SAND (SM)** as above	
30					None			
40					None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, subangular; includes ~5% fines to 3/4 inch gravel (angular)	
50					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 3/4), sand is fine to medium, subangular	Samples collected by direct mud rotary drilling. Note: That samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
60	Mud Rotary	Grab			None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
					None			
80					None			
					None			
90					None			
					None			
100					None			
					None			
110					None		**POORLY GRADED SAND (SP)** as above	
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
140					None			
					None			
150					None			
					None			
160								
170					None		**POORLY GRADED SAND (SP)** as above	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
190					None		**POORLY GRADED SAND (SP)** above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
200					None			
210					None			
220					None		**WELL GRADED SAND WITH GRAVEL (SW)** fine sand to fine gravel, subangular	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
250					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
260					None			
270					None			
280					None			
290					None			
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
310					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
320					None			
330					None			
340					None			
350					None			
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
370					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
380					None			
390					None			
400					None			
410					None			
420								

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None			
					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
440					None			
450					None			10" steel casing placed in the alluvial portion of the well. Casing is landed without a bottom in rock at ~454' bgs. Airlift swab development of the screened section of the 10-inch casing in alluvial portion of the well.
460	Dual Tube Reverse	Grab			Slight		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	Begin drilling at 454' bgs via dual tube reverse air rotary without additives.
470					Strong			Munsell color chart used for descriptions below 458' bgs.
480								10/23/2009 (14:15)

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including crystals up to 1/8 inch, chips up to 1 inch, subangular to angular	
					Strong			
500					Moderate		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	10/23/2009 (16:09)
510					Strong			
520					Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including	10/23/2009 (22:30)
530					Strong		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	
540								10/24/2009 (06:12)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab			Strong		**DOLOMITE** light greenish gray (10BG 7/1), as chips up to 1/2 inch, abundant of alteration/secondary mineralization	
					Strong			
560					Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	10/24/2009 (16:09)
570					Strong			
580					Strong			10/24/2009 (22:20)
590					Strong			
600								10/25/2009 (09:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab			Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	
					Strong			
620					Strong			10/25/2009 (14:40)
630					Strong			
640					Strong			10/25/2009 (17:42)
650					Slight			
660								10/25/2009 (21:25)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			Moderate		**DOLOMITE** dark bluish gray (5B 4/1), cuttings are much smaller 1/64 to 1/16 inch, suggesting different hardness	
					Strong			
680					Strong			10/26/2009 (03:57)
690					Moderate		**DOLOMITE** multicolored 1/8 to 1/2 inch chips, colors range from dark bluish gray (5B 4/1), to light bluish gray (5PB 8/1)	
700					Moderate			10/26/2009 (07:56)
710					Strong			
720								10/26/2009 (12:06)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					Strong			10/26/2009 (14:02)
730	Dual Tube Reverse	Grab			Moderate		**DOLOMITE** as above, except overall sample color is darker (90%+), dark bluish gray (10B 4/1)	
740					Strong			10/26/2009 (16:25)
750					Slight			10/26/2009 (17:35)
760					Strong			10/26/2009 (20:30)
770					Strong		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
780								10/27/2009 (00:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
790					Moderate		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
800					Slight			10/27/2009 (05:14)
810					Slight			
820					Slight			10/27/2009 (08:51)
830					Slight			
840								10/27/2009 (13:24)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			10/27/2009 (15:53)
850					None		**DOLOMITE** as above, except clasts are multicolored gray and orange primarily, orange and lighter colored clasts may be interbeds of shales and/or sandy limestone	
860					Slight		**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/27/2009 (17:54)
870					Moderate			
880					Slight			10/28/2009 (21:30)
890					Moderate			
900							**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/28/2009 (01:38)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
910					Strong		**SANDY LIMESTONE** dark bluish gray (10B 4/1), sand is very fine to fine in a matrix of limestone	
920					Moderate			10/28/2009 (04:53)
930					Moderate			
940					Moderate			10/28/2009 (08:24)
950					Slight			
960								10/28/2009 (12:40)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Slight		**SANDY LIMESTONE** as above	
970					Slight			
980					Slight			
990					Slight			
1000							End of Boring	Total depth of borehole = 1,002' bgs
1010								
1020								

APPENDIX B

Soil Boring Log – TW-2

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Grab samples from Bucket Auger Rig crew.
0	Bucket Auger	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** yellowish brown (10YR 5/4), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		as above, dark grayish brown (10YR 4/2), coarse sand to gravel, more well rounded (subrounded)	
30					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), fine to medium sand (60%), coarse sand to fine gravel, angular to subrounded	Sample collected by flooded reverse rotary drilling. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
40	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel, some coarse gravel (15%) (up to 55mm), subangular to subrounded, coarse sand (15%)	
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (5Y 4/2), fine gravel (subrounded) with coarse sand (40%)	
100					None			
110					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), subangular to subrounded	
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, some coarse gravel (5%)	
					None			
140					None			
150					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, sand fraction ~40%-50%, mostly coarse sand	
200					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), mostly medium to coarse sand, some fine gravel	
210					None			
220					None		as above, % fine gravel increasing (40%)	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
					None		as above, gravel fraction decreasing (20%)	
260					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some gravel (10%) and fines (5%)	
270					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), fine to coarse sand with fine gravel (30%)	
280					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some fine gravel (10%), and fines (5%)	
290					None		as above, sand is coarser	
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above	
					None			
320					None			
330					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), mostly medium to coarse sand, some fine sand, fine gravel (20%)	
340					None		**CLAYEY SAND (SC)** yellowish brown (10YR 5/4), medium to coarse sand, some fine gravel with fines (20%)	
350					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None		as above, % gravel decreasing (20%)	
380					None			
390					None		as above, trace coarse gravel	
400					None		as above, % gravel increasing (40%)	
410					None		as above, 50/50 coarse to fine gravel (40%), gravel up to 60mm (angular to subrounded), some weathered lithics	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel all fine gravel (40%)	
					None		gravel is fining, maximum diameter 10 mm, more fine sand than above (20%)	
440					None		gravel is all fine gravel (25%), trace clayey sand balls	
450					None		**POORLY GRADED SAND (SP)** dark yellowish brown (10YR 4/4), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		**SILTY SAND (SM)** yellowish brown (10YR 5/6), fine to coarse sand, trace fine gravel, fines (40%), soft, low plasticity	
470					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with some fine sand, fine gravel (40%), angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (25%), trace coarse gravel	
					None		**SILTY SAND (SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (15%)	
500					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (40%)	
510					None		as above, % gravel decreasing (20%)	
520					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
530					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, fine gravel (20%), silt (10%)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Mud Rotary	Grab			None		**SILTY SAND (SM)** brown (10YR 5/3), fine to coarse sand, silt (15%), fine gravel (10%)	
					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, silt (10%), fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None		as above, % fine gravel increasing (30%)	
570					None			
580					None			
590					None			
600					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** medium to coarse sand with fine sand (10%), and fine gravel (30%) (angular to subangular)	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine to coarse gravel (70/30) angular to subrounded, with medium to coarse sand	
620					None			
630					None		as above, no coarse gravel, fines (5%)	
640					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** medium to coarse sand with silt (10%), and fine sand, fine gravel (35%) (angular to subrounded)	
650					None			
660					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None		**SILTY SAND WITH GRAVEL (SM)** brown (10YR 5/3), fine to coarse sand with silt (20%), and fine gravel (25%) (subangular to rounded)	
670					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), with silt (10%), and fine gravel (30%) (angular to subrounded)	
680					None			
690					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel (angular to subrounded), with medium to coarse sand, trace fines and fine sand	
700					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), some fine sand and fines	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None		**LEAN CLAY (CL)** as above	
730					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand (more coarse), with fine gravel (rounded to angular), and silt	
740					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, trace fine sand and fines	
750					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (subangular to subrounded)	
760					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay with fine to coarse sand (30%)	
770					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand (10%), some weathered lithics	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, and fines (10%)	
					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay as above with fine sand to fine gravel (40%)	
800	Dual Tube Reverse				None		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), mostly fine sand, little medium sand, trace fine gravel (subrounded), trace coarse sand (subrounded)	10" steel casing landed at 799' bgs. Airlift swab/pump development and aquifer testing of the screened section of the 10-inch casing in alluvial portion of the well.
810					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), mostly medium to coarse sand (angular to subrounded), some fine gravel (subangular to subrounded), granitic and volcanic in composition	Resume drilling at 800' bgs via dual-tube reverse air rotary without additives.
820					None			
830					None		as above, mostly coarse sand, some medium sand (subrounded to subangular), little fine gravel (subangular)	
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, mostly fine to medium sand, little fine gravel (subrounded), granitics and volcanic in composition	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (10YR 4/2), mostly fine to coarse gravel (subrounded to angular), igneous, metamorphics, volcanics, angular broken clasts with oxidized surfaces, some medium to coarse sand (subangular to angular), abundant K-feldspar	
860					None		**CRYSTALLINE BEDROCK** gray (5Y 6/1), granitic, mostly quartz	Approximate alluvium-bedrock contact at 860' bgs.
870					None		light gray (5Y 7/1), granitic, quartz, weathered white feldspar with chalky consistency	
880					None		pinkish gray (5YR 6/2), quartz, less white feldspar, some K-feldspar	
890					None		light gray (5YR 7/1), granitic, weathered white feldspar with chalky consistency	
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** light gray (5YR 7/1), granitic, quartz, K-feldspar, few weathered white feldspar with chalky consistency	
					None		very pale brown (10YR 7/3), granitic, quartz, K-feldspar	
920					None		reddish brown (5YR 5/3), granitic, abundant K-feldspar and quartz, few mafics	
930					None			
940					None		white (5YR 8/1), granitic, quartz, white feldspar (some weathered), chalky consistency	
950					None		reddish brown (5YR 5/3), granitic, K-feldspar, quartz, trace mafics	
960					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Dual Tube Reverse	Grab			None			
					None			
980					None			
990					None		**CRYSTALLINE BEDROCK** white (5YR 8/1), granitic, quartz, white feldspar	
1000					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1010					None			
1020					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1030	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** pinkish gray (5YR 7/2), granitic, Fe-oxide staining, decreasing K-feldspar, weathered mafics	
					None			
1040					None			
1050					None		reddish gray (5YR 5/2), granitic, quartz, some K-feldspar, few mafics	
1060					None			
1070					None			
1080								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1090	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic, quartz, decreasing K-feldspar	
					None			
1100					None		pinkish gray (5YR 7/2), granitic, quartz, K-feldspar	
1110					None			
1120					None		red gray (5YR 5/2), granitic, increase in K-feldspar	
1130					None			
1140								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1150	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** very dark gray (5YR 3/1), diabase?, mafic, aphanitic texture	
					None		pinkish gray (5YR 7/2), granitic, quartz, white feldspar, few mafics	
1160					None			
1170					None			
1180					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1190					None			
1200					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1210	Dual Tube Reverse	Grab			None			
					None			
1220					None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic	
1230					None			
1240					None		pinkish gray (5YR 6/2), granitic, quartz weathered white feldspar with chalky consistency, decreasing K-feldspar	
1250					None		pinkish gray (5YR 6/2), granitic, some Fe-oxide staining	
1260					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1270	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** red brown (5YR 5/3), granitic, increasing K-feldspar	
					None			
1280					None		light gray (5YR 7/1), granitic, quartz, white feldspar, decreasing K-feldspar	
					None			
1290					None			
1300					None		reddish gray (5YR 5/2), granitic, increasing K-feldspar, trace mafics	
1310					None			
1320					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1330	Dual Tube Reverse	Grab			None			
					None			
1340					None		**CRYSTALLINE BEDROCK** dark red gray (5YR 4/2), granitic, quartz, K-feldspar	
1350					None		pinkish gray (5YR 7/2), granitic	
1360					None			
1370					None			
1380					None			Total depth of borehole: 1380' bgs

APPENDIX C

Soil Boring Log – TW-3

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Stratex	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), coarse to fine gravel (angular to subrounded) with coarse to medium sand (45%) (angular to rounded), trace fine sand	Samples collected by dual tube reverse air rotary without additives. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
10							as above	
20							**SILTY SAND (SM)** yellowish brown (10YR 5/4),coarse to fine sand (angular to subrounded) with silt (15%), and fine gravel (10%)	0'-960' logged from cuttings according to USCS. Contact between young and old alluvium (conglomerate) is unknown.
30							as above, increase in silt (25%)	
40							**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** light grayish brown (10YR 6/2), fine to coarse sand with silt and fine gravel, coarser grains (angular to subrounded), mostly granitic, some lithics and volcanics	
50							**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (10YR 6/2), coarse to fine sand with fine gravel (40%), coarse grains (angular to subrounded)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Stratex	Grab					as above, gravel is coarser, 30% fine, 15% coarse	
70							**SILTY SAND (SM)** light brownish gray (10YR 6/2), fine to coarse sand with silt (15%), and fine gravel (10%), coarse, mostly granitic with some lithics	
80							**POORLY GRADED GRAVEL WITH SAND (GP)** brown (7.5YR 4/3), mostly fine gravel, some coarse gravel (10%), with medium to coarse sand (30%), angular to subangular, granitic and lithics	
90	Dual Tube Reverse						as above, coarse gravel is subrounded, more medium sand	
100							as above, increasing sand content	
110								
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							POORLY GRADED SAND WITH GRAVEL (SP) dark gray (5YR 4/1), medium to coarse sand, trace fine sand with fine gravel, granitics, lithics, subangular to subrounded	
130	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, mostly granitic with some lithics	
140							as above, gravel is larger, some coarse gravel	
150							as above, % gravel decreasing	
160							as above, gravel includes angular to subangular dolomite fragments (strong HCL reaction)	
170							**POORLY GRADED SAND WITH GRAVEL (SP)** dark gray (5YR 4/1), medium to coarse sand with fine gravel, trace coarse gravel, granitics, limestone, mudstone (subangular to rounded)	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, more fine gravel (40%), granitics and lithics (subangular to subrounded	
200							as above, gravel includes dolomite	
210							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, gravel mostly granitic, lithics, some dolomite	
220							as above	
230							as above, gravel decreasing in abundance	
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), mostly granitic, lithics, and carbonates	
260							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), fine gravel (angular to subrounded) with medium to coarse sand, 50/50 granitic/carbonate fragments	
270							**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel, mostly granitics with carbonates and lithics	
280							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand, granitics and carbonates with some lithics	
290							as above, gravel mostly granitic	
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45%	
320							as above, sand decreasing to 30%	
330							as above, some fine gravel likely from larger clasts (some weathered surfaces with some fresh surfaces)	
340								
350								
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (2.5Y 5/2), fine gravel (subangular to subrounded) with fine to coarse sand, mostly granitic, some carbonates and lithics	
380							as above, sand decreasing to 30%, increase in carbonates	
390							as above, dark red gray (5YR 4/2), mostly granitic	
400							as above, dark reddish brown (5YR 3/3)	
410							as above, very dark gray (5YR 3/1)	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** carbonates increasing in abundance	
440							**POORLY GRADED GRAVEL (GP)** very dark gray (N3), 95% angular carbonate fragments (possible boulder)	
450							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (angular to subrounded), with medium to coarse sand, mostly granitics and carbonates	
460							**POORLY GRADED GRAVEL (GP)** very dark gray (5YR 3/1), fine gravel (angular to subrounded), 70% lithics (possible boulder)	
470							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand (40%), trace fine sand, gravel made up of granitics, lithics, and carbonates	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
500							as above, more than 50% carbonate fragments	
510							as above, carbonates decreasing to 30%	
520							as above, gravel mostly granitic (60%), with carbonates and lithic fragments (subangular to subrounded)	Rig chatter, cuttings are angular granitic fragments.
530								
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45%, abundant lithics in gravel	
560							as above, 50/50 fine gravel and medium to coarse sand, mostly granitic with carbonates, lithics, and quartzite (white)	
570							as above, granitic, lithics, and carbonates, absence of quartzite	
580							as above, carbonates increasing to 30%	
590								
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (angular to subrounded), with fine gravel (subangular to subrounded), 30% granitics, carbonates, and lithics	
620							as above, some fine sand	
630							as above, gravel increasing to 45%	
640							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand (45%), granitics, carbonates, and lithics	
650							as above, gravel increasing to 60%, mostly granitics and carbonates	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), granitics, lithics increasing and carbonates	
680							as above, trace fine sand, 40% granitic, 30% carbonates, 30% lithic, trace coarse gravel	Measure water level in borehole after sitting overnight. Measured through drill pipe. DTW = 446.1' bgs
690							as above, granitics increasing to 75%, fine gravel decreasing to 30%	
700								
710							as above, fine sand increasing to 15%	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), medium to coarse sand with fine sand (15%), and fine gravel (40%) (subangular to subrounded), mostly granitic, some lithics and carbonates	
740							as above, fine sand increasing, gravel decreasing in percent and size, average size at ~ 10mm	
750							as above, sand contains quartz, feldspar, carbonates, and lithics	
760							as above, gravel increasing to 40%	Discharge water temperature at 84.5 ° F
770							as above, carbonates increasing in abundance, sand and gravel fraction	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (10YR 5/2), mostly medium to coarse sand, with some fine sand (angular to subrounded), fine gravel (40%), granitics, lithics, and carbonates	
800								
810							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), mostly fine gravel (angular to subrounded), with medium to coarse sand, granitics, lithics, and carbonates, trace coarse gravel	
820							**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), mostly medium to coarse sand with fine gravel (30%), lithology as above	
830							as above, gravel decreasing in size and abundance (30%)	
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, carbonates increasing in abundance	
860							as above, gravel increasing to 40%, mostly granitics and carbonates	
870							as above, gravel decreasing to 30%	
880							as above, gravel size increasing to 10-20 mm	
890								
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), fine to coarse sand (mostly medium size sand) (angular to subrounded), with fine gravel, trace coarse gravel, mostly granitics and carbonates	
920								
930							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand, granitics, carbonates, and lithics	
940								
950							as above, more fine to medium sand than above	Stop drilling with T3 rig. Set pre-collar to 960' bgs for core rig.
960								Begin HQ coring.

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				43			**CONGLOMERATE** yellowish brown (10YR 5/6), fine to coarse gravel and cobbles (up to 150 mm). Formation is clast-supported, little sand (fine to coarse) and trace fines (silt and clay)	
				56				
970				90				
				62	Weak		sand and gravel (angular to subrounded), mostly granitics and carbonates (strong HCL reaction), moderately cemented, some sandy/silty sand interbeds, 0.25' thick interbeds	
980				100				
				100	Weak		granite cobble (110 mm)	
990	Rock Core	Continuous		54				
				94				
1000				40				
				100			1' of sandy silt/silty sand, layer moderately cemented	
							granite and carbonate cobbles	
1010				94				
				85			carbonate cobble (140 mm), matrix of silty fine sand	
1020				100				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1030	Rock Core	Continuous		82			**CONGLOMERATE** as above, fine to coarse gravel and cobbles (up to 150 mm), subangular to subrounded in matrix of sand to silty sand, moderately cemented, generally cLast supported, cobbles mostly carbonate and granitics, gravel, is same composition, but includes lithics	
				92				
				56				
1040				76				
				60			matrix fine to medium sand, some silty lenses	
1050				96				
				76				
1060				76				
				62			granite, quartzite, and carbonate cobbles	
1070				100			abundant cobbles	
				90	None		0.5' silt layer, moderately cemented, abundant coarse gravel and cobbles	
1080				100				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1090	Rock Core	Continuous		100	Weak		**CONGLOMERATE** as above, matrix yellowish brown (10YR 5/4), abundant cobbles, mostly granitic, some carbonates, fine to coarse sand with silt	
				80				
				90	Weak			
1100				100	None		matrix, sandy, moderately cemented	
				100			matrix, silty fine sand, not cemented	
1110				100	Weak		matrix, sandy, abundant cobbles	
				100				
1120				100	Weak			
				84			matrix fine sand, soft matrix, sandy, moderately cemented	
1130				74	Weak			
				100			mostly fine to coarse gravel, clast supported, very little matrix material	
1140				100	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1150	Rock Core	Continuous	100	100	Weak		**CONGLOMERATE** abundant cobbles (up to 200 mm), mostly carbonates and granitics, some volcanics and lithics	
			100					
			100		Weak		matrix fine silty sand	
1160			100		Weak		large granitic cobble (220 mm), ~1' of fine sand, few coarse sand, fine gravel fragments	
			100					
1170			100		Weak		large carbonate cobbles	
			82				sand interval, mostly fine to medium sand, some coarse sand to coarse gravel, yellowish brown (10YR 5/3)	
			82				coarse gravels and cobbles	
1180			40		Weak			
			70				~1' sand intervals	
1190			100					
			90		Weak			
1200								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
			50		None			
1210			13		None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/5), core is less cohesive than above (poor recovery)	
			0					
			63					
1220			40					
			50		None		**CONGLOMERATE** yellowish brown (10YR 5/3), cobbles (quartzite and carbonate), with fine to coarse gravel	
			60					
1230			100		None		~0.5'-1' silty sand, interval, soft, gravel/cobbles (angular to subrounded), consist of carbonates, granitics, and lithics	Telescope from HQ to NQ core pipe.
			68		None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/4), intervals of gravel/sand are ~1-3' thick, gravel layers are generally thicker, sand is fine to medium with silt	
1240			100		Weak			
1250								
			100					
1260								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** as above, increase in abundance of lithics in gravel and cobbles	
				76	Weak		~1' fine sand interval coarse sand and fine gravel matrix with cobbles (clast supported), cobbles are quartzite and lithics	
1270								
				0			**CONGLOMERATE** yellowish brown (10YR 5/4), fine gravel to cobbles with matrix of mostly coarse sand with fines	
1280								
				79	None			
1290								
				35			cobble with parallel fractures ~1" apart, fracture surface show Fe-oxide staining and slickensides	
				73	Weak		as above, carbonate cobble (strong HCL reaction), 160mm	
1300								
				0	None		quartzite fragment (only recovery)	
1310								
				0	None		loose gravel/cobble, quartzite, granitics, carbonates (strong HCL reaction)	
1320								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous		88	Weak		**CONGLOMERATE** yellowish brown (10YR 5/3), fine gravel to cobbles, with fine to coarse sand, gravel mostly carbonates and lithics, some granite	
				93			~1' sand/silty sand at 1326' bgs cobble fractured and filled with sediment	
1330								
				25			some gravel/cobbles have flat/planar surfaces (fracture?) and smooth	
				64				
1340								
				55	None			
				0			shoe recovered, loose gravel	
				0			loose gravel and sandy silt	
1350								
				0			loose gravel, mostly sedimentary quartzite	
				0			**CONGLOMERATE** angular to subrounded gravel in silty sand matrix	
1360								
				0				
				25			as above, smooth planar surface on cobble (fracture?)	
				90	Weak		cobbles of quartzite (sedimentary) and granite with gravel including, carbonates, shale, and lithics	
1370								
							fractured quartzite cobble	
				80				
1380								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 24 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1390	Rock Core	Continuous		84	Weak		**CONGLOMERATE** yellowish brown (10YR 5/4), color of matrix, cobbles mostly quartzite and carbonates (strong HCL reaction), gravel to coarse sand, includes shale, some quartz, with fines (some clay) formation is clast supported	
1400				92				
				50	None		matrix is sandier than above quartzite cobble with parallel fractures	
1410				75			matrix becomes finer	
1420				93	Weak		**SANDSTONE** yellowish brown (10YR 5/4), fine sand with silt and coarse sand to cobbles, fractured larger grains, mostly carbonates, shale, quartzite, few granitics	
1430				90			**CONGLOMERATE** transition back to (GP), granite cobble	
1440				80				

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE** as above, matrix is brown (10YR 5/3), clast supported fine gravel and coarse sand with coarse gravel and cobbles, matrix is silty sand, some clay	
1450				74	None		larger grains are angular to subrounded and mostly shale, carbonate, quartzite, with some lithics and granitics, cobbles mostly carbonates (strong HCL reaction)	
1460				95	None		mostly fine gravel to coarse sand	
1470				95	None		carbonate boulder (~1.5'/~450mm), largest clast cored fractured quartzite	
1480				69	Weak		quartzite cobble, fracture filled with reddish carbonate material (strong reaction with HCL)	
1490				95	Weak		matrix is sandier with medium to coarse sand **SANDSTONE** yellowish brown (10YR 5/4), mostly fine sand, some medium to coarse sand with silt and fine gravel, cobbles, fractured cobbles and fracture in sand interval (filled with clay)	
1500				78				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 26 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					None		**SANDSTONE** brown (10YR 5/3), fine to medium sand with some coarse sand, fines mostly silt, fine gravel to cobbles include granitics, lithics/volcanics, quartzite, carbonates	
1510	Rock Core	Continuous		100	Weak		fractured granitic cobble matrix is becoming finer quartzite cobble	
1520				94	Strong		fractured quartzite cobble with calcite growth on fracture surface resting on top of a carbonate cobble ~1' gravel zone	
1530				100	Strong		calcite cementation matrix still fine sand with silt	
1540				97	Weak		fractured cobble granite cobble (260 mm)	
1550				80	Weak		core becomes sandier (fewer fines)	
1560				91	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 27 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					None		**SANDSTONE** yellowish brown (10YR 5/4), fine to coarse sand (angular to subrounded) with fines and fine gravel to cobbles	
1570	Rock Core	Continuous		70	Strong		matrix becoming finer (silt and clay)	
1580				89	None		abundant volcanics in gravel very hard (fracture?), 2' silt layer with some 1" clay intervals	
1590				100	Weak		**SANDSTONE** abundant volcanics in gravel gravel abundance decreasing (sand with silt), fracture in sand	
1600				93	None		gravel zone, most gravel is subrounded, abundance of fines decreasing	
1610				87	Strong		~0.5' altered zone with calcite crystals in clayey matrix	
1620				100	None		coarse sand/gravel zone	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 28 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1630	Rock Core	Continuous			None		**SANDSTONE** yellowish brown (10YR 5/4), fine sand, some medium to coarse sand with fine gravel to cobbles, trace fines, gravel size and abundance increases at 1625' bgs	
			80		None		**SHALE** olive brown (2.5Y 4/3), fractured, sandy at 1630', clayey at 1632', shear plane at fracture (1635') with slickensides	
1640			0		Weak		**LIMESTONE** olive gray (5Y 4/2), sandy, some intervals, hard to scratch, no reaction with HCL, fractured with calcite formation on fracture surfaces	
			37		None			
1650			46		None			
			40		Strong			
1660			94		Variable		laminated, some intervals have strong reaction with HCL, some intervals have no reaction with HCL, Fe-oxide staining in some layers	
1670			46		Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands	
1680			70				**SHALE** olive brown (2.5Y 4/3)	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 29 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1690	Rock Core	Continuous		92	None		2' zone, highly deformed with calcite bands, and shale and limestone fragments included in fine matrix	
				80	Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands, deformed, parts easily along fine grained bedding surfaces	
							1689': rock becomes harder with abundant calcite veins	
				50	None		**SHALE** olive brown (2.5Y 4/4)	
1700				53	Strong		**LIMESTONE** gray (2.5Y 6/1), to dark yellowish brown (10YR 4/6), colors mottled, contains nodules (elliptical) (15-25 mm), with concentric rings (algal?) with smaller (10-15 mm), elongate objects with no rings (shell casts), calcite veins and vugs with calcite crysta	
1710				82	Strong		deformed zone containing shale fragments and limestone in a fine matrix, shear planes with slickensides	
							1711': transitions into shaley limestone, then limestone as above	
1720				94	Strong		1715', 1717', 1720.5', 1728' vugs with calcite crystals	
1730				95	Strong		1733-1734.5' and 1737'-1738.5' calcite matrix including rock fragments (breccia zone?)	
1740				90	Strong		vugs with calcite	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 30 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1750	Rock Core	Continuous			Strong		**LIMESTONE** as above, less nodules, more calcite veins 1744'-1745': vugs with calcite (~15mm opening)	
				50			shale interval	
1760				0	Strong		increase in nodules/fossils	
				100	Strong		abundant reddish brown, mottling, circular to elongate/band forming	
1770				41	None		**SHALE** olive gray (5Y 4/2), abrupt contact, with above limestone finely laminated with some sandy carbonate rich interbeds (~10-20 mm) fracture at 1771' bgs	
1780				18	None		dark olive brown (2.5Y 3/3), some dark gray/black sandy interbeds (~10-30 mm)	
				0				
1790				18			fractured shale in fine (clay) matrix	
				33	None		very dark grayish brown (2.5Y 3/2), less fractured than above	
1800					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 31 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous		25			**SHALE** dark yellowish brown (10YR 4/4), fractured, matrix is sandy, some sandy layers (up to 50 mm thick)	
1810				43	Variable		gray (2.5Y 5/1) to black (2.5Y 2.5/1), some carbonate rich/sandy layers (weak HCL reaction) fractures with slickensides	
				26	Variable			
1820				35	None		**QUARTZITE** light gray (5Y 7/1), to olive brown (2.5Y 4/4), fractured with sand matrix, individual sand grains visible in hand sample	
				0	None		white soft mineralized zone (matrix) with quartzite fragments	
1830				0				
				0	None			
1840				0	None		finer grained, recovered rocks fragments (no matrix)	
				20			highly weathered/deformed zone, rock fragments (quartzite, granite), in brownish yellow (10YR 6/6), clayey sand matrix	
1850				0	Variable		weathered/altered rock, white/green/red, some calcite reaction and quartz greenish gray/white clayey zone with slickensides	
				0			**LIMESTONE/SHALE** poor recovery, all rock recovered were gravel sized fragments of olive gray shale (no HCL reaction) and gray limestone (strong HCL reaction)	
1860								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 32 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1870	Rock Core	Continuous			Variable		**LIMESTONE/SHALE** as above, poor recovery, limestone and shale fragments as loose gravel, (no matrix)	
				0				
				0				
1880							**GRANITE** alternating intervals of hard crystalline rock and weathered/altered zones, rock is granitic (feldspar, quartz, biotite) fracture surfaces have Fe-oxide staining and calcite crystallization	
				0				
				21				
1890				0				
				0				
				28			altered zones contain broken fragments of granitic rock in a clayey matrix (typically white and green), some chlorite alteration and pyrite crystallization	
1900				20				
				19				
1910								
				33				
1920				37				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 33 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1930	Rock Core	Continuous					**GRANITE** as above, contains altered zones with chlorite, very brittle	
				23				
				0				
1940				12				
							End of Boring	
1950								
1960								
1970								
1980								

APPENDIX D

Soil Boring Log – TW2-MW

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), dry, silt to medium sand (well graded fraction ~90%) with fine to 1/2" gravel, subangular	
10							
20						**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), dry, silt to fine sand, with occasional subangular gravel to 1/2"	
30						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), silt to fine gravel, with occasional subangular gavel (1/4"-3/4")	samples are moist from here down, expected to be due to drilling fluids/circ. system required to keep borehole stable
40							
50							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), medium sand to 1/8" gravel (well graded fraction), with gravel to 3/4", all clasts are subangular	
70							
80						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
90							
100							
110							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
130							
140							
150							
160							
170							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab				**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), fine sand to fine gravel, subangular with <3% subangular to angular gravel, 1/4"-3/4"	
190				None			
200							
210				Slight		**SILT (ML)** brown (10YR 5/3), coarse, no plasticity, no other grain sizes	
220				None			
230							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab				**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), silt to fine gravel, silt is non cohesive, sand/gravel clasts are subangular to subrounded	
250				Slight			
260				Moderate			
270						**GRAVELLY WELL GRADED SAND (SW)** medium sand to 1/8" gravel, subangular to subrounded	
280				Slight			
290							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**GRAVELLY WELL GRADED SAND (SW)** medium sand to 1/8" gravel, subangular to subrounded	
310				None			
320				Strong			
330				None			
340				Slight			
350							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
370				Slight		**WELL GRADED SAND WITH SILT (SW-SM)** same as above, except with low plasticity silt	
380				Moderate			
390				None			
400							
410						**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
430							
440							
450							
460							
470							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
490						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, smaller clasts, subangular to subrounded, larger clasts are subangular to angular	
500						**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
510							
520							
530							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
550							
560							
570							
580							
590							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	
670							
680							
690							
700							
710							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 13

SOIL BORING LOG: TW2-MW

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 922.37 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W
WATER LEVELS: **START:** 10/15/2010 **END:** 10/20/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** medium sand to fine gravel, subangular to subrounded	Total depth of borehole = 740' bgs
730							
740							
750							
760							
770							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX E

Soil Boring Log – CH-5

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		Slight		**POORLY GRADED SAND WITH SILT (SP-SM)** very pale brown (10YR 7/3), dry, loose (surface) 90% is coarse silt to very fine sand (e.g. aeolian)	
10						**POORLY GRADED SAND WITH GRAVEL (SP)** as above, except dry, loose, with ~20% fine to 1/2" gravel (subangular)	
20							
30							
40							
50		Grab				**POORLY GRADED SAND (SP)** brown (10YR 5/3), with coarse silt (no low plasticity), sand is very fine to fine sand, wet (from drilling method)	

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel	
70							
80							
90							
100							
110							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
130							
140							
150							
160							
170							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-colored grains, medium sand to fine gravel (subrounded), with <5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
190							
200						**WELL GRADED GRAVEL (GW)** same as above, except dominant grain size is gravel (fine to 3/4"), subrounded to subangular	
210						**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel	
220							
230							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
250							
260							
270							
280							
290							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel *(Soil Description Repeated)*	
310							
320							
330						**WELL GRADED SAND WITH SILT (SW-SM)** same as above, except with non-cohesive silt	
340						**WELL GRADED SAND (SW)** brown (10YR 5/3), multi-color grains, medium sand to fine gravel (subrounded) with < 5% 1/4" to 1/2" subrounded gravel	
350	Rock Core	Continuous		Strong on Matrix		**FANGLOMERATE** well cemented, moist to dry, matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized, up to 3" to 4", clasts include multi-colored igneous intrusive and extrusive (volcanics), matrix is very pale brown (10YR 7/3) to brown (10YR 5/4)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), well cemented, matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized, up to 3" to 4", clasts include multi-colored igneous intrusive and extrusive (volcanics)	
370							
380							
390						less consolidated/cemented, matrix can be disaggregated with moderate force	
400				Moderate on Matrix - Slight on Clasts		at 401', 6" granitic cobble at 403', 1' granitic cobble	
410						at 409.5, shattered, metamorphic rock with staining on surface of break, more consolidated several 6" to 1' thick gravel zones (% gravel > % sand)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous		Strong on Matrix - Slight / Moderate on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized	
430						429-431' - vugs in matrix, suggesting dissolved carbonate	
440							
450				Strong on Matrix - Strong on Clasts		very hard, can be disintegrated with a hammer, pits/vugs in core suggest weathered out carbonates at 449.5' (also secondary mineralization), 458', 458.5' and 461'	
460							
470				Strong on Matrix		carbonate clast at 474', ~10-30% of gravelly cobble clasts are carbonates	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), very hard cobble at 480'	
						heavily cemented interval from 478-490'	
490						moderate to strong cementation, carbonate clasts ~20-40% (gravel/cobbles)	
500							
510							
520						at 525' calcite (?) crystals to 1/8" on face of carbonate clast	
530							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized at 595' small crystals on face of clast	
550							
560							
570							
580							
590							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized 2' diameter granitic boulder 604-606'	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		Slight to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), most clasts are cobbles, gravels up to 2"	
670							
680							
690							
700							
710				Strong on Matrix - Slight on Clasts			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), matrix supported clasts, matrix is fine to coarse sand with silt/clay fines, clasts are gravel to cobble sized softer than above	
730							
740							
750							
760							
770							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 14 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4)	
790						matrix composed of fines to coarse sand/fine gravel (well graded), hard to firm (alternating within several feet/core run), cementation various from weak/moderate to strong, occasional boulders/cobbles every 2-3 feet, otherwise gravels to 2" - 3" (angular to subangular)	
800							
810							
820							
830						dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 15 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Rock Core	Continuous		Strong on Matrix - Slight on Clasts		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
850							
860							
870				Moderate to Strong			
880							
890							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 16 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
900	Rock Core	Continuous		Moderate to Strong		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
910				None		911-916', dry, mottled clay layer, very hard	
920				Moderate to Strong			
930							
940				Slight to Moderate			
950				None to Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 17 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
960	Rock Core	Continuous		None to Slight		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above firm sand with occasional gravel, sand is very fine to fine sand with <5% gravel up to 2"	
970							
980						984-990' - very hard interval	similar to what was seen in CH-1 above granitics
990							cannot be broken by hand, possibly buried weathered surface (?)
1000							
1010							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 18 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1020	Rock Core	Continuous		None to Slight		**FANGLOMERATE** yellowish brown (10YR 5/4), dominant grain size in matrix is fine to medium sand (poorly graded), with fines and coarse sand to fine gravel, overall sample is harder than above	
1030						hard, possibly old weathering/exposed surface, matrix appears to be primarily fine to medium sand, includes coarse sand, gravels, cobbles	
1040				Slight to Strong			
1050							
1060				Moderate to Strong			
1070							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 19 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1080	Rock Core	Continuous					
1090				Moderate to Strong			
1100						**DECOMPOSED GRANITE** heavily decomposed, white/gray with abundant yellow to rust colored residuum, remnants of large crystals to 1/2" diameter	
1110							
1120				None to Slight (slight on fracture surfaces)			
1130							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 20 of 20

SOIL BORING LOG: CH-5

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 975.34 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/24/2010 **END:** 11/4/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1140	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**DECOMPOSED GRANITE** heavily decomposed, white/gray with abundant yellow to rust colored residuum, remnants of large crystals to 1/2" diameter *(Soil Description Repeated)*	
1150						more competent less weathered	
1160							
1170						highly weathered	
1180							
1190							Total borehole depth = 1191' bgs

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

APPENDIX F

Soil Boring Log – DT-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		Moderate		**GRAVELY POORLY GRADED SAND (SP)** very pale brown (10YR 7/4), dry, coarse silt to fine sand with >5% fine to 1/4" gravel, angular to subangular, loose	10' stratex 0-65' bgs (12/16/2010) 10" stratex added 65-165' bgs (1/10/2011-1/11/2011)
10						**WELL GRADED GRAVEL (GW)** dry, medium sand to 1" gravel, subrounded to subangular	
20							
30				Slight			
40							
50							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Stratex	Grab		Slight		**WELL GRADED GRAVEL (GW)** dry, medium sand to 1" gravel, subrounded to subangular *(Soil Description Repeated)*	
70							
80							
90							
100							
110						**POORLY GRADED SAND (SP)** light brownish gray (10YR 6/2), very fine to fine sand with up to 5% fine gravel (subrounded)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Stratex	Grab		Slight		**POORLY GRADED SAND (SP)** light brownish gray (10YR 6/2), very fine to fine sand with up to 5% fine gravel (subrounded) *(Soil Description Repeated)*	
130						**WELL GRADED SAND WITH GRAVEL (SW)** fine to very coarse sand with gravel to 3/4", coarse grained fragments are subrounded	
140							
150							
160							
170	Dual Tube Reverse	Grab					

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab				**WELL GRADED SAND WITH GRAVEL (SW)** fine to very coarse sand with gravel to 3/4", coarse grained fragments are subrounded *(Soil Description Repeated)*	
190				Slight			
200							
210							
220				Moderate			
230				Slight		**POORLY GRADED SAND (SP)** pale brown (10YR 6/3), very fine to medium sand (90% very fine to fine sand), <5% fine gravel (subrounded)	1/12/2011 1918

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Slight		**POORLY GRADED SAND (SP)** pale brown (10YR 6/3), very fine to medium sand (90% very fine to fine sand), <5% fine gravel (subrounded) *(Soil Description Repeated)*	1/11/2011 2021 1/11/2011 2025
250							
260						**WELL GRADED SAND WITH GRAVEL (SW)** sand is fine to coarse, gravel is fine to 1/8", subrounded	
270							1/11/2011 2148 1/11/2011 2153
280							
290						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, subrounded to subangular	1/11/2011 2400 1/12/2011 0100

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND WITH GRAVEL (SW)** sand is fine to coarse, gravel is fine to 1/8", subrounded	
310							1/12/2011 0220 1/12/2011 0230
320							
330						**WELL GRADED GRAVEL (GW)** medium sand to 1/2" gravel, subrounded to subangular	1/12/2011 0400 1/12/2011 0410
340						**WELL GRADED SAND WITH SILT (SW-SM)** light yellowish brown (10YR 6/4), sand is fine sand to 1/8" gravel	
350							1/12/2011 0520 1/12/2011 0600

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND WITH SILT (SW-SM)** light yellowish brown (10YR 6/4), sand is fine sand to 1/8" gravel *(Soil Description Repeated)*	
370							1/12/2011 0720 1/12/2011 0730
380							
390							1/12/2011 0830 1/12/2011 0830
400							
410				Moderate		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded	1/12/2011 1030 1/12/2011 1130

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Dual Tube Reverse	Grab		Moderate		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded *(Soil Description Repeated)*	
430							1/12/2011 1202 1/12/2011 1304
440							
450							1/12/2011 1538 1/12/2011 1546
460							
470							1/12/2011 1654 1/12/2011 1710

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Dual Tube Reverse	Grab		Slight		**WELL GRADED GRAVEL (GW)** light yellowish brown (10YR 6/4), coarse sand to fine gravel, subangular to subrounded *(Soil Description Repeated)*	
490							1/12/2011 1932 1/12/2011 2109
500							
510							1/12/2011 2224 1/12/2011 2232
520						**SILTY SAND (SM)** yellowish brown (10YR 5/4), sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity	
530							1/12/2011 2325 1/13/2011 1300 1/13/2011 1332 1/13/2011 1343

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Dual Tube Reverse	Grab		Slight		**SILTY SAND (SM)** yellowish brown (10YR 5/4), sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity *(Soil Description Repeated)*	
550						**WELL GRADED SAND WITH SILT (SW-SM)** sand is fine sand to 1/4" gravel, coarse sand and gravel clasts are angular to subangular	1/13/2011 1509 1/13/2011 1516
560						**SILTY SAND (SM)** sand is poorly graded, fine to medium and with <5% fine to 1/8" gravel, silt is low plasticity	
570						**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular	1/13/2011 1631 1/13/2011 1639
580							
590							1/13/2011 1806 1/13/2011 1845

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
610							1/13/2011 2007 1/13/2011 2013
620							
630							1/13/2011 2152 1/13/2011 2200
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
670							1/14/2011 0105 1/14/2011 0115
680							
690							1/14/2011 0220 1/14/2011 0300
700							
710							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
730							1/14/2011 0525 1/14/2011 0530
740							
750							1/14/2011 0720 1/14/2011 0735
760							
770							1/14/2011 1025 1/14/2011 1045

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 14 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
790							
800							
810							
820							
830						- fine sand to 1/4" gravel, subrounded to subangular	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 15 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
850							
860							
870						- medium sand to 1/4" gravel, subangular to subrounded	
880							
890							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 16 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
900	Dual Tube Reverse	Grab		Slight		**WELL GRADED SAND (SW)** fine sand to 1/2" gravel with some silt, coarse clasts are angular to subangular *(Soil Description Repeated)*	
910							
920							
930				None		**QUARTZITE** some staining (iron?) on some surfaces suggesting fracturing	Samples below 925' are not recent alluvial deposits or soil. However samples are described according to the USCS classification system for consistency with other project lithologic logs. When possible, geologic formation names are indicated.
940						yellow (10YR 8/6), grains are medium sand to 1/4" gravel, all angular shards two primary colors, yellow (10YR 7/6) and dark grayish brown (10YR 4/2), medium sand to 1/4" gravel sized angular shards	
950						dark yellowish brown (10YR 4/6), fine sand to fine gravel sized subangular to angular shards, abundant quartz light gray (10YR 7/2), 40% very fine to medium sand sized, subangular to angular shards, 5% fine to 1/4" gravel sized shards, abundant quartz color is significantly different, very dark grayish brown (10YR 3/2) and not much quartz, mostly mafic minerals	Even though cuttings are described as 'sands' or 'gravels', it is an indication of grain size distribution only. A sedimentary depositional environment should not be inferred by the use of the USCS nomenclature from 925' to TD.

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 17 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
960	Dual Tube Reverse	Grab		None		**QUARTZITE** brown (10YR 5/3), fine sand to fine gravel sized subangular to angular shards	
970						light gray (10YR 7/1), very fine to coarse sand sized subangular to angular shards with up to 5% fine to 1/2" gravel sized pieces dark gray (10YR 4/1)	
980						light red (2.5YR 6/6)	
990						light reddish brown (2.5YR 7/3)	
1000						light reddish brown (2.5YR 7/4), 98% very fine to fine sand sized particles with up to 2% 1/5" gravel sized clasts	
1010							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 18 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1020	Dual Tube Reverse	Grab		None		**QUARTZITE** reddish brown (2.5YR 5/4)	
1030							
1040							
1050						light yellowish brown (2.5Y 6/4)	
1060							
1070							

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 19 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1080	Dual Tube Reverse	Grab		None		**QUARTZITE** light yellowish brown (2.5Y 6/4)	
1090							
1100				Strong		weak red (2.5YR 5/2)	
1110				None		light reddish brown (2.5YR 6/4), almost 100% very fine to medium sand sized sands/clasts	
1120				Slight			
1130				None			
				Slight			

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 20 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1140	Dual Tube Reverse	Grab		Slight		light reddish brown (2.5YR 6/3), very fine to coarse sand sized shards/clasts	
1150				Moderate		light reddish brown (2.5YR 6/4), 98% very fine to fine sand sized particles	
1160				Slight		reddish brown (2.5YR 5/4), very fine to coarse sand sized, subangular to angular shards/clasts	
1170							
1180							
1190							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 21 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1200	Dual Tube Reverse	Grab		Slight		reddish brown (2.5YR 5/4), very fine to coarse sand sized, subangular to angular shards/clasts	
1210							
1220							
1230						higher proportion of medium to coarse sand sized particles	
1240							
1250						light reddish brown (2.5YR 6/3)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 22 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1260	Dual Tube Reverse	Grab		Slight			
1270				Moderate			
1280				Slight		**GRANITE** gray (2.5Y 5/1), comes out as sand sized particles, salt and pepper look	Contact with Jurassic granite (Jgr)
1290						color has more red: reddish brown (2.5YR 5/3)	
1300				Moderate			
1310				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 23 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1320	Dual Tube Reverse	Grab		None		**GRANITE** reddish brown (2.5YR 5/3), cuttings are sand sized particles	
1330						yellowish brown (10YR 5/4)	
1340							
1350						reddish brown (5YR 5/4)	
1360							
1370				Strong		mix of greenish black (5GY 2.5/1) and yellowish brown (10YR 5/4)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 24 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1380	Dual Tube Reverse	Grab				**GRANITE** mix of greenish black (5GY 2.5/1) and yellowish brown (10YR 5/4)	
						yellowish brown (10YR 5/4)	
1390							
						mix of greenish black (10GY 2.5/1) and yellowish brown (10YR 5/4)	
				Slight			
1400							
						mix of very dark grayish green (5G 3/2) and yellowish brown (10YR 5/4)	
1410							
						yellowish brown (10YR 5/4)	
				None			
1420							
1430							
						reddish brown (5YR 5/3)	
				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 25 of 25

SOIL BORING LOG: DT-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 1,084 ft msl (estimated) **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/RD-20
WATER LEVELS: **START:** 12/16/2010 **END:** 2/24/2011 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
1440	Dual Tube Reverse	Grab				**GRANITE** reddish brown (5YR 5/3), cuttings are sand sized particles	
				Slight			
1450							
						yellowish brown (10YR 5/4)	
1460							
						yellowish brown (10YR 5/4)	
1470							
				None			
1480							
1490							Total borehole depth = 1500' bgs

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

APPENDIX G

Soil Boring Log – TW-2B

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Samples collected by dual tube reverse air rotary without additives. Note: Samples appear to be artificially sorted due to the drilling method, and probably do not accurately represent the full range of grain sizes.
0	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** pale brown (10YR 6/3), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		**POORLY GRADED SAND WITH SILT (SP-SM)** brownish yellow (10YR 6/6), mostly fine sand, little medium sand, trace fine gravel (subrounded)	
30					None		**POORLY GRADED GRAVEL WITH SAND (GP)** gray (10YR 5/1), fine to coarse gravel, angular to subangular	
40					None		as above, dark grayish brown (10YR 4/2), fine gravel, little coarse gravel, subangular to subrounded, some fine to coarse sand	
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		as above, grayish brown (2.5Y 5/2), fine gravel (subrounded) with coarse sand (40%)	
100					None		**POORLY GRADED SAND WITH GRAVEL (SP)** grayish brown (2.5Y 5/2), medium to coarse sand with fine gravel (40%), subangular to subrounded	
110					None			
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Dual Tube Reverse	Grab			None			
					None			
140					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
150					None			
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (2.5Y 6/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, brown (10YR 5/3), sand fraction ~ 40%-50%, mostly coarse sand	
200					None			
210					None			
220					None			
230					None		**POORLY GRADED SAND WITH GRAVEL (SP)** pale brown (10YR 6/3), mostly medium to coarse sand, some fine gravel	
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
260					None			
270					None			
280					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel, angular, medium to coarse sand, angular	
290					None			
300					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab			None			
					None			
320					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light gray (10YR 7/2), mostly medium to coarse sand, some fine sand, fine gravel (15%)	
330					None			
340					None			
350					None		as above, yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None			
380					None			
390					None		as above, % gravel decreasing (20%)	
400					None			
410					None			
420					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, % gravel increasing (40%)	
					None			
440					None			
					None			
450					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		as above, brown (7.5YR 4/2), fine to coarse sand, increase in fine gravel, angular	
					None			
470					None		as above, dark grayish brown (10YR 4/2), medium to coarse sand with some fine sand, fine gravel, angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel	
					None			
500					None		**POORLY GRADED SAND WITH GRAVEL (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel (40%)	
510					None			
520					None		as above, % gravel decreasing (20%)	
530					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
550					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand, fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None			
570					None		as above, % fine gravel increasing (30%)	
580					None		as above, medium to coarse sand with fine sand (10%), and fine gravel (25%) (angular to subangular)	
590					None			
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
610					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 4/3), fine gravel, angular to subrounded, with medium to coarse sand	
620					None			
630					None			
640					None			
650					None		**POORLY GRADED SAND (SP)** brown (10YR 4/3), medium to coarse sand, and fine sand, trace fine gravel (angular to subrounded)	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (15%) (angular to subrounded)	
					None			
680					None			
690					None			
700					None		as above, very dark brown (10YR 2/2), medium to coarse sand, trace fine sand, fine gravel (angular to subrounded)	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand (more coarse), with fine gravel (rounded to angular)	
					None			
740					None			
750					None		as above, fine to coarse sand, little fine gravel, angular to subangular	
760					None			
770					None			
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, fine to coarse sand, little fine gravel, angular to subangular	
					None			
				100			**CONGLOMERATE** very pale brown (10YR 7/3), gravel and cobbles of granitic and volcanic origin, coarse grained, moderately weathered	Stop drilling with T3 rig. Set pre-collar to 798' bgs for core rig.
800	Rock Core	Continuous		31	None			Begin HQ core.
				42				
				70				
810				33			**CRYSTALLINE BEDROCK** white (N8) to greenish gray (5GY 6/1), quartz, white feldspar, granitic, coarse grained, moderately weathered, weathered white feldspars with chalky consistency, slightly to highly weathered, fractures throughout	
				0				
820				0				
				19				
				21			some chlorite alteration	
830				8			chlorite alteration	
				0				
				0				
840				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				31				
				22				
				0				
				0				
850				0				
				11			**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, presence of K-feldspar, coarse grained, slightly to highly weathered, fractures throughout, weathered white feldspar, highly weathered feldspar at 849.5'	
				7				
860				0			increase in K-feldspar, presence of Fe-oxide	
				20				
				0			light reddish brown (5YR 6/4), granitic, quartz, K-feldspar, coarse grained, moderately weathered, Fe-oxide stained	
870	Rock Core	Continuous		33	None			
				0				
				0				
880				46				
				0				
				0				
890				0				
				25				
				19				
900				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Rock Core	Continuous		0	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, some K-feldspar, coarse grained, slightly to highly weathered, fractures throughout	
				0				
				10				
				13				
				24				
920				25				
				0				
				0				
				0				
930				0				
				0				
				0				
				0				
940				38				
				0			weathered white feldspar (no reaction with HCL)	
				14				
950				50				
				100	Strong		mafic interval (952'-955'), brown (7.5YR 5/2), mafics, calcite veins (HCL strong reaction), fine grained, clays with void-filling calcite at top contact	
				37				
960				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Rock Core	Continuous		30	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, slightly to highly weathered, fractured throughout	
				26				
				55				
				0				
980				23				
				38			highly weathered/altered, abundant chlorite	
				76				
990				60				
				63				
1000				55			2' altered chlorite zone	
				85				
1010							End of Boring	
1020								

APPENDIX H

Soil Boring Log – CH-1

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab		None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), dry, sand is fine to medium, sample has some non-plastic silt (~5%)	
10						**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), dry, sample is fine sand to 1" gravel, 10% of sample is fine sand to fine gravel, all clasts are subangular to angular	
20							
30							
40							
50						decrease in coarse gravel	

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Stratex	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), sample is fine sand to 1" gravel, increase in gravel to 10%, all clasts are subangular to angular	
70							
80							
90							
100							
110							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Stratex	Grab		None		**WELL GRADED SAND (SW)** yellowish brown (10YR 5/4), sample is fine sand to 1" gravel, 10% gravel, all clasts are subangular to angular	
130							
140							
150							
160							
170		Grab				**WELL GRADED GRAVEL WITH SAND (GW)** dry, coarse sand to 1" gravel, 90% of sample is coarse sand to 1/4" gravel, subangular to angular	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		None		**WELL GRADED GRAVEL WITH SAND (GW)** dry, coarse sand to 1" gravel, 90% of sample is coarse sand to 1/4" gravel, subangular to angular *(Soil Description Repeated)*	
190						**WELL GRADED SAND WITH SILT (SW-SM)** brown (10YR 5/3), very fine sand to coarse sand, subangular, silt is low plasticity	
200							
210							
220							
230							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		None		**WELL GRADED SAND WITH SILT (SW-SM)** brown (10YR 5/3), very fine sand to coarse sand, subangular, silt is low plasticity *(Soil Description Repeated)*	
250							
260						**SILTY SAND (SM)** brown (10YR 5/3), sand is very fine to coarse sand with <5% gravel (1/8"-5/8"), subangular to angular	
270							
280							
290				Slight			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab		Slight		**SILTY SAND (SM)** brown (10YR 5/3), sand is very fine to coarse sand with <5% gravel (1/8"-5/8"), subangular to angular *(Soil Description Repeated)*	
310						**WELL GRADED GRAVEL (GW)** coarse sand to 1/2" gravel, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	these samples may be "washed" to some degree due to the drilling method
320							
330							
340						**WELL GRADED GRAVEL WITH SILT (GW-GM)** yellowish brown (10YR 5/4), coarse sand to 1/2" gravel with silt, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	
350							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Dual Tube Reverse	Grab		None		**WELL GRADED SAND (GW)** coarse sand to 1/2" gravel, larger clasts are subrounded to subangular, smaller clasts are subangular to angular	sample from 360-398' appear to be heavily washed and coarse biased
370							
380							
390							
400	Rock Core	Continuous		Slight to Moderate		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), weakly cemented/consolidated, composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	begin coring, core can be easily broken with a hammer into smaller pieces, these pieces do not disintegrate in to individual grains, gravel
410							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous				**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), grain size ranges from fine to medium sand, slightly less cemented/consolidated than above	
430				Slight to Moderate			
440						gravel increase to 5-10%	
450				Moderate			
460							
470							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous				**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	
490				Slight to Moderate			
500							
510				Moderate			
520				Slight to Moderate		several large clasts of heavily weathered/vuggy rock	transition from Quaternary alluvium to Miocene fanglomerate
530				Moderate to Strong			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous		Moderate to Strong		**POORLY GRADED SAND (SP)** composed of interbedded gravels, sands, fines (silts/clasts), sand varies from very fine to coarse, gravel is fine gravel to 2" clasts or cored pieces of cobbles, overall sample color is yellowish brown (10YR /4) with variation depending on larger clast contents (%), larger clasts include igneous and volcanic rocks	
550				Slight to Moderate			
560				Moderate to Strong			
570				Strong		Distinctive contact, very hard and well cemented, possibly contact metamorphism	
580							
590						interbed of gravel/sand	contact with Jurrasic granite (Jgr)

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**GRANITE** fractured granite, fracture frequency is ~6"-1'	
610							
620							
630							
640							
650							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 12

SOIL BORING LOG: CH-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 908.77 ft msl **DRILLING CONTRACTOR:** Layne Christensen, Inc.
DRILLING METHOD AND EQUIPMENT: Stratex and Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/12/2010 **END:** 10/18/2010 **LOGGER:** T. Henderson

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		None to Slight (slight on fracture surfaces)		**GRANITE** fractured granite, fracture frequency is ~6"-1', calcite mineralization on fracture surfaces	
670							
680							
690							
700						garnet minerals integrated into rock	
710						breciatted cake white pulverized	Total borehole depth = 711' bgs

SAMPLE TEST 386303CADIZ.GPJ CADIZLIBRARY.GLB 8/17/11

APPENDIX I

Soil Boring Log – CH-4

GEOSCIENCE

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 1 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
0	Stratex	Grab				**POORLY GRADED GRAVEL WITH SAND (GP)** light yellowish brown (10YR 6/4), fine to coarse gravel (70%) with fine to coarse sand, gravel is granitic, volcanic, lithics, some silt fragments	
10						sand is mostly medium to coarse, some carbonate fragments	
20						brown (10YR 5/3), sand mostly coarse	
30				Weak		**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (10YR 6/2), fine to coarse sand with gravel (most fine), most gravel granitic and lithic, some volcanic (rounded to subrounded)	
40						**POORLY GRADED GRAVEL WITH SAND (GP)** gray (10YR 5/1), fine gravel with coarse to medium sand, gravel (subround to subangular), volcanics and granitics	
50	Dual Tube Reverse	Grab				**POORLY GRADED SAND (SP)** grayish brown (10YR 5/2), mostly medium coarse sand, some fine gravel	

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 2 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
60	Dual Tube Reverse	Grab				**POORLY GRADED SAND WITH GRAVEL (SP)** same as above except, percentage of fine gravel increases	
70						**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (10YR 4/2), fine to coarse gravel with medium to coarse sand, gravel (subround to subangular), volcanic, lithics, granitics	
80						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with fine gravel, gravel as above	
90				Weak		percentage of gravel increases, some coarse gravel	
100						all gravel is fine gravel	
110						some fine sand/silt	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 3 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
120	Dual Tube Reverse	Grab				**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with fine gravel, percentage of gravel increases	
130				Weak			
140							
150						dark grayish brown (10YR 4/2), fine to coarse sand with fine gravel, gravel (subrounded to subangular), mostly volcanics/lithics	below 150' difficult to distinguish reaction to HCL on individual grains of medium sand and smaller grain sizes
160				Weak			
170							

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 4 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
180	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), medium to coarse sand with some fine gravel	
190				None		abundant fragments of black volcanic rock (from larger cobble)	
200							
210							
220				Weak			
230						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), percentage of fine sand and fine gravel increases	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 5 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
240	Dual Tube Reverse	Grab		Weak		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), mostly medium to coarse sand with fine gravel (subround/subangular)	
250							
260							
270						percentage of fine sand increases	
280							
290						**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), increase in fine gravel, gravel is mostly volcanic (subangular)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 6 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
300	Dual Tube Reverse	Grab				**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), fine to coarse sand with some fine gravel	
310				Weak		percentage of fine sand decreases and fine gravel increases	
320							
330							
340							
348	Rock Core	Continuous				**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/6), interbedded strongly to weakly cemented sands and gravels, coarser intervals generally have stronger cementation	start coring at 348'
350				None			
				Strong			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 7 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
360	Rock Core	Continuous		None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/6), interbedded strongly to weakly cemented sands and gravels, coarser intervals generally have stronger cementation, gravels are round to subround, majority of large clasts are volcanic, some lithics, granitics, and carbonate clasts	
				Weak			
370				None			
380				Weak			
390				None to Strong		stronger HCL reaction in sandy intervals, weak or no reaction in gravelly interval ~ 0.5' weakly cemented sand lense (no reaction)	
400				None to Weak		sand and fine gravel (round/subround), gravel still mostly volcanic clasts	
410				Weak		well cemented sand and gravel ~0.5' clay/silt interval (hard)	412-418', core difficult to break by hand, requires hammer

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 8 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
420	Rock Core	Continuous		None to Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4) to brown (10YR 5/3), interbedded sands and gravels, coarser intervals, have stronger reactions with HCL, large gravel/cobbles are mostly volcanic (up to 4"), some granitic lithic and carbonate clasts	420-480', core generally hard to break unless otherwise noted
				Weak to Strong			
430				None to Strong			
						mostly medium/coarse sand with gravelly interbeds (~2-4")	
440				Strong			
				None to Strong		silty interval (~1') at 448', becomes coarser with more gravel/cobbles (up to 7")	
450				Strong			
						cobbly interval	
460				Weak to Strong			
						~1' coarse sand interval, sugary texture on grains, no fines in matrix	
						abundant volcanic gravel	
470				Strong		1' fine to medium sand, less cemented	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 9 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
480	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** same as above, gravel/cobble beds (beds up to 1'), some well cemented lenses (1-2") with all medium to coarse sand (no matrix)	480-540', generally difficult to break core by hand unless otherwise noted
				Weak to Strong			
490						coarse sand and fine gravel	
						more friable, 1' fine/medium sand	
500				Strong			
						at 509-511' - interbeds of coarse sand with no matrix, well cemented	
510						2' fine to coarse sand, percentage gravel increasing (now conglomerate)	
						at 516' carbonate cobble	
520				Weak to Strong		gravel/cobble mostly volcanic (round to subround), up to 4"	
530				Strong			
						2" vug formed by dissolved gravel fragment (strong reaction in cavity)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 10 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
540	Rock Core	Continuous				**POORLY GRADED SAND WITH GRAVEL (SP)** interbedded sands and gravels, larger clasts, predominantly volcanic	540-600', core is hard to break by hand unless otherwise noted
				Strong			
550						3' (at 553') silt/fine sand interval with strong reaction to HCL, sand is more friable than coarse intervals, still requires significant pressure to break	
				Weak to Strong			
560				Strong			
				None to Strong		medium to coarse sand, cemented, little to no fines as matrix	
570				Strong		1' fine sand, more friable, strong reaction to HCL fine to coarse sand with gravel, cemented and finer matrix	
580				Weak to Strong		580-589', increase in gravel with fine to coarse sand	
590				Strong		at 590' 2' friable fine sand with cobble	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 11 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
600	Rock Core	Continuous				**POORLY GRADED SAND WITH GRAVEL (SP)** interbedded, sands and gravel/cobbles, large clasts mostly volcanic, round to subround, some carbonate, granitic and lithics	600-660', core is hard to break unless otherwise noted
				Weak to Strong			
610				Strong		613-616' cobbly interval	
						2-3" beds of coarse sand/gravel with sugary texture and calcite crystals, no fines (sand are silt) as matrix	
620						620-628' abundant visible crystallization and sand/gravel grains	
				Weak to Strong			
630				Strong			
				Weak to Strong		at 636' 7" volcanic cobble, calcite crystals in vessicles 637-640' friable medium sand, fines downward into silt (weak reaction), 1" white hard fine grained interval at 639' (strong reactions)	
640							
				Strong		645-660 increasing gravel and cobbles	
650							
				Weak to Strong		at 656' 1' clayey gravel (weak reaction)	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 12 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
660	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4) to brown (10YR 4/3), interbedded sand and gravel/cobbles, some silt beds	660-720', core hard to break unless otherwise noted
670				Weak to Strong		at 671' 7" volcanic cobble with calcite crystal vessicles 674.5-676' friable medium sand with weak reaction	
680				Strong		683-686' friable medium sand, interval 686-688' silt with strong reaction 687-688' silt has vertical sand banding (clastic dikes?)	
690						at 691.5' 1" white cemented layer (fine grained) 694-701' coarse sand/gravel with clayey matrix	
700				Weak to Strong		701.5-703' silt interval (hard, strong reaction) includes 1" white cemented layers	
710						709-715' matrix of sand/gravel is clayey	
				Strong		719-721' fine sand/silt interval (strong reaction) some ~1" white cemented intervals	

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 13 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
720	Rock Core	Continuous		Strong		**POORLY GRADED SAND WITH SILT (SP-SM)** dark yellowish brown (10YR 4/6), to brown (10YR 5/3), interbedded fine sand and silt with 1" white cemented fine grained interbeds (strong reaction)	reaction to HCL varies in silt/sand layers
				None to Strong			
730				Strong			
				None to Strong		at 734', transition to coarse sand and gravel, poorly consolidated angular/subangular sand grains, gravel is subround to subangular, mostly granitic (pink and white) with some carbonates, no volcanic clasts	granitic fragments look similar to underlying rock
740				Strong			
750				None to Strong		silt/clay intervals 0.5-1' thick	
760				None to Weak		**DECOMPOSED GRANITE** red (2.5YR 5/6), to light reddish brown (2.5YR 6/4), mottled color texture, transition into decomposed granite, highly altered, (beaks easily), some slickensides at 762'	
				None to Strong			
770				None to Weak		at 771', white (10YR 8/1) fractured granite, some reaction on fracture surfaces	
				None			

SAMPLE TEST, 386303CADIZ.GPJ, CADIZLIBRARY.GLB, 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 14 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
780	Rock Core	Continuous		None		**GRANITE** white (2.5YR 8/1), to reddish brown (2.5YR 4/4), fractured with highly altered/deformed zones	calcite crystals on granite fragment
				None to Strong			
790				None		at 789' slickensides altered zone	
800				Weak		802-804' dark green and white altered zone	
				None		807-808' transition from white to reddish granite, fractured with fines/slickensides on fracture surface, weak reaction on fracture surface	
810				None to Weak		808-820' fractured reddish granite	
820						at 820' transition back to white granite that is highly altered/deformed, some red granite fragments	
830						at 832' still highly altered, compend granite fragments (50/50 white/red)	

SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

CH2MHILL

PROJECT NUMBER: 386303.AA.05 **Sheet** 15 of 15

SOIL BORING LOG: CH-4

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: 903.57 ft msl **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3W; Rock Core/LF-90
WATER LEVELS: **START:** 10/23/2010 **END:** 10/28/2010 **LOGGER:** B. Lechler

DEPTH (FT)	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	HCl REACTION	GRAPHIC LOG	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, & INSTRUMENTATION
840	Rock Core	Continuous		None to Weak		**GRANITE** white (10YR 8/1) to reddish brown (2.5YR 4/4), highly weathered/altered with slickensides on fracture surfaces, no reaction on competent granite, some finer grained weathered interval or fracture, surfaces have weak reaction	strong reaction in fine weathered/altered zone
850							
860							Total borehole depth = 860' bgs
870							
880							
890							

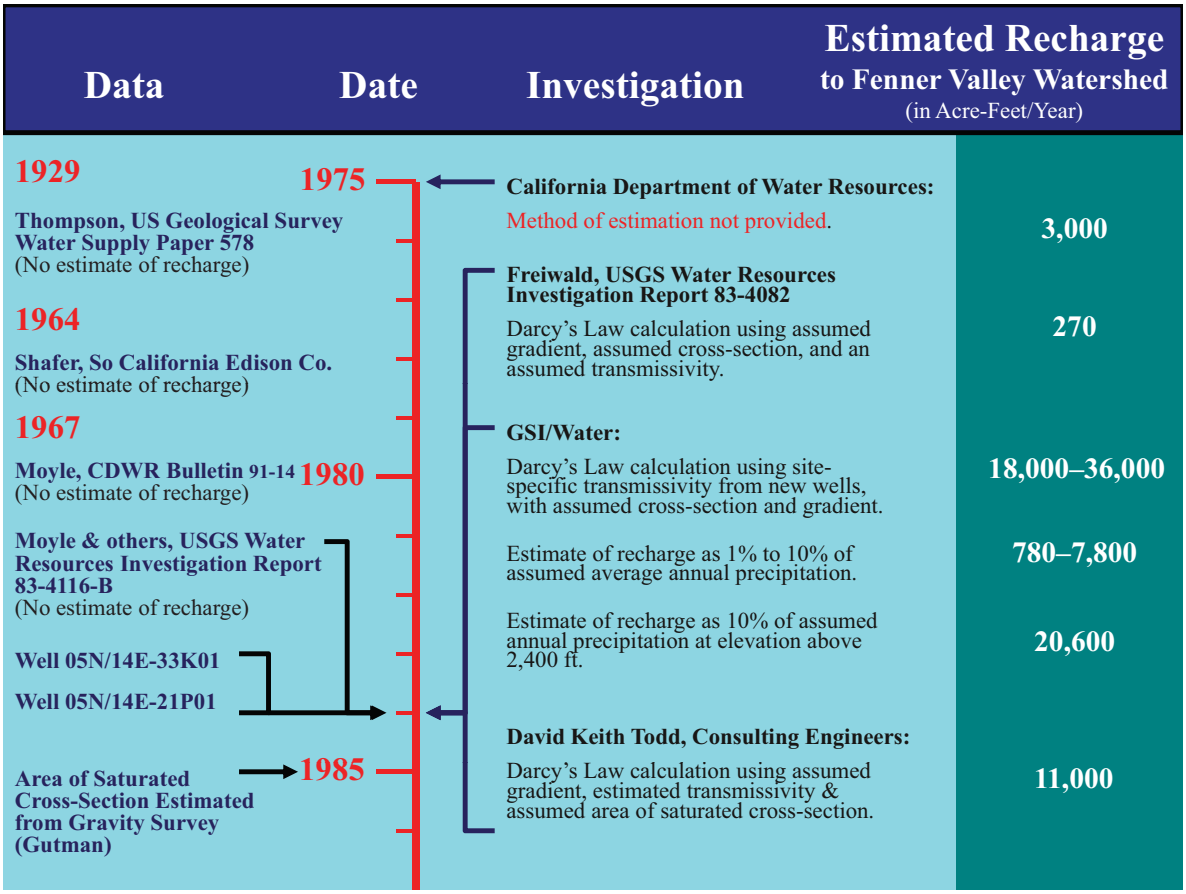
SAMPLE TEST_386303CADIZ.GPJ_CADIZLIBRARY.GLB_ 8/17/11

APPENDIX D

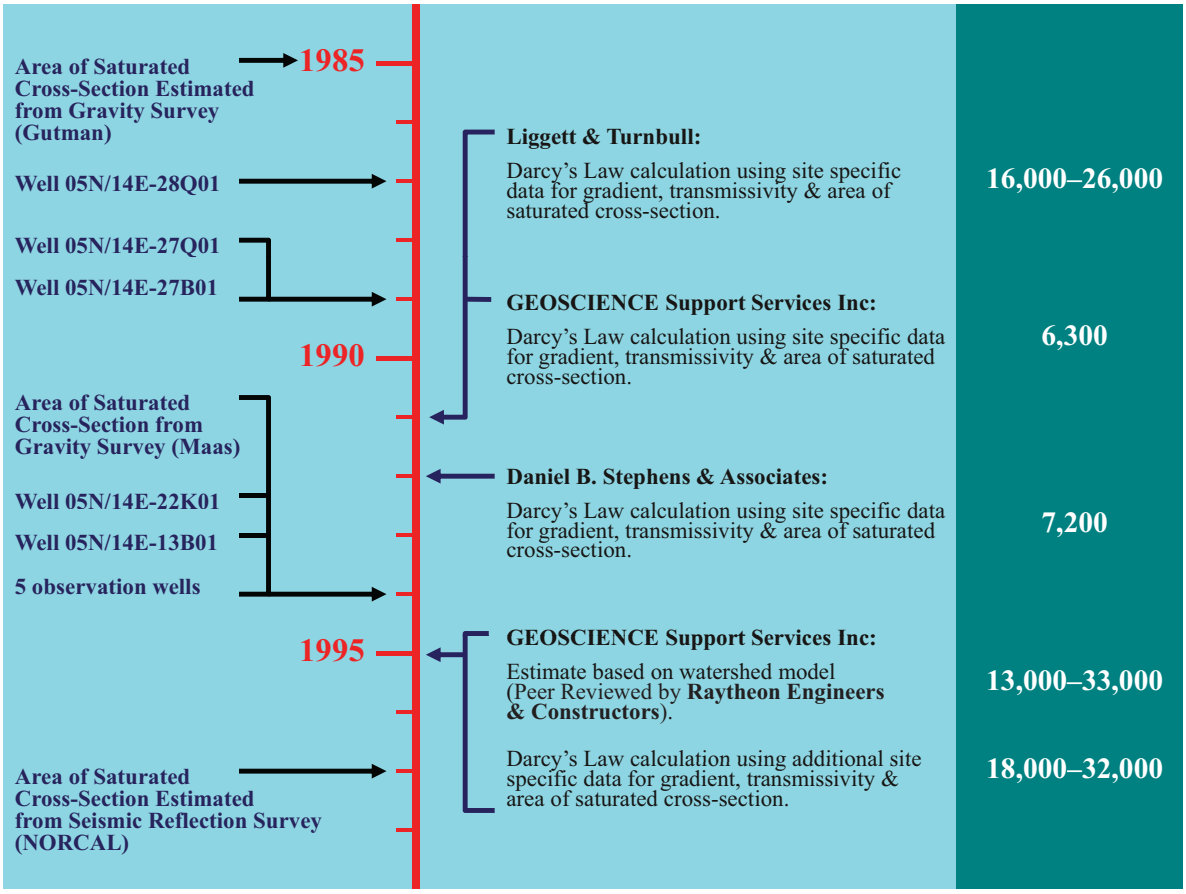
Timeline- Chronology for

Estimates of Natural Recharge to the Cadiz Project Area

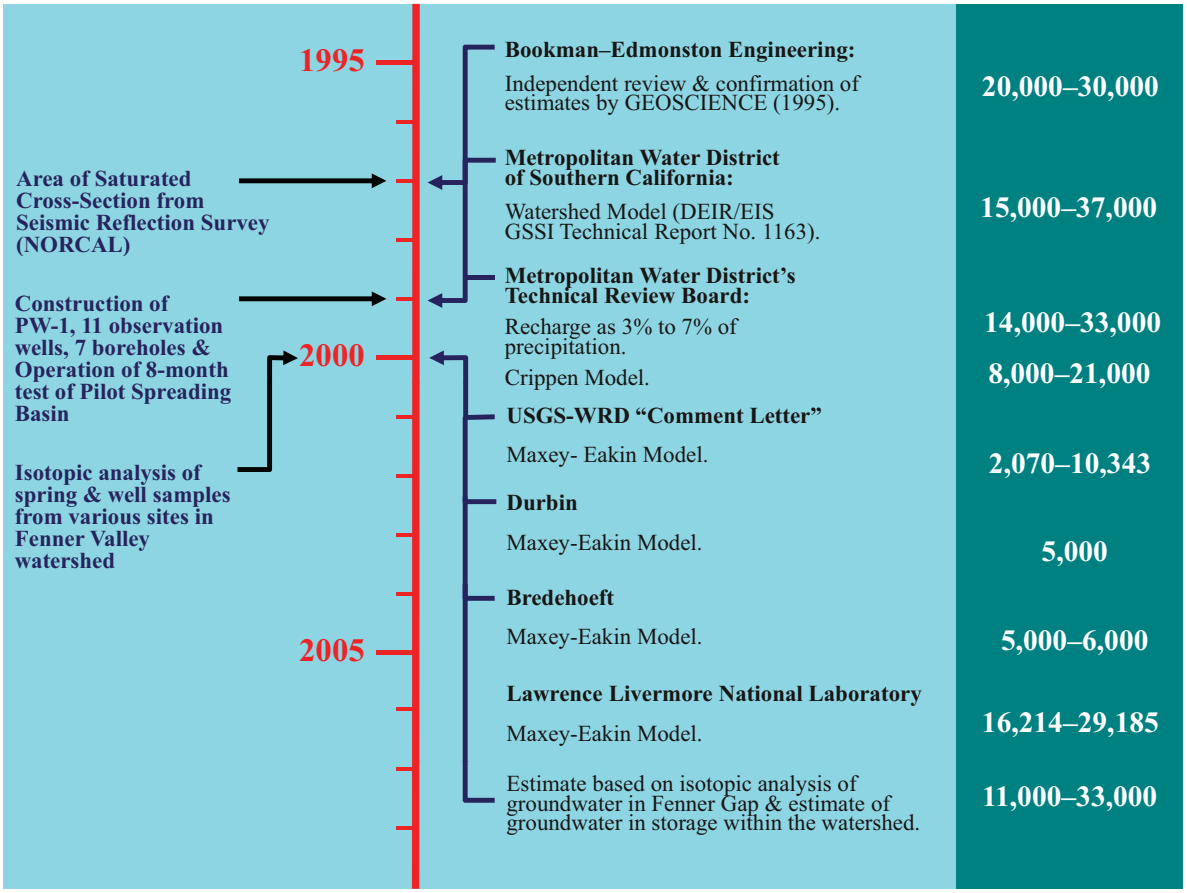
GEOSCIENCE

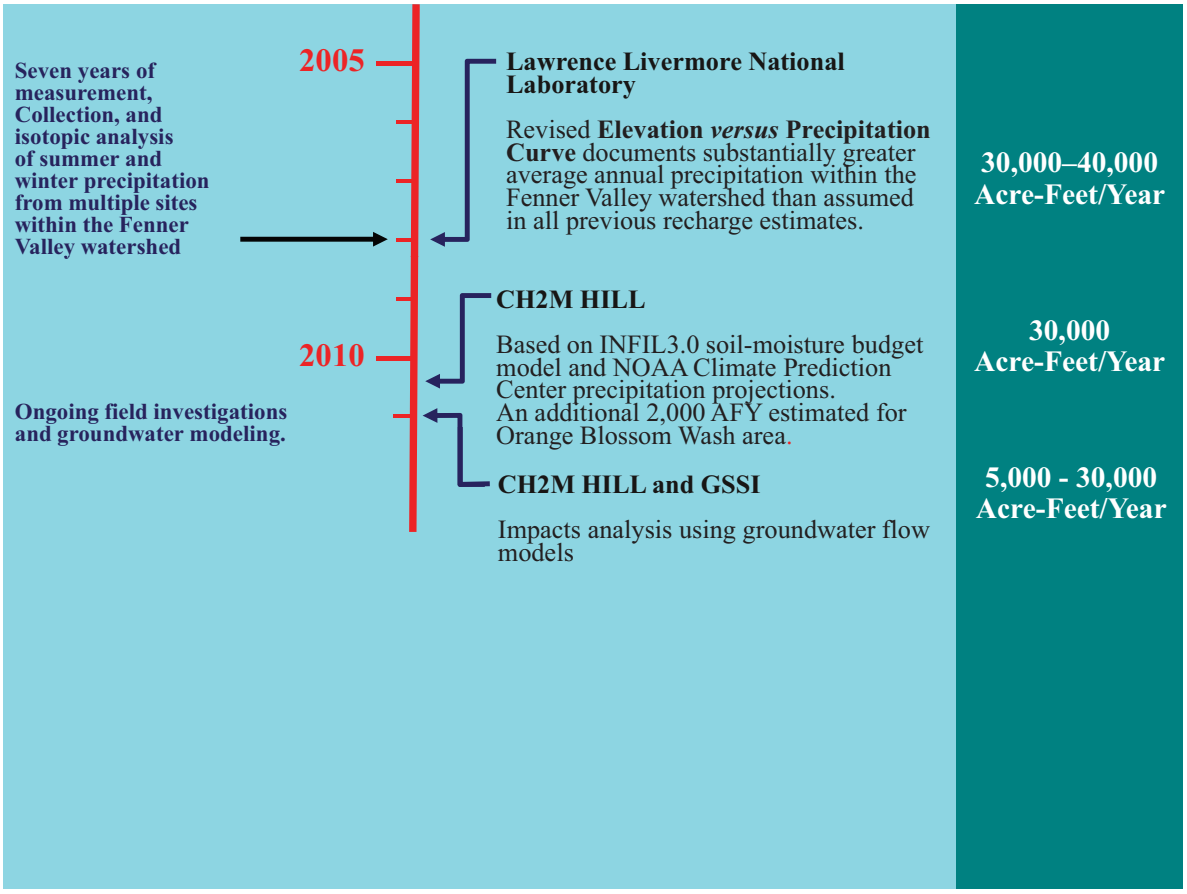

Data
Date
Investigation
Estimated Recharge
to Fenner Valley Watershed
(in Acre-Feet/Year)
1929
1975
Thompson, US Geological Survey
Water Supply Paper 578
(No estimate of recharge)
California Department of Water Resources:
Method of estimation not provided.
3,000
1964
Shafer, So California Edison Co.
(No estimate of recharge)
Freiwald, USGS Water Resources
Investigation Report 83-4082
Darcy's Law calculation using assumed gradient, assumed cross-section, and an assumed transmissivity.
270
1967
Moyle, CDWR Bulletin 91-14
(No estimate of recharge)
1980
GSI/Water:
Darcy's Law calculation using site-specific transmissivity from new wells, with assumed cross-section and gradient.
18,000–36,000
Moyle & others, USGS Water
Resources Investigation Report
83-4116-B
(No estimate of recharge)
Estimate of recharge as 1% to 10% of assumed average annual precipitation.
780–7,800
Well 05N/14E-33K01
Well 05N/14E-21P01
Estimate of recharge as 10% of assumed annual precipitation at elevation above 2,400 ft.
20,600
David Keith Todd, Consulting Engineers:
Area of Saturated
Cross-Section Estimated
from Gravity Survey
(Gutman)
1985
Darcy's Law calculation using assumed gradient, estimated transmissivity & assumed area of saturated cross-section.
11,000
Appendix D

D-1


Area of Saturated
Cross-Section Estimated
from Gravity Survey
(Gutman)
1985
Liggett & Turnbull:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
16,000–26,000
Well 05N/14E-28Q01
Well 05N/14E-27Q01
Well 05N/14E-27B01
GEOSCIENCE Support Services Inc:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
6,300
1990
Area of Saturated
Cross-Section from
Gravity Survey (Maas)
Daniel B. Stephens & Associates:
Darcy's Law calculation using site specific data for gradient, transmissivity & area of saturated cross-section.
7,200
Well 05N/14E-22K01
Well 05N/14E-13B01
5 observation wells
1995
GEOSCIENCE Support Services Inc:
Estimate based on watershed model (Peer Reviewed by Raytheon Engineers & Constructors).
13,000–33,000
Darcy's Law calculation using additional site specific data for gradient, transmissivity & area of saturated cross-section.
18,000–32,000
Area of Saturated
Cross-Section Estimated
from Seismic Reflection Survey
(NORCAL)
Appendix D

D-2


1995
2000
2005
Area of Saturated Cross-Section from Seismic Reflection Survey (NORCAL)
Construction of PW-1, 11 observation wells, 7 boreholes & Operation of 8-month test of Pilot Spreading Basin
Isotopic analysis of spring & well samples from various sites in Fenner Valley watershed
Bookman–Edmonston Engineering:
Independent review & confirmation of estimates by GEOSCIENCE (1995).
20,000–30,000
Metropolitan Water District of Southern California:
Watershed Model (DEIR/EIS GSSI Technical Report No. 1163).
15,000–37,000
Metropolitan Water District's Technical Review Board:
Recharge as 3% to 7% of precipitation.
14,000–33,000
Crippen Model.
8,000–21,000
USGS-WRD "Comment Letter"
Maxey- Eakin Model.
2,070–10,343
Durbin
Maxey-Eakin Model.
5,000
Bredehoeft
Maxey-Eakin Model.
5,000–6,000
Lawrence Livermore National Laboratory
Maxey-Eakin Model.
16,214–29,185
Estimate based on isotopic analysis of groundwater in Fenner Gap & estimate of groundwater in storage within the watershed.
11,000–33,000


2005
2010
Seven years of measurement, Collection, and isotopic analysis of summer and winter precipitation from multiple sites within the Fenner Valley watershed
Ongoing field investigations and groundwater modeling.
Lawrence Livermore National Laboratory
Revised Elevation *versus* Precipitation Curve documents substantially greater average annual precipitation within the Fenner Valley watershed than assumed in all previous recharge estimates.
30,000–40,000 Acre-Feet/Year
CH2M HILL
Based on INFIL3.0 soil-moisture budget model and NOAA Climate Prediction Center precipitation projections.
An additional 2,000 AFY estimated for Orange Blossom Wash area.
30,000 Acre-Feet/Year
CH2M HILL and GSSI
Impacts analysis using groundwater flow models
5,000 - 30,000 Acre-Feet/Year

APPENDIX E

Hydrographs for Transient Model Calibration

With Natural Recharge of 32,000 acre-ft/yr

GEOSCIENCE

APPENDIX E

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

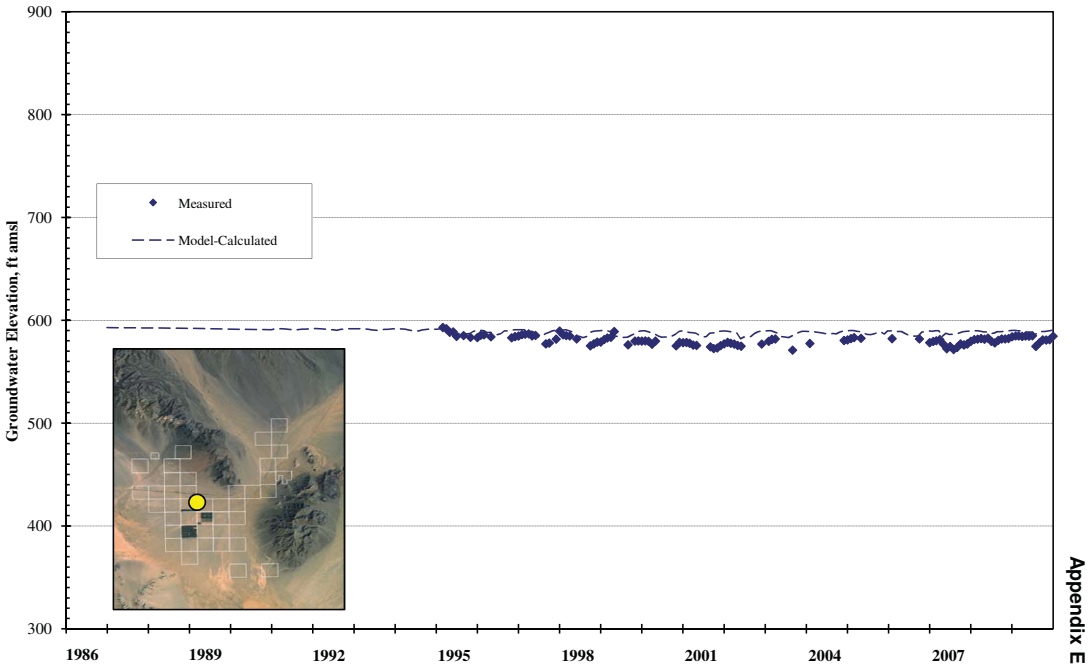
WITH NATURAL RECHARGE OF 32,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N E-1
Hydrograph for Cadiz Well 21S E-2
Hydrograph for Cadiz Well 22 ..... E-3
Hydrograph for Cadiz Well 27N E-4
Hydrograph for Cadiz Well 27S E-5
Hydrograph for Cadiz Well 28 ..... E-6
Hydrograph for Cadiz Well 33 ..... E-7
Hydrograph for Cadiz Dorm Well E-8
Hydrograph for Cadiz Labor Well E-9
Hydrograph for Cadiz Park Well E-10
Hydrograph for Cadiz Well 6N/15E-01 ..... E-11
Hydrograph for Cadiz Well 6N/15E-29 ..... E-12
Hydrograph for Cadiz Well 5N/14E-13 ..... E-13
Hydrograph for Well SCE 5 ..... E-14
Hydrograph for Well SCE 9 ..... E-15
Hydrograph for Well SCE 10 ..... E-16
Hydrograph for Well SCE 11 ..... E-17
Hydrograph for Well SCE 17 ..... E-18
Hydrograph for Well SCE 18 ..... E-19
Hydrograph for Well CI 1 ..... E-20

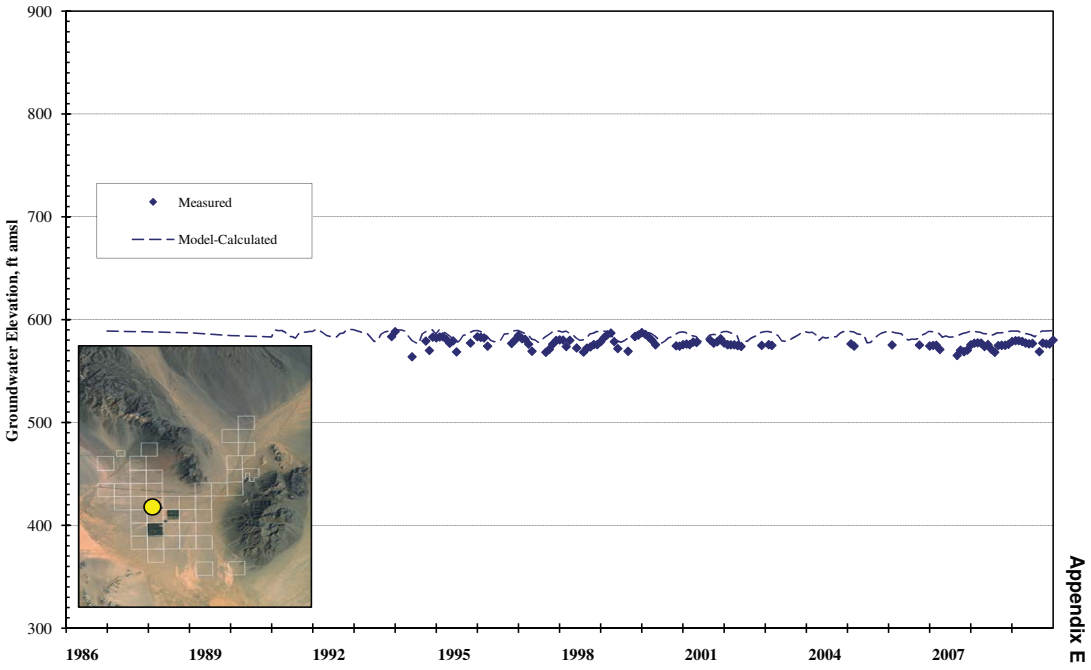
Hydrograph for Well CI 2 ..... E-21
Hydrograph for Well CI 3 ..... E-22
Hydrograph for Well MW 1 ..... E-23
Hydrograph for Well MW 2 ..... E-24
Hydrograph for Well MW 3 ..... E-25
Hydrograph for Well MW 5 ..... E-26
Hydrograph for Well MW 6 ..... E-27
Hydrograph for Well MW 7 ..... E-28
Hydrograph for Well MW 7A E-29

Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



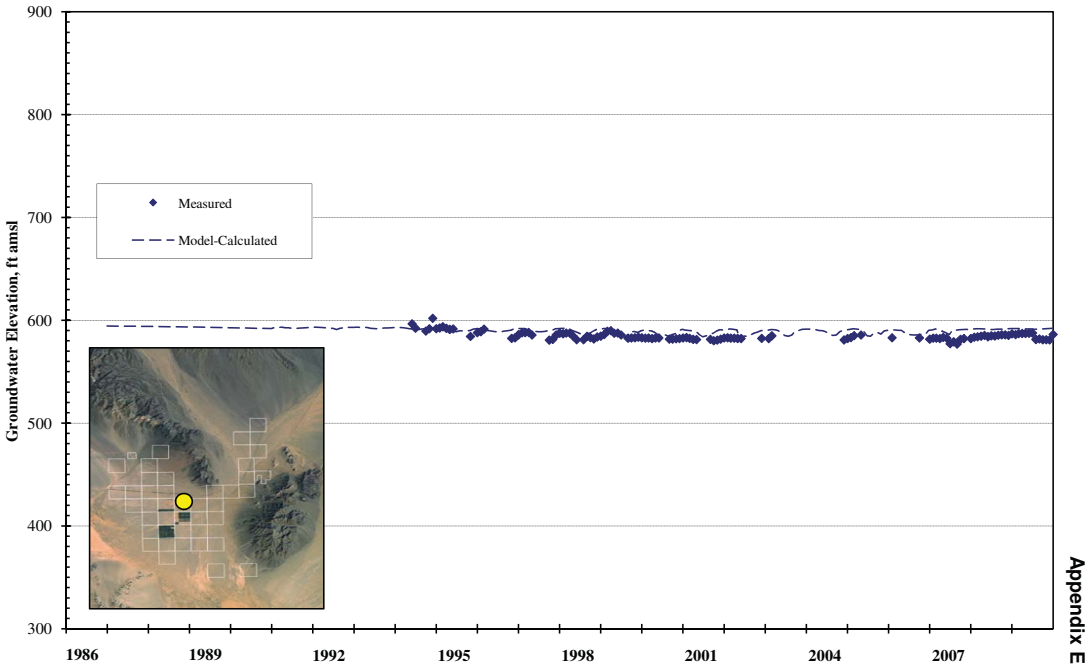
Appendix E

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



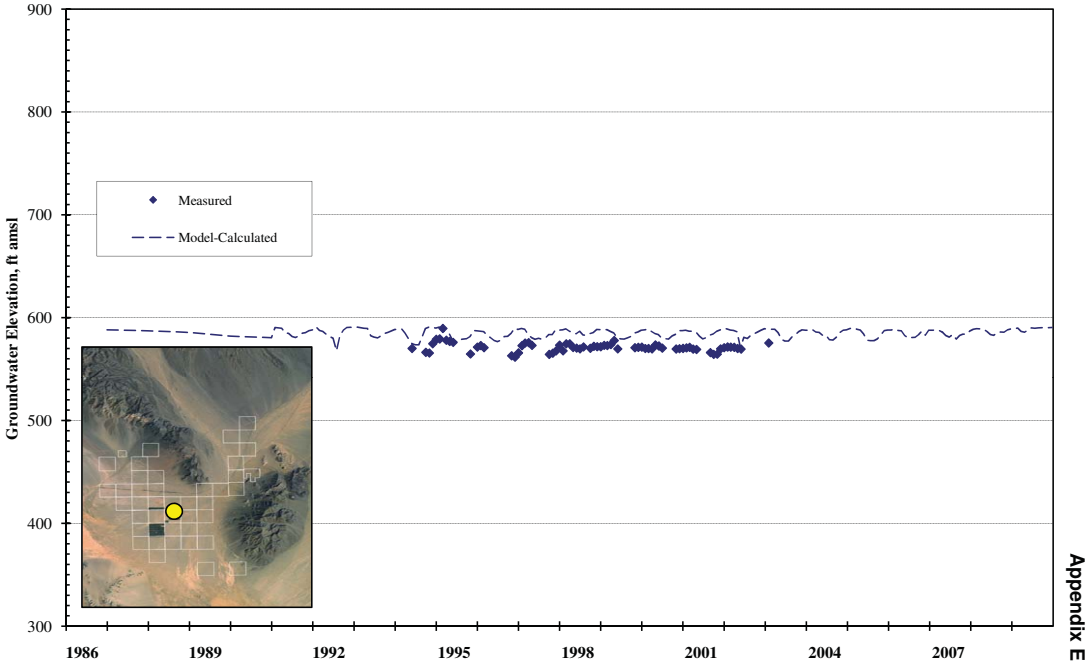
Appendix E

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



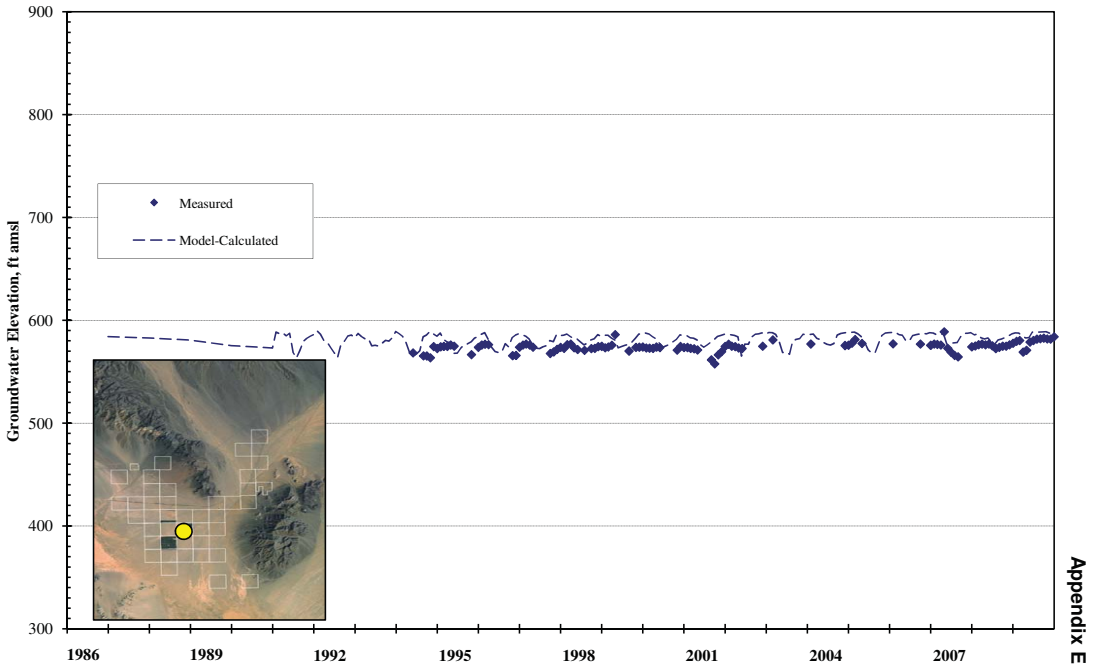
Appendix E

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



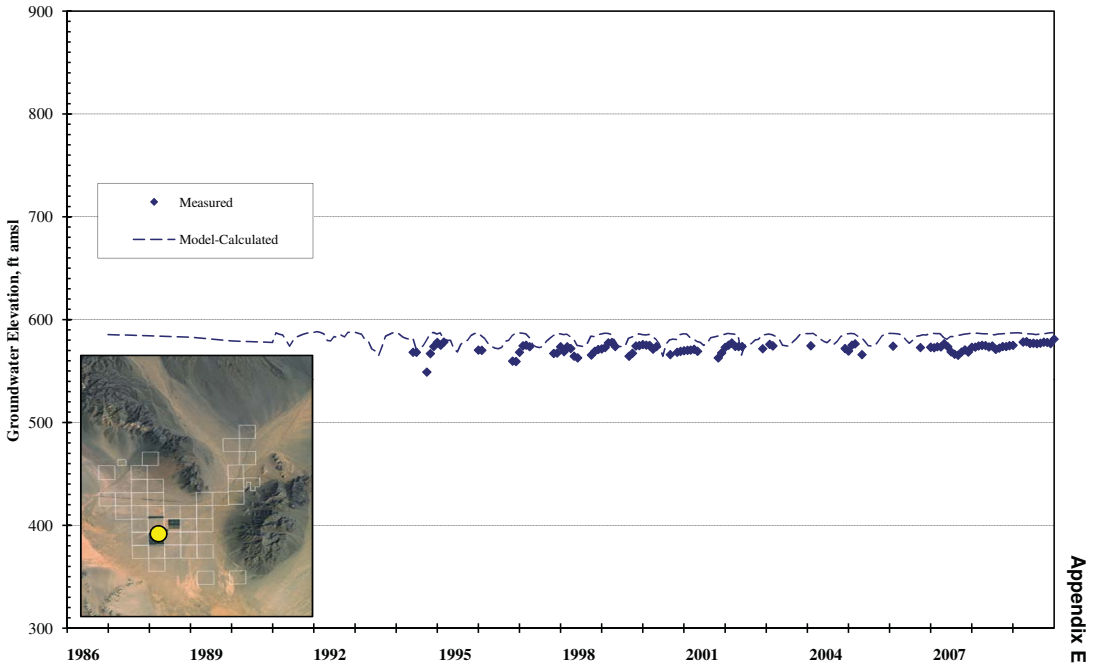
Appendix E

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



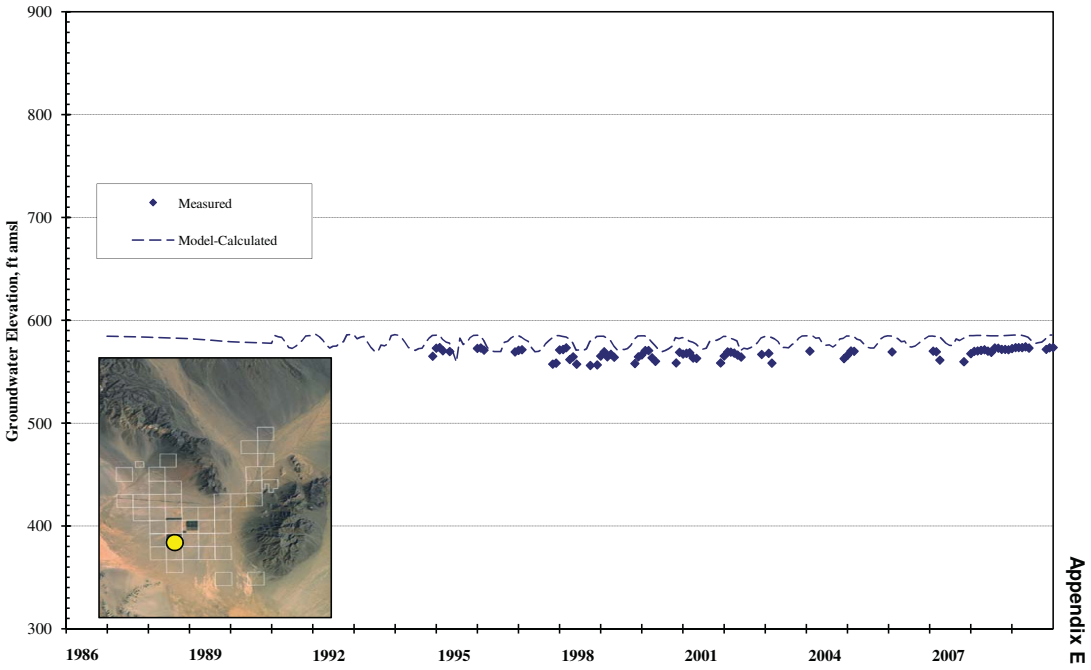
Appendix E

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



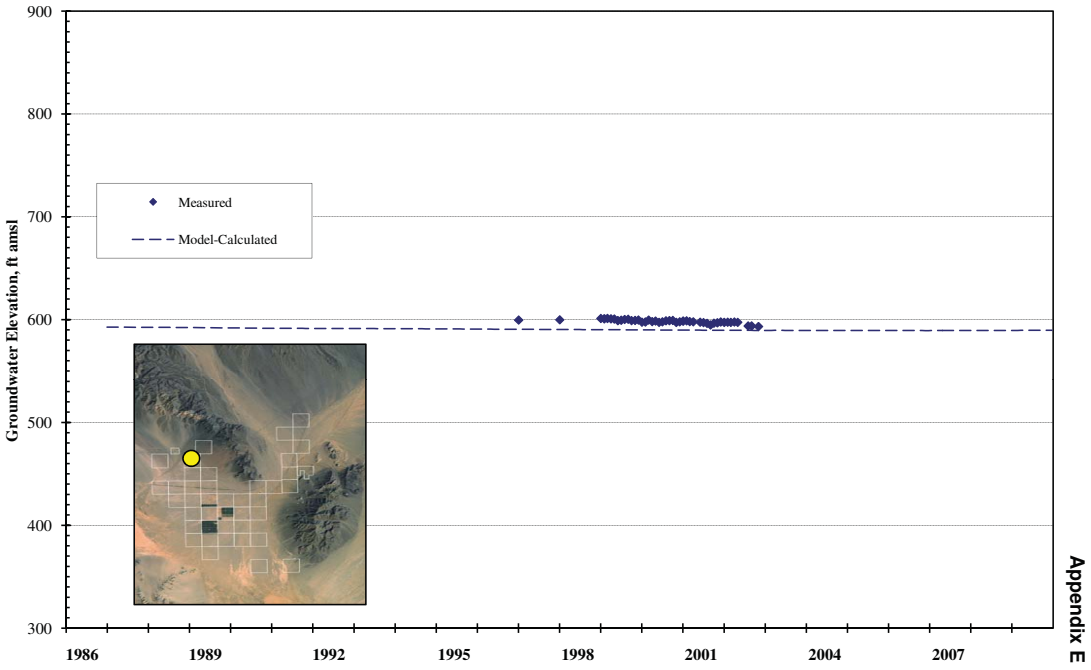
Appendix E

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



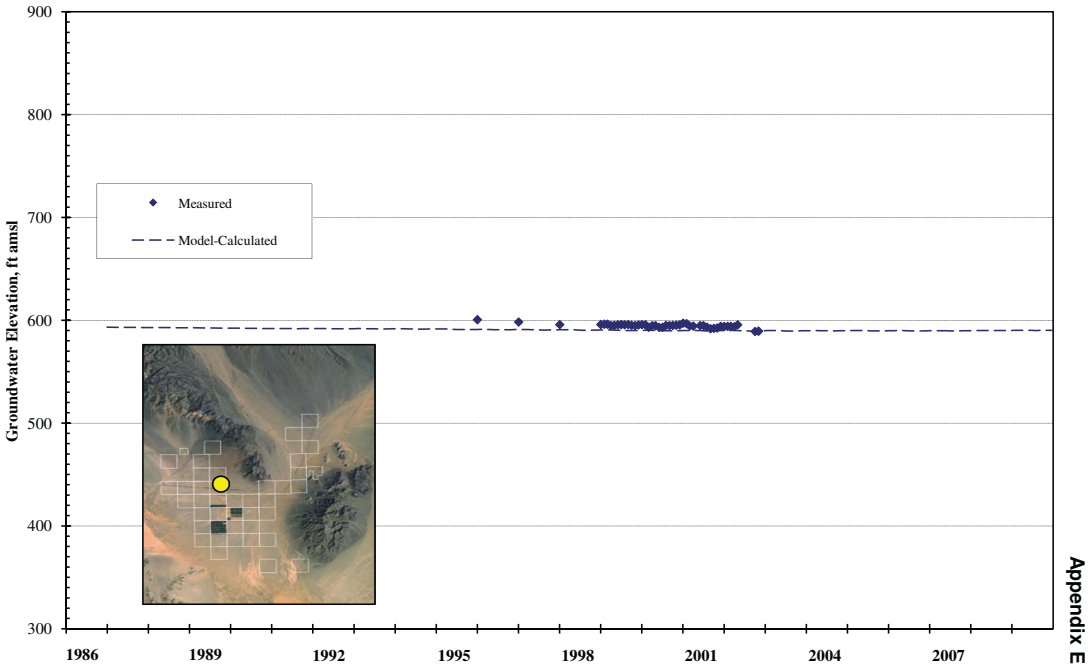
Appendix E

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



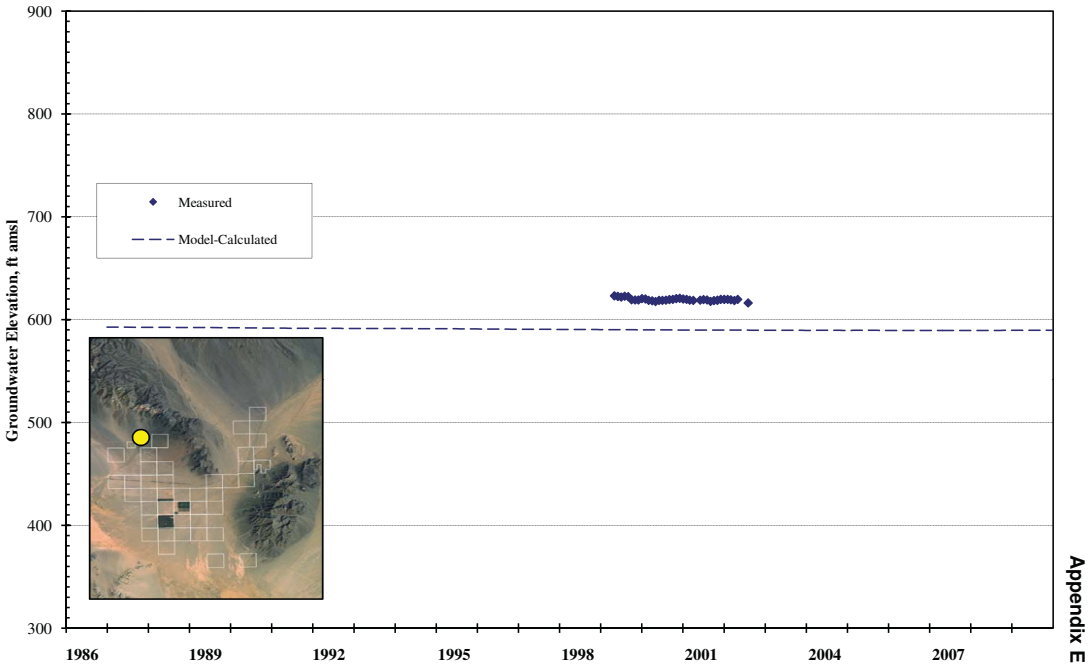
Appendix E

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



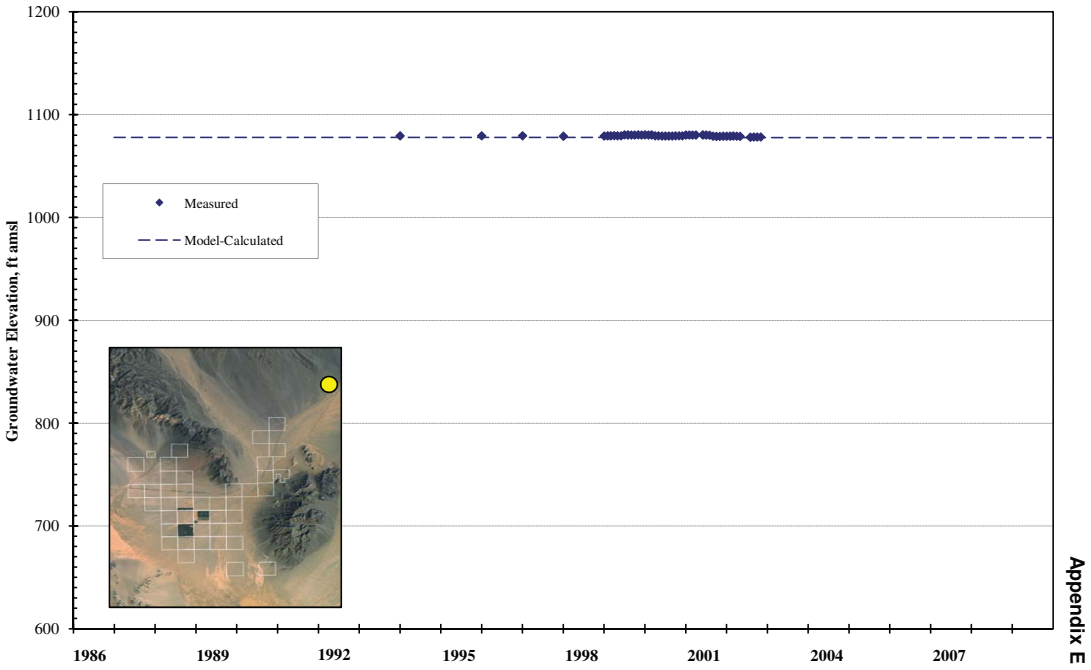
Appendix E

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



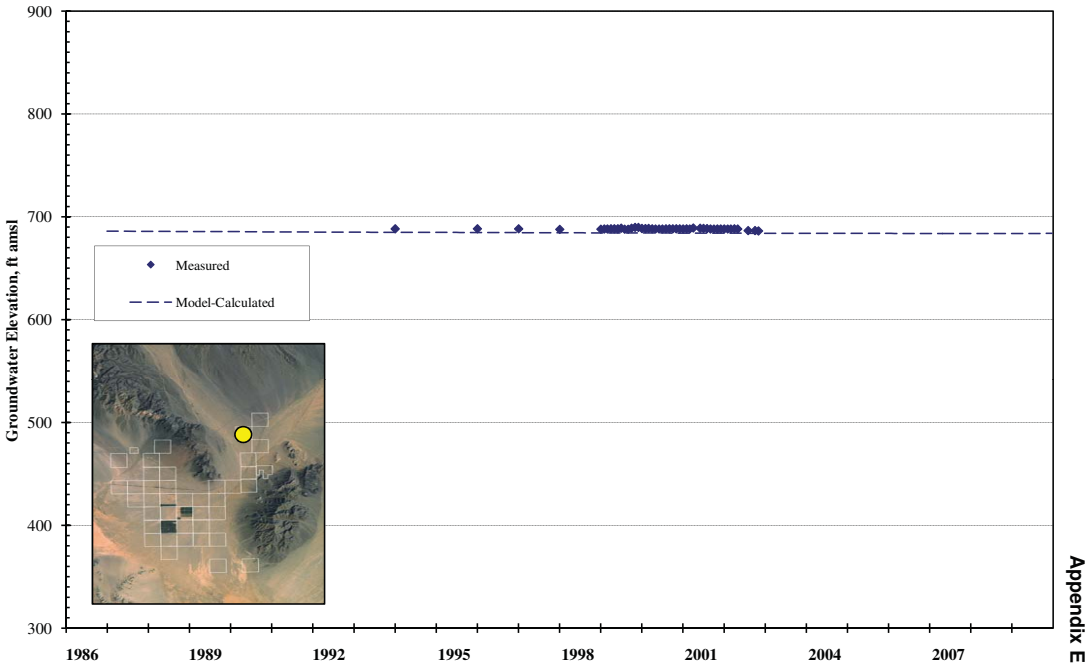
Appendix E

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



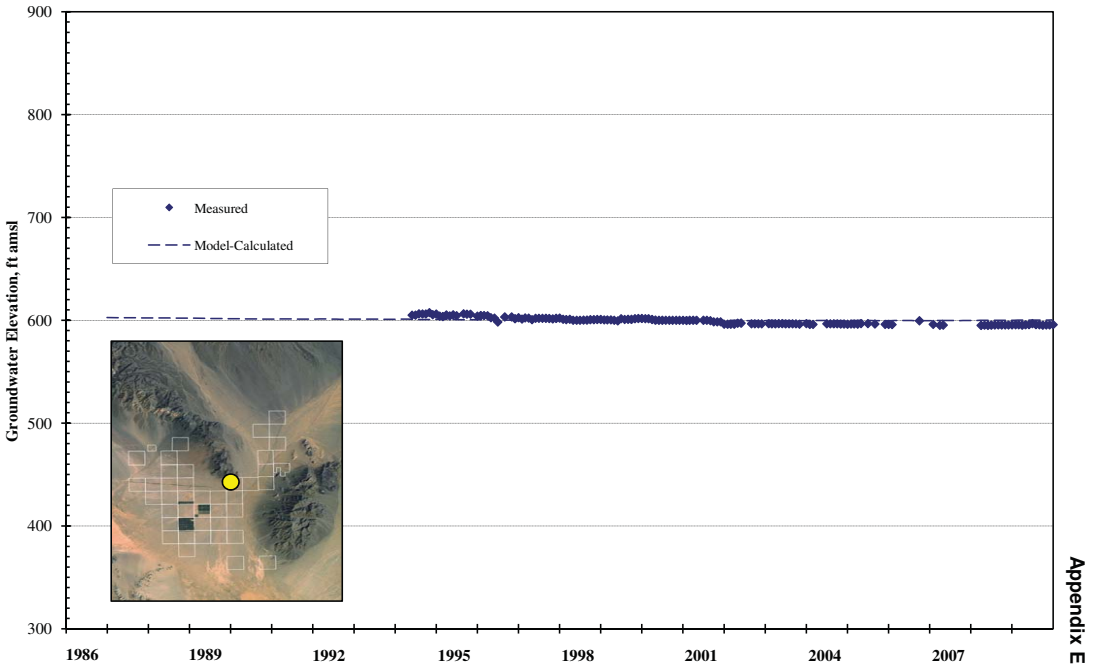
Appendix E

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



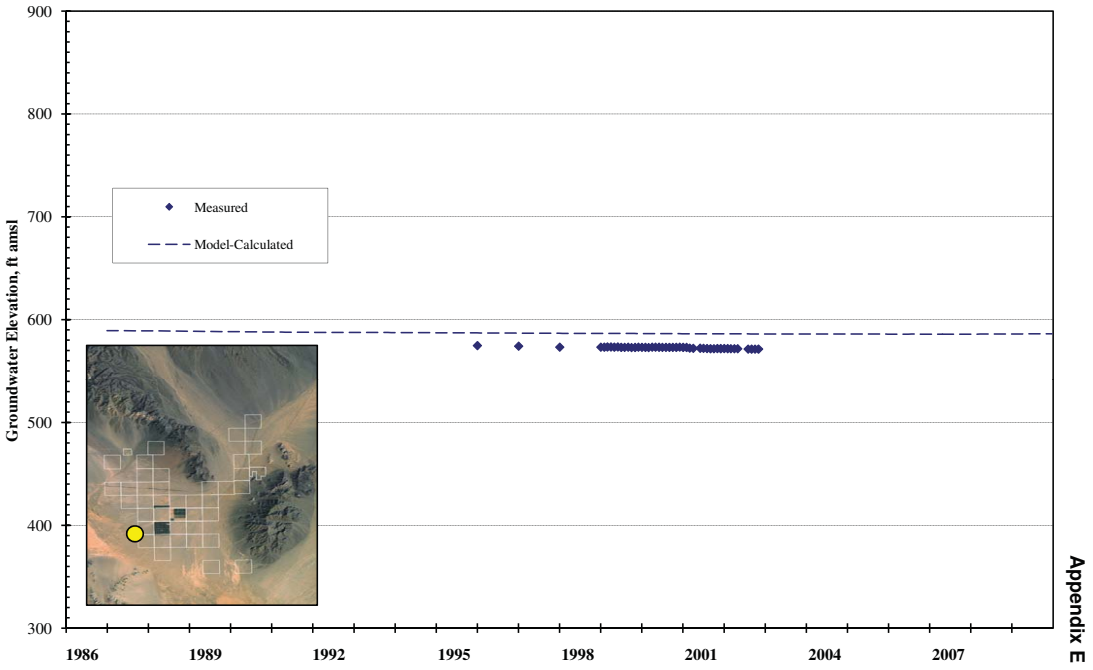
Appendix E

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



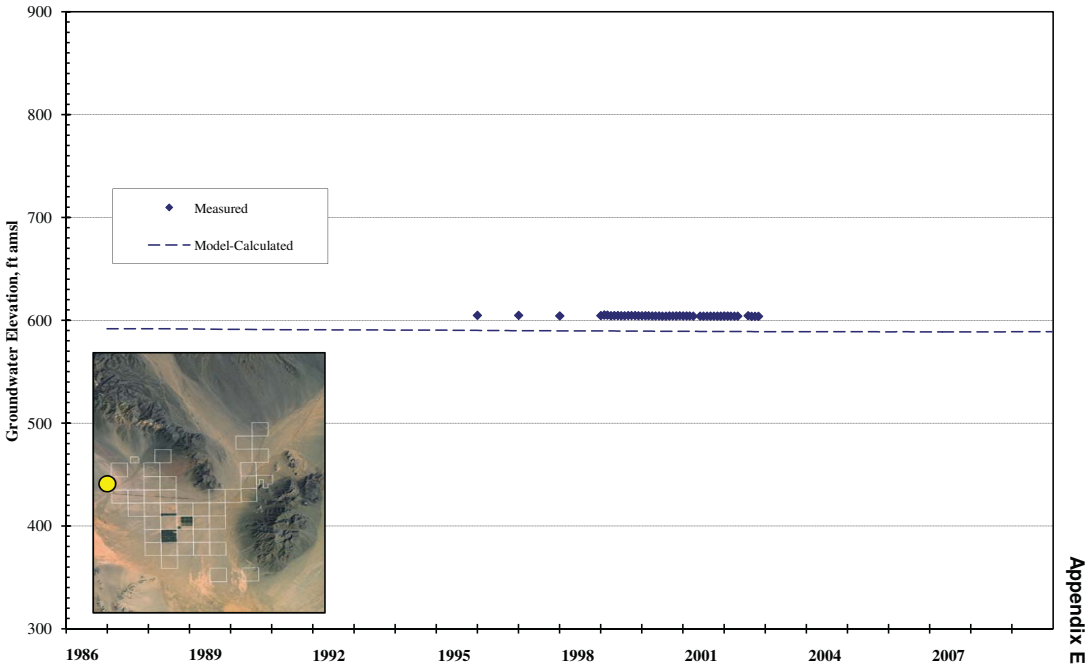
Appendix E

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



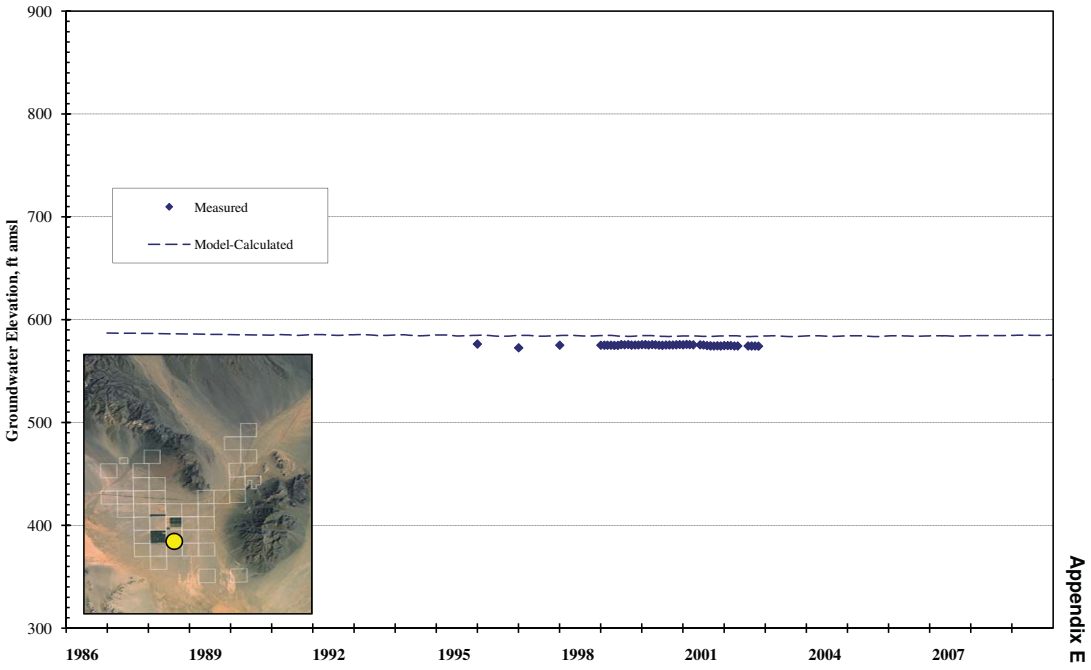
Appendix E

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



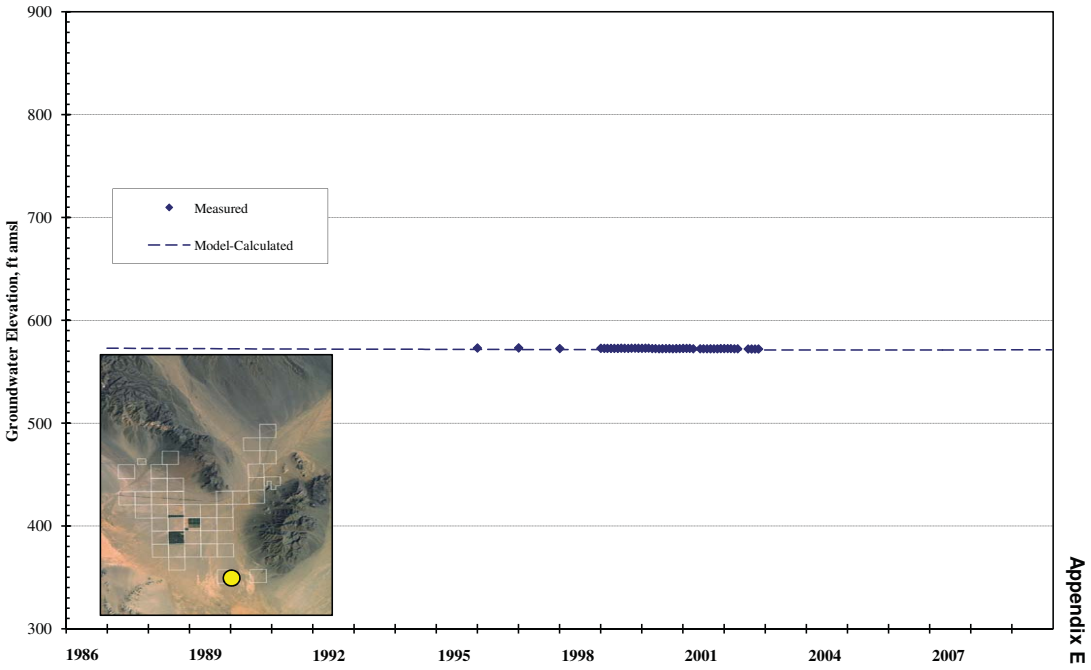
Appendix E

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



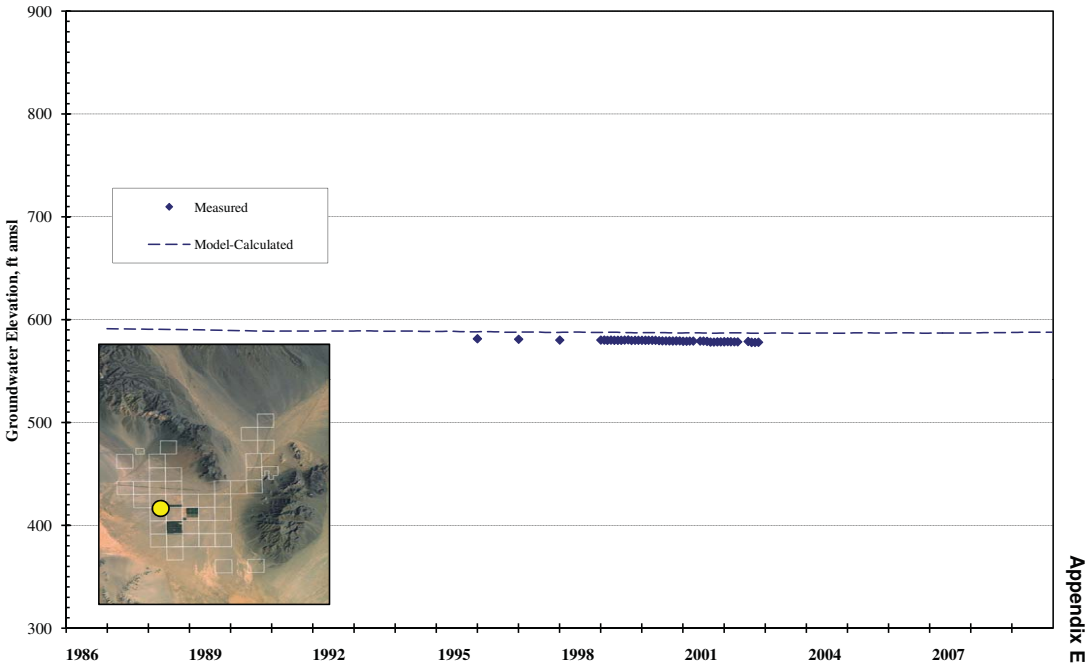
Appendix E

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



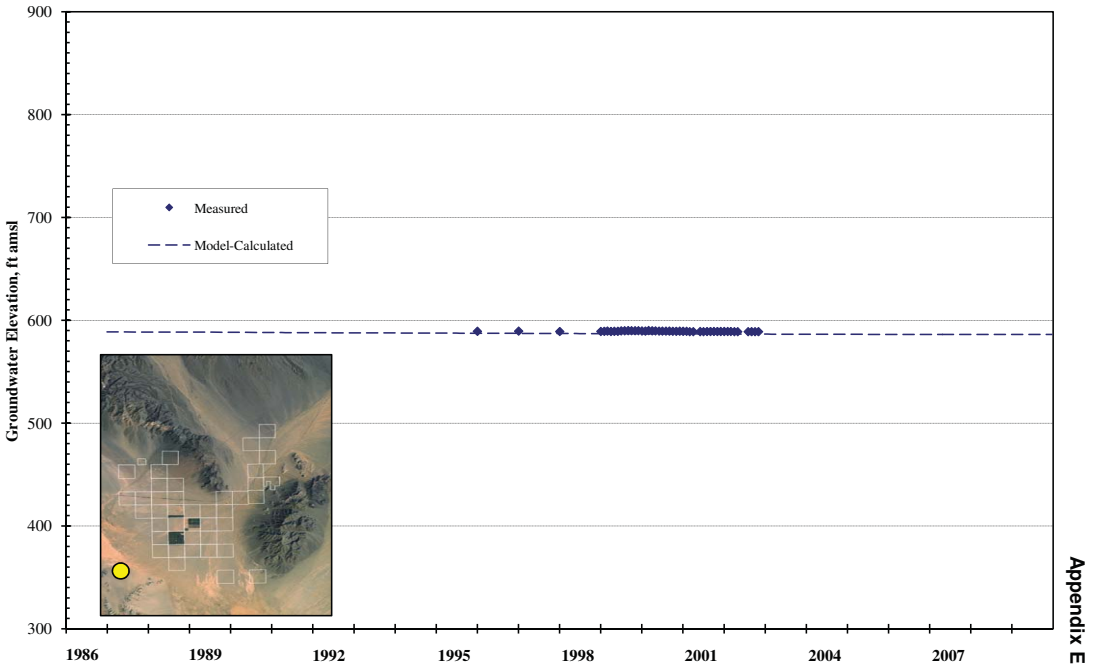
Appendix E

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



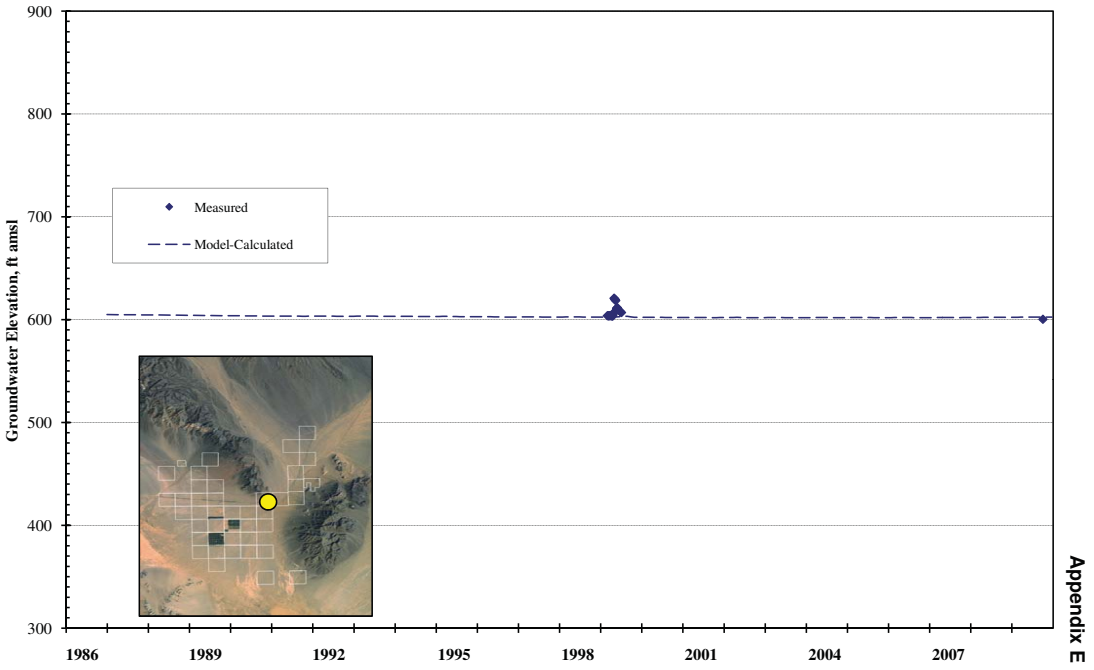
Appendix E

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



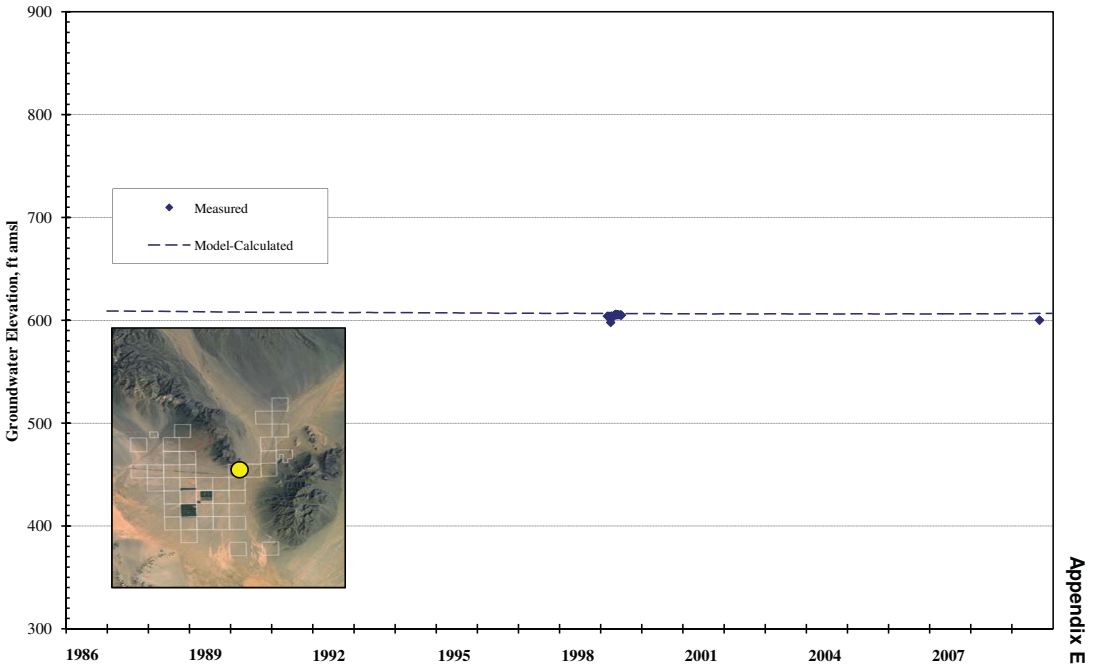
Appendix E

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



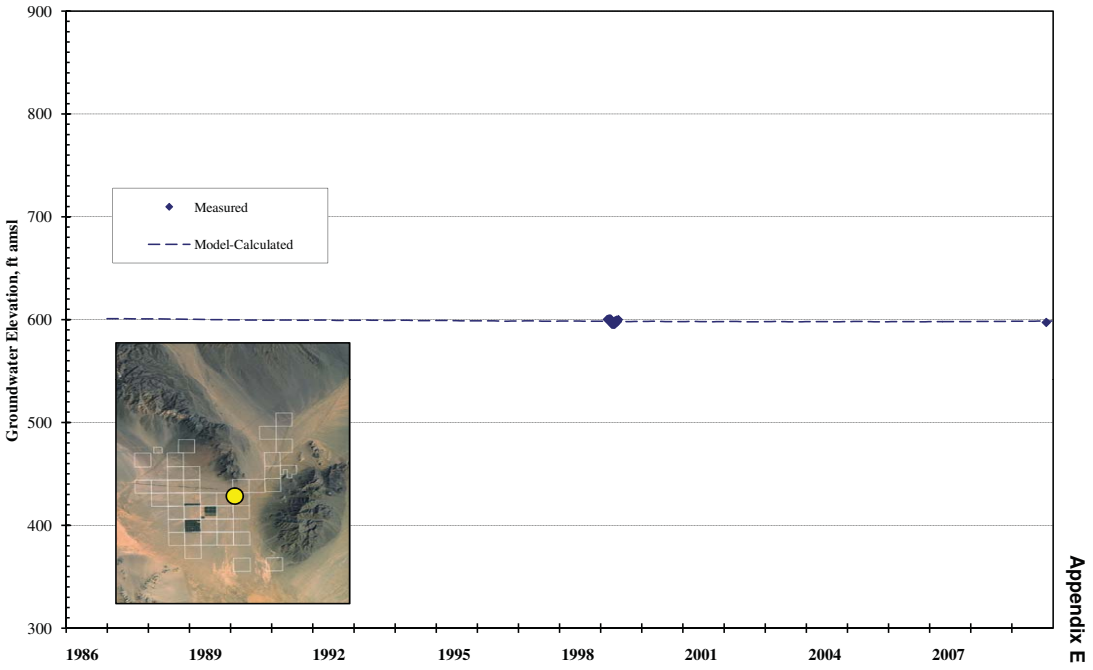
Appendix E

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



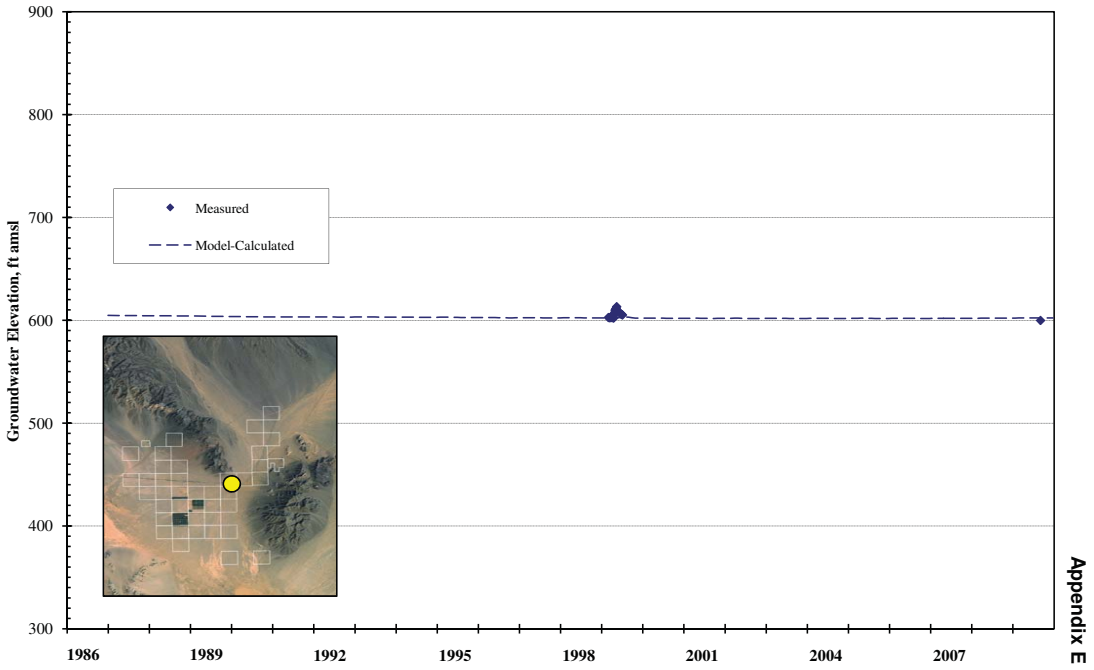
Appendix E

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



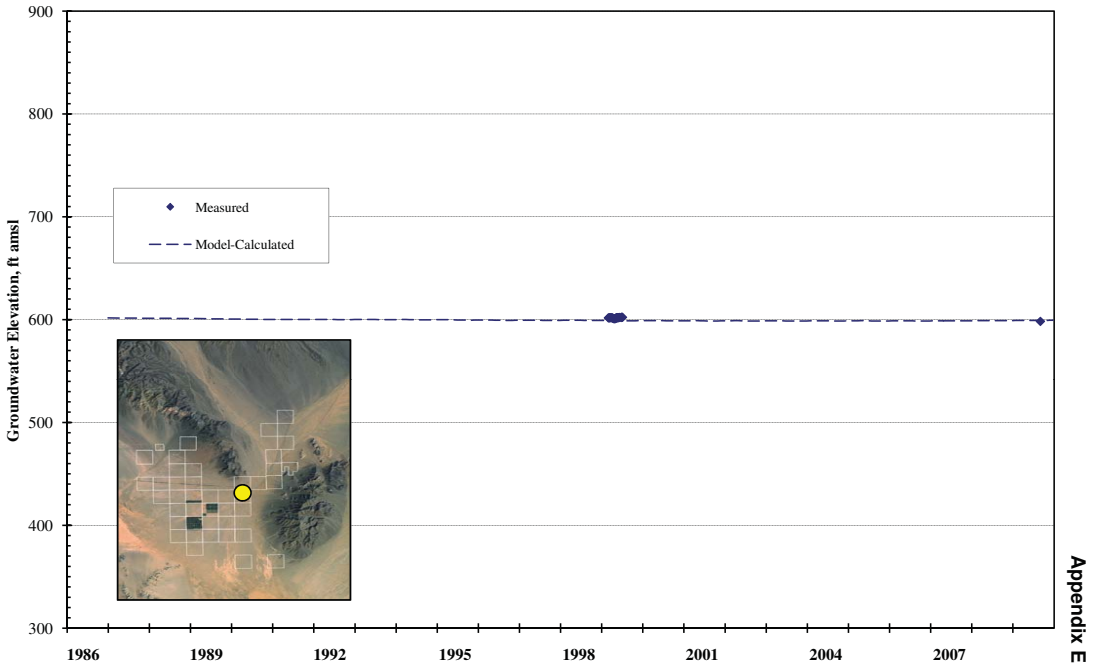
Appendix E

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



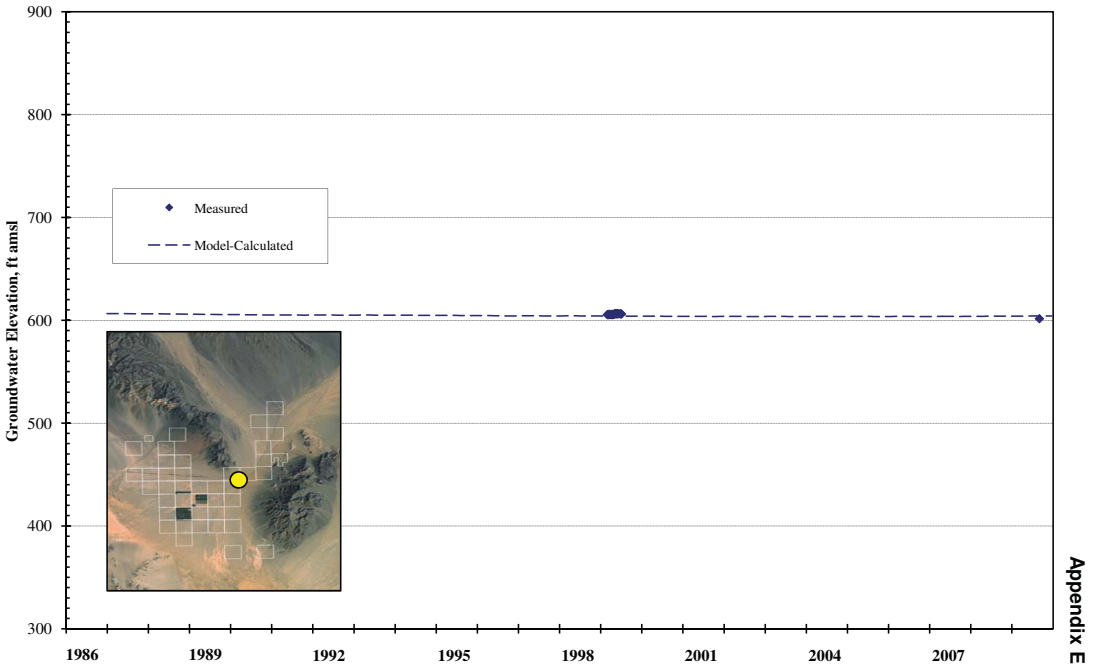
Appendix E

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



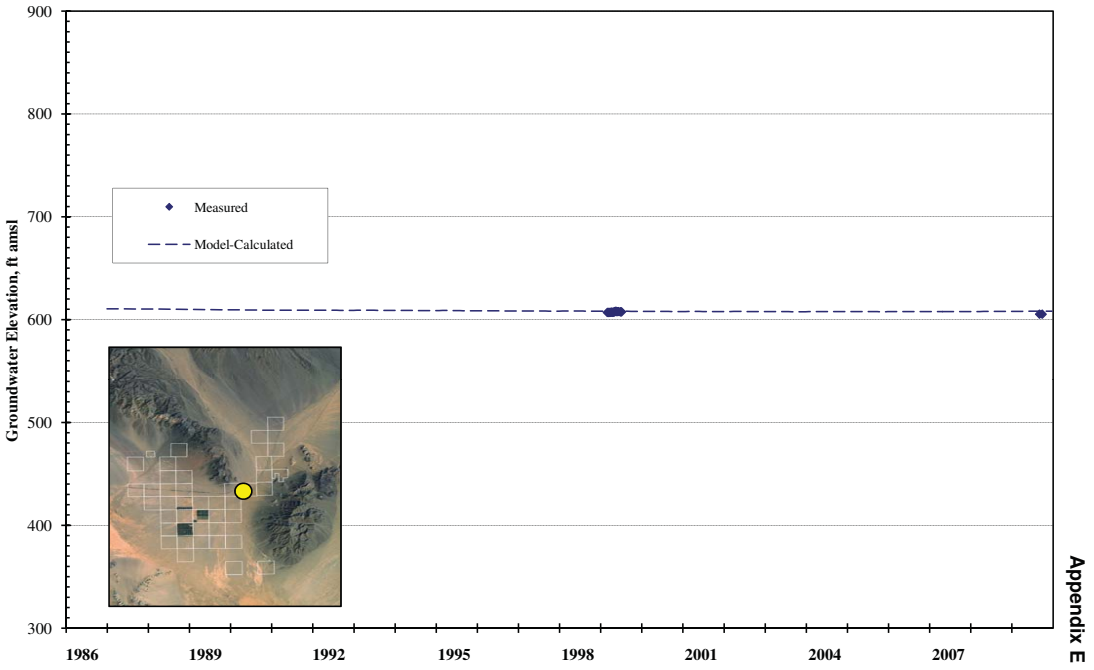
Appendix E

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



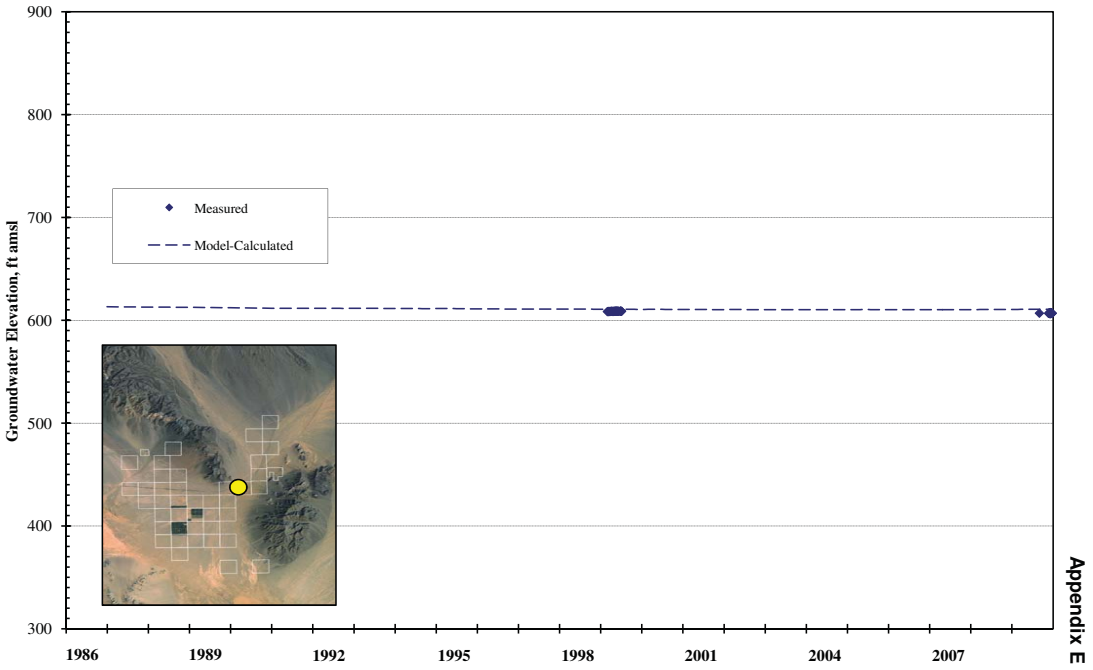
Appendix E

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



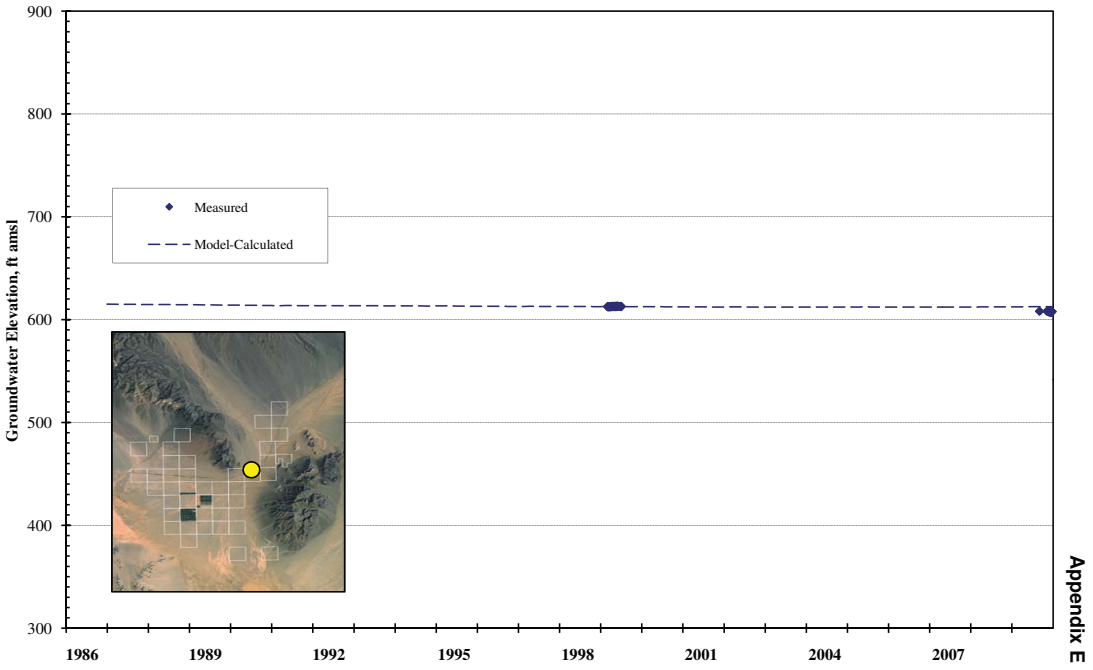
Appendix E

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



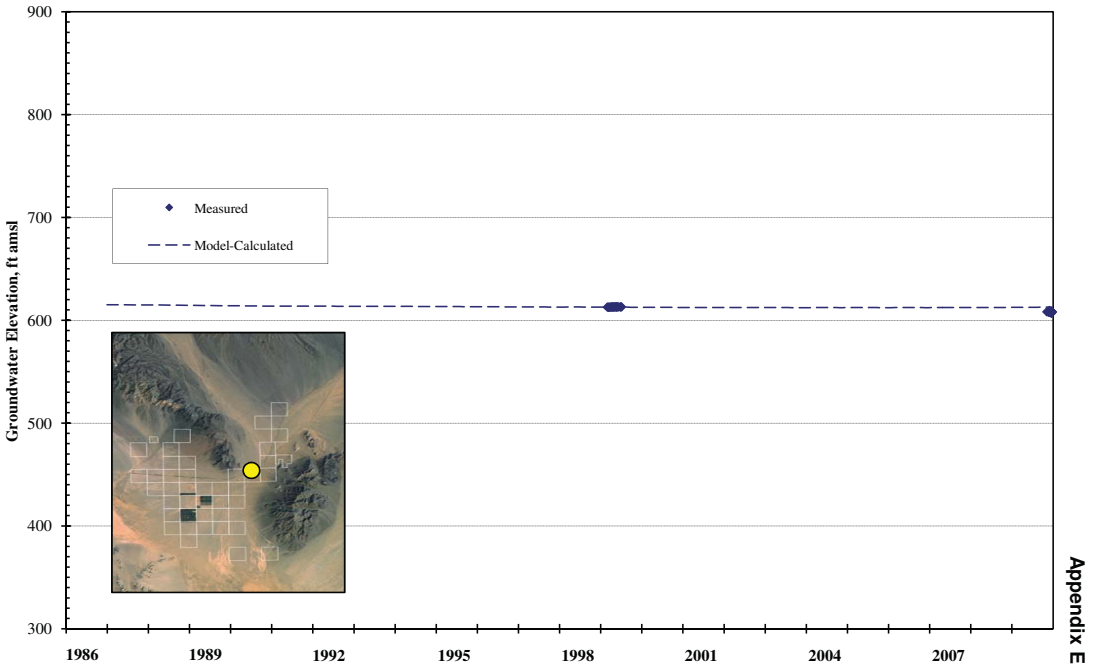
Appendix E

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



Appendix E

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 32,000 acre-ft/yr)



Appendix E

APPENDIX F

Hydrographs for Transient Model Calibration

With Natural Recharge of 16,000 acre-ft/yr

GEOSCIENCE

APPENDIX F

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

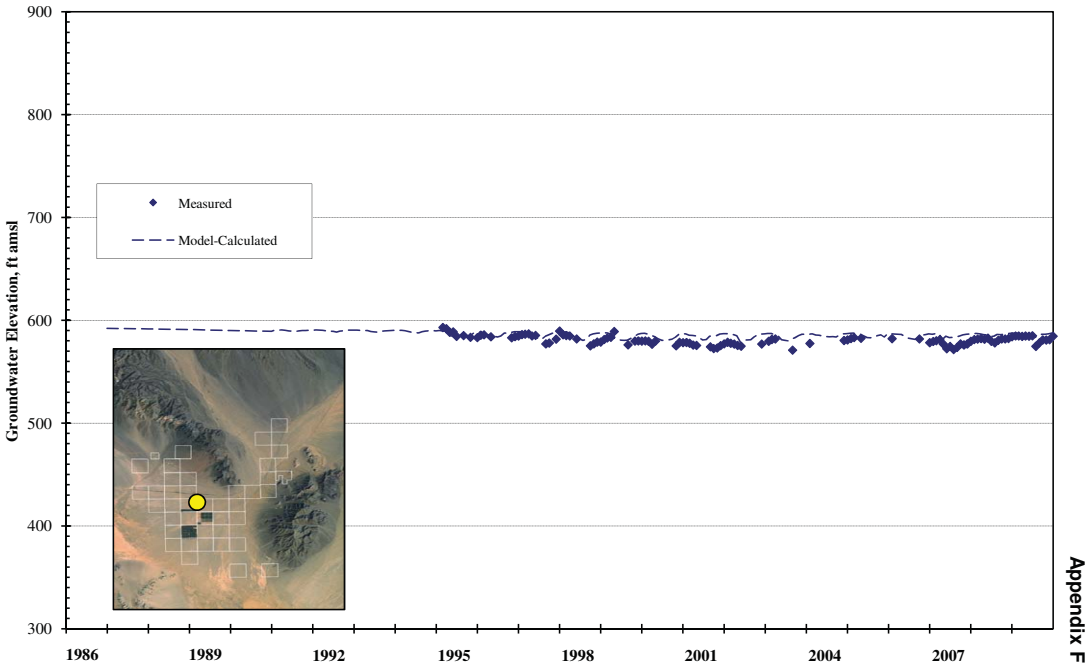
WITH NATURAL RECHARGE OF 16,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N F-1
Hydrograph for Cadiz Well 21S F-2
Hydrograph for Cadiz Well 22 ..... F-3
Hydrograph for Cadiz Well 27N F-4
Hydrograph for Cadiz Well 27S F-5
Hydrograph for Cadiz Well 28 ..... F-6
Hydrograph for Cadiz Well 33 ..... F-7
Hydrograph for Cadiz Dorm Well F-8
Hydrograph for Cadiz Labor Well F-9
Hydrograph for Cadiz Park Well F-10
Hydrograph for Cadiz Well 6N/15E-01 ..... F-11
Hydrograph for Cadiz Well 6N/15E-29 ..... F-12
Hydrograph for Cadiz Well 5N/14E-13 ..... F-13
Hydrograph for Well SCE 5 ..... F-14
Hydrograph for Well SCE 9 ..... F-15
Hydrograph for Well SCE 10 ..... F-16
Hydrograph for Well SCE 11 ..... F-17
Hydrograph for Well SCE 17 ..... F-18
Hydrograph for Well SCE 18 ..... F-19
Hydrograph for Well CI 1 ..... F-20
Hydrograph for Well CI 2 ..... F-21

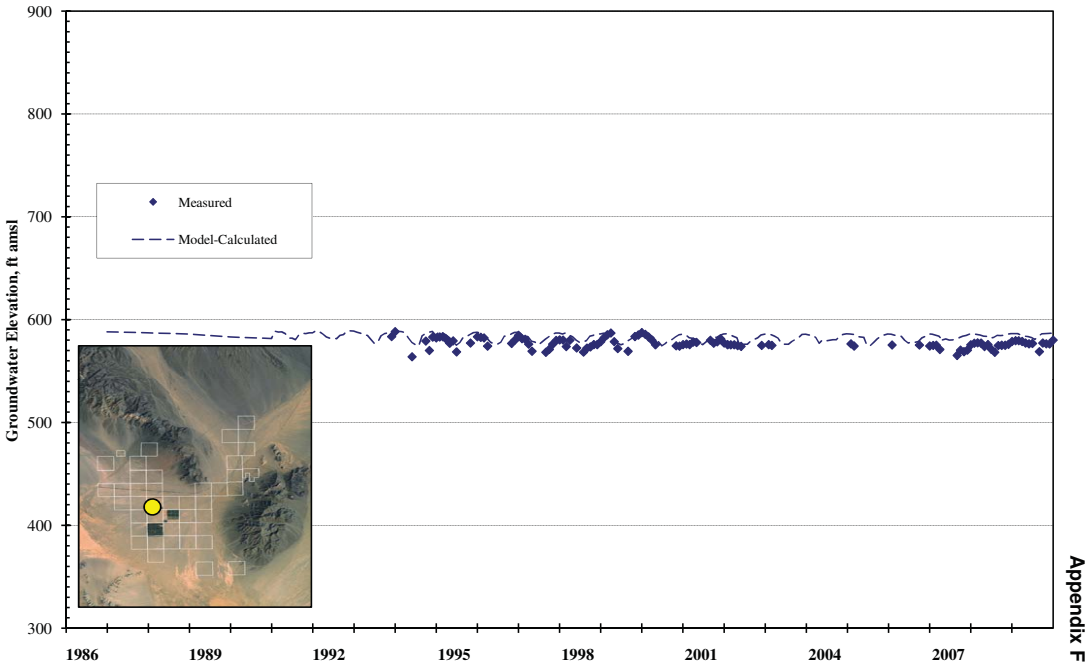
Hydrograph for Well CI 3 ..... F-22
Hydrograph for Well MW 1 ..... F-23
Hydrograph for Well MW 2 ..... F-24
Hydrograph for Well MW 3 ..... F-25
Hydrograph for Well MW 5 ..... F-26
Hydrograph for Well MW 6 ..... F-27
Hydrograph for Well MW 7 ..... F-28
Hydrograph for Well MW 7A F-29

Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



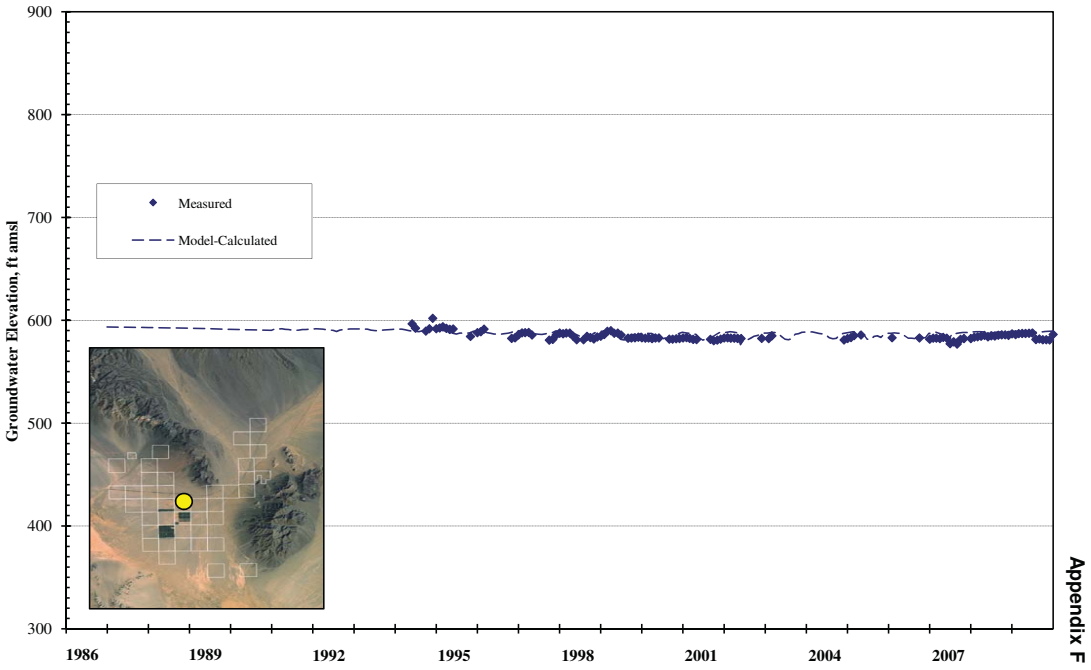
Appendix F

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



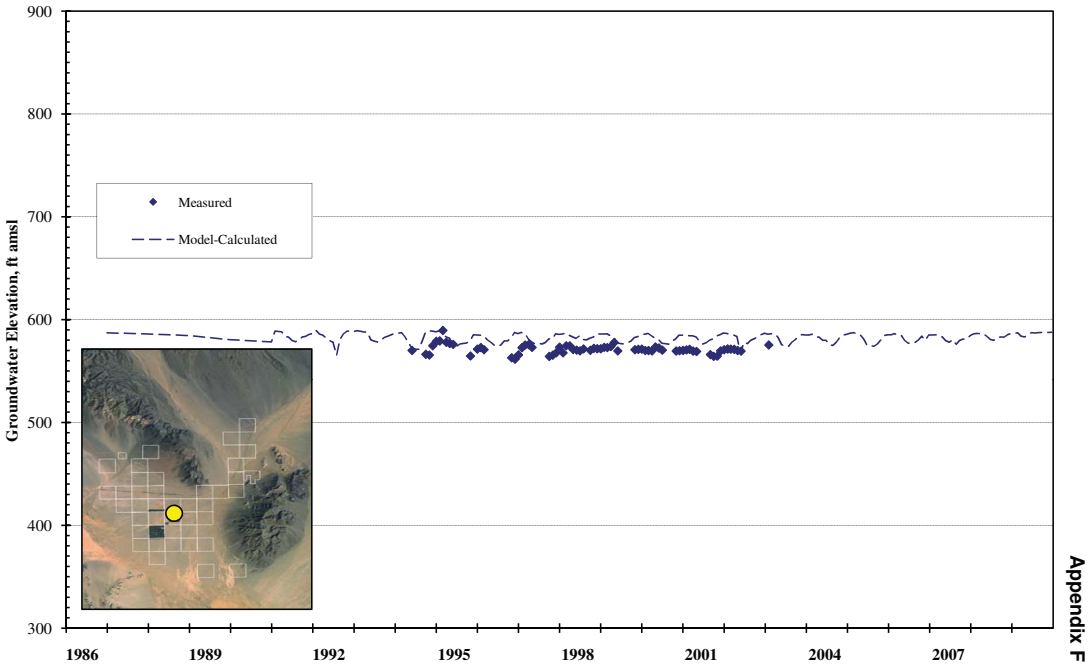
Appendix F

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



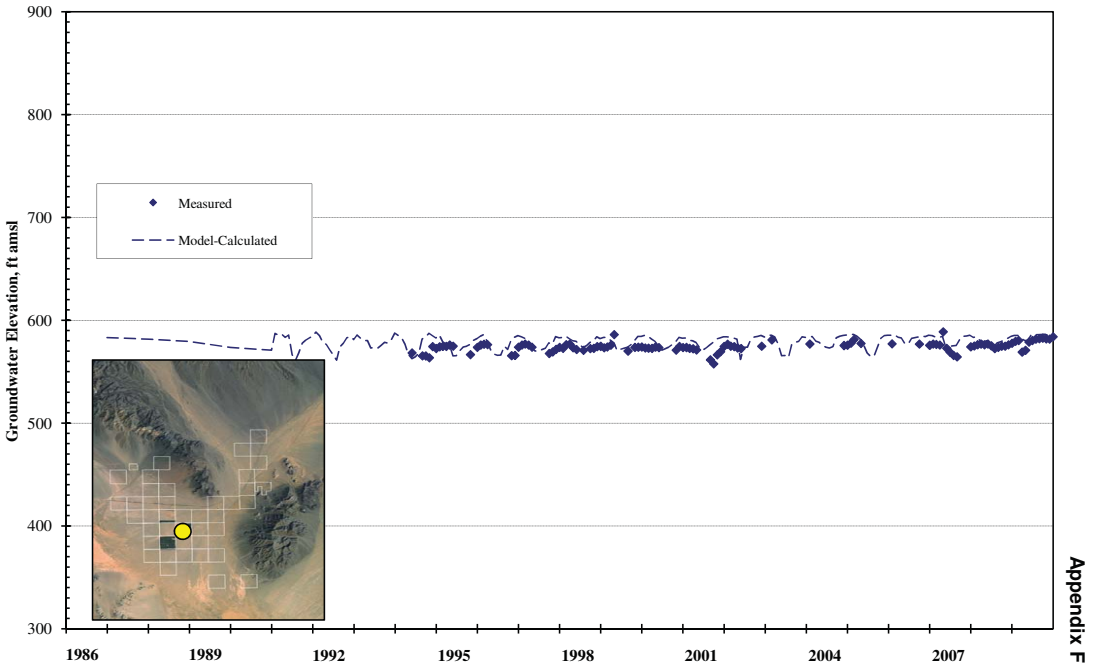
Appendix F

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



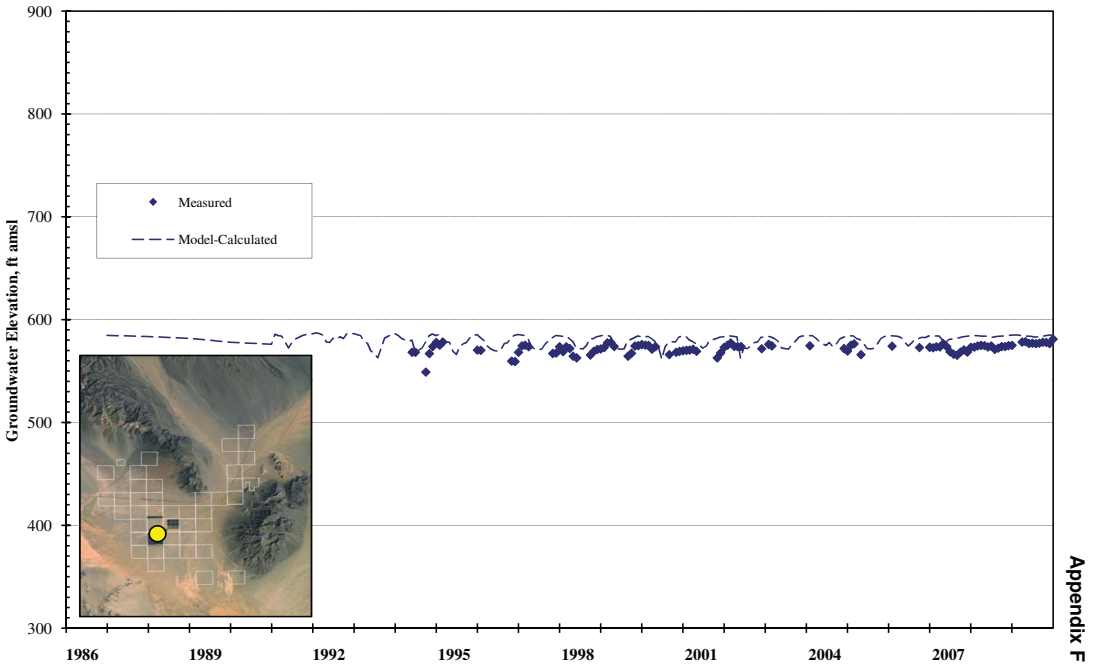
Appendix F

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



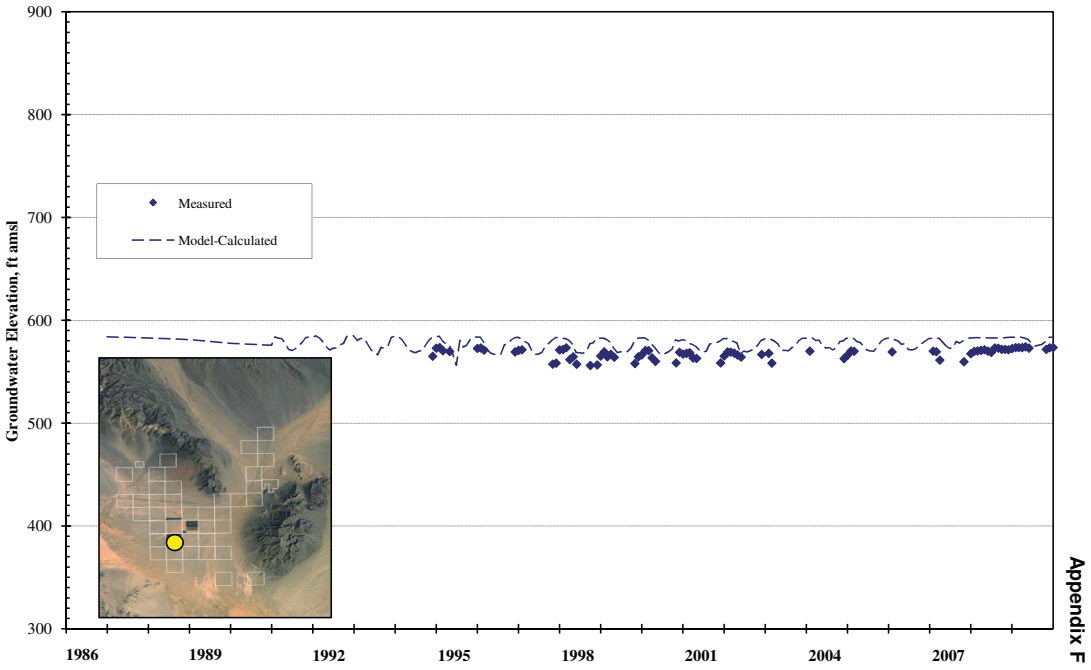
Appendix F

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



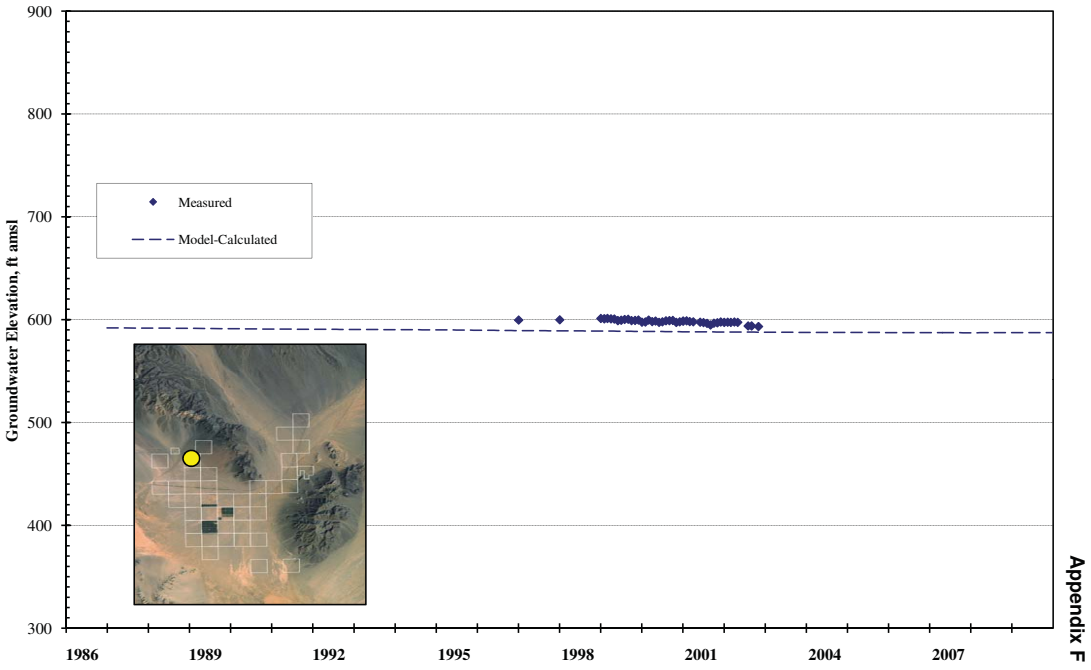
Appendix F

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



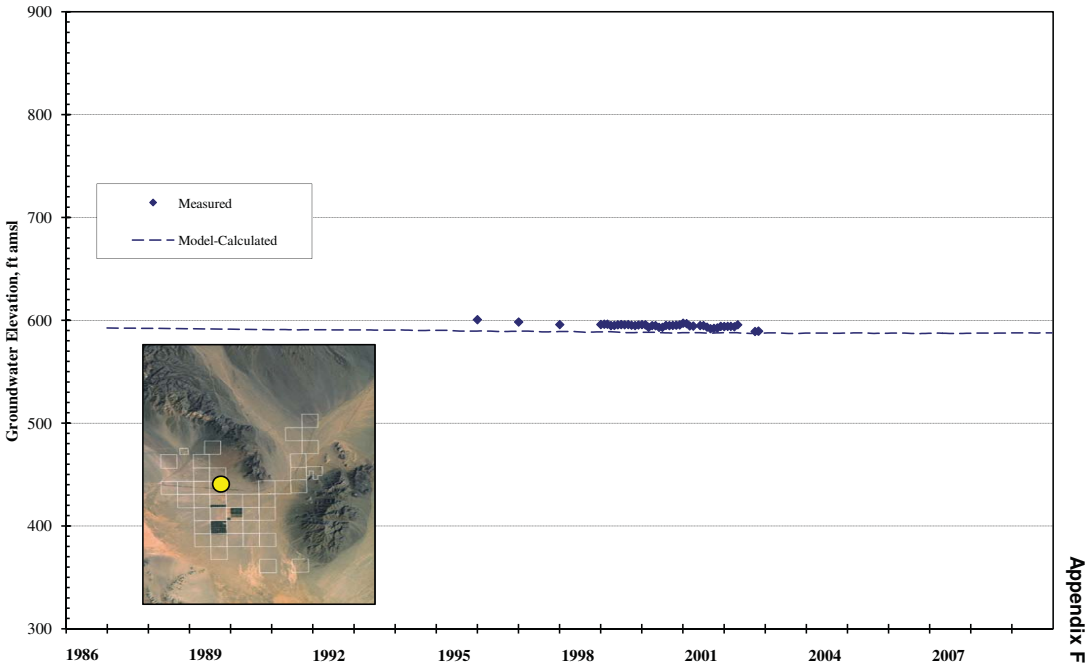
Appendix F

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



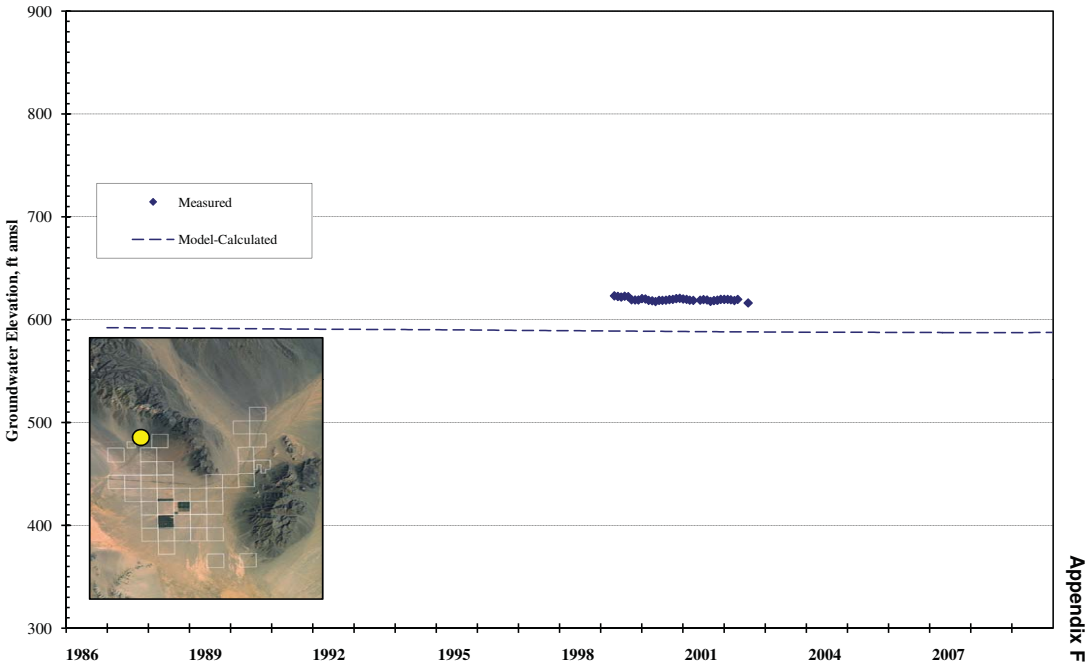
Appendix F

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



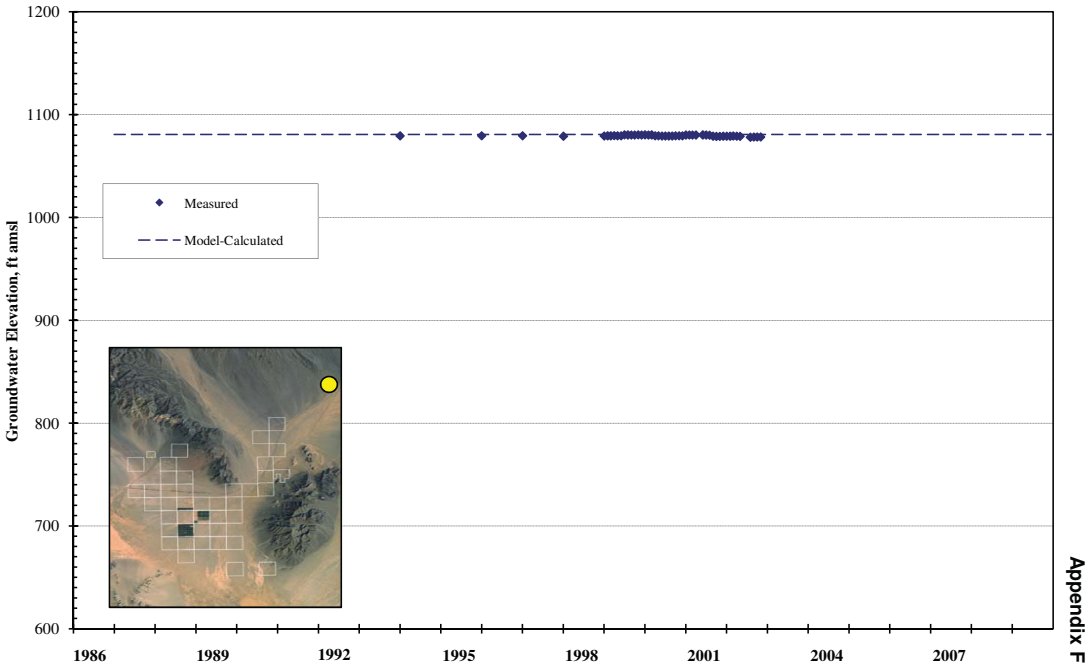
Appendix F

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



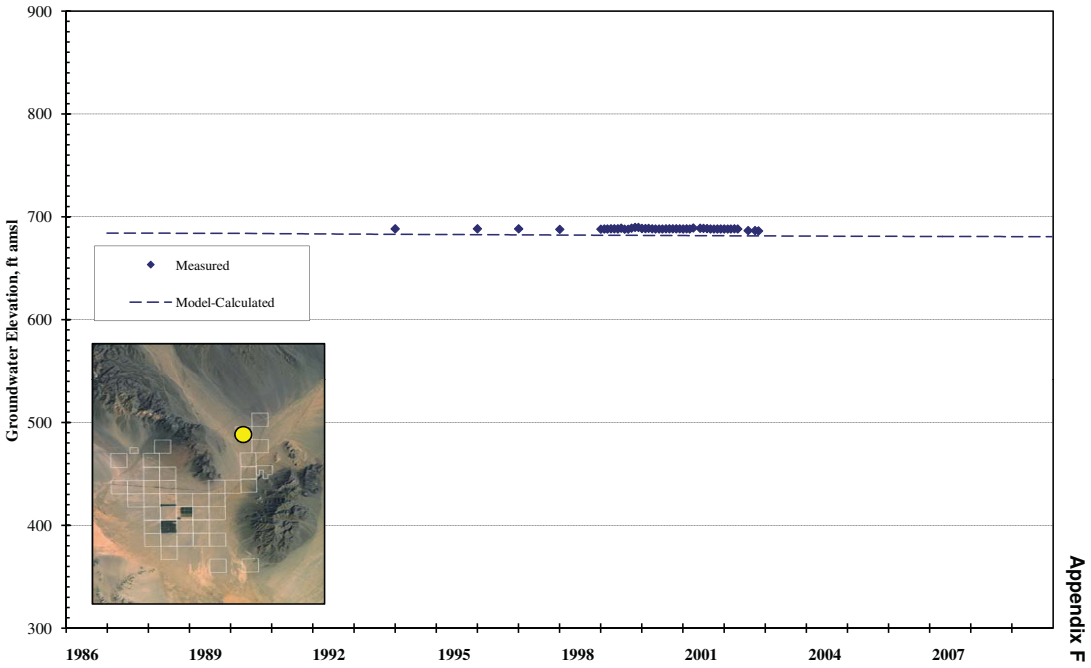
Appendix F

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



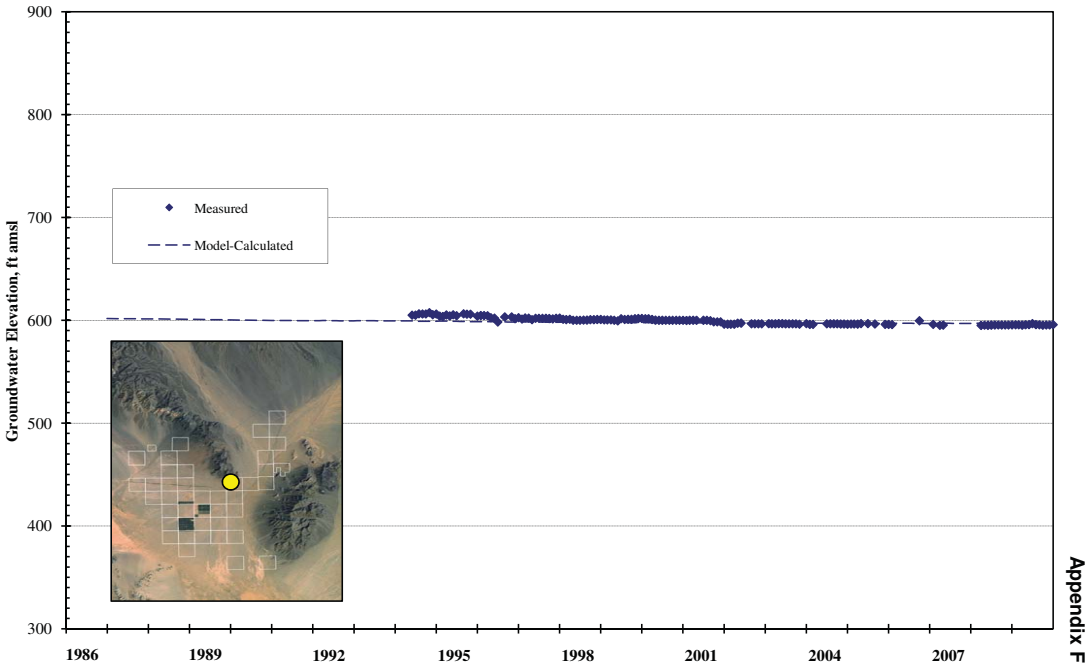
Appendix F

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



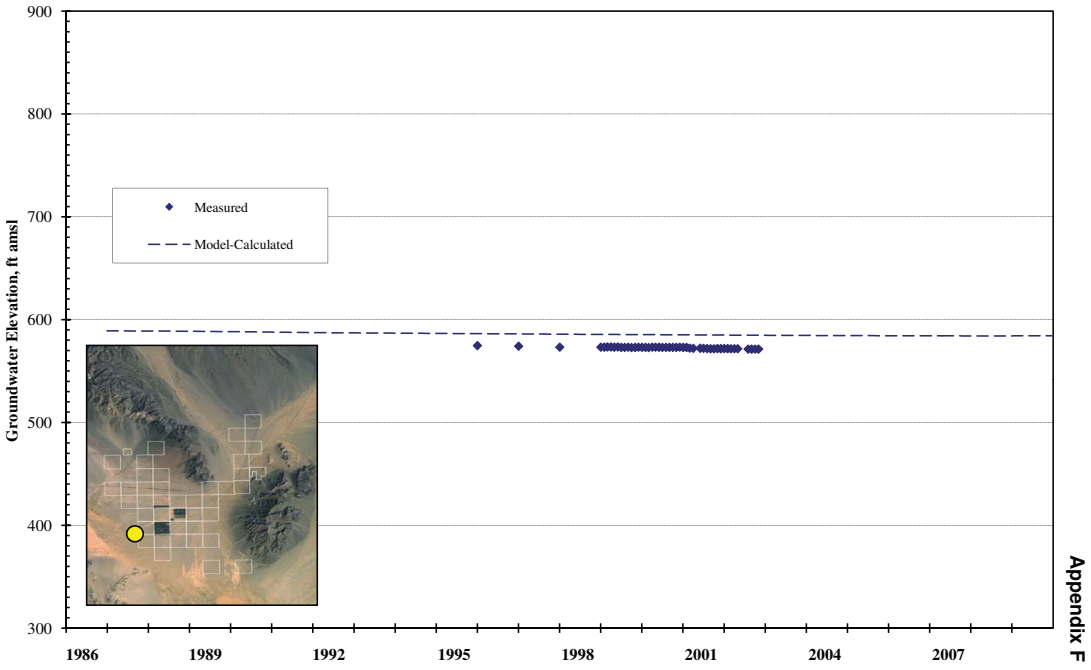
Appendix F

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



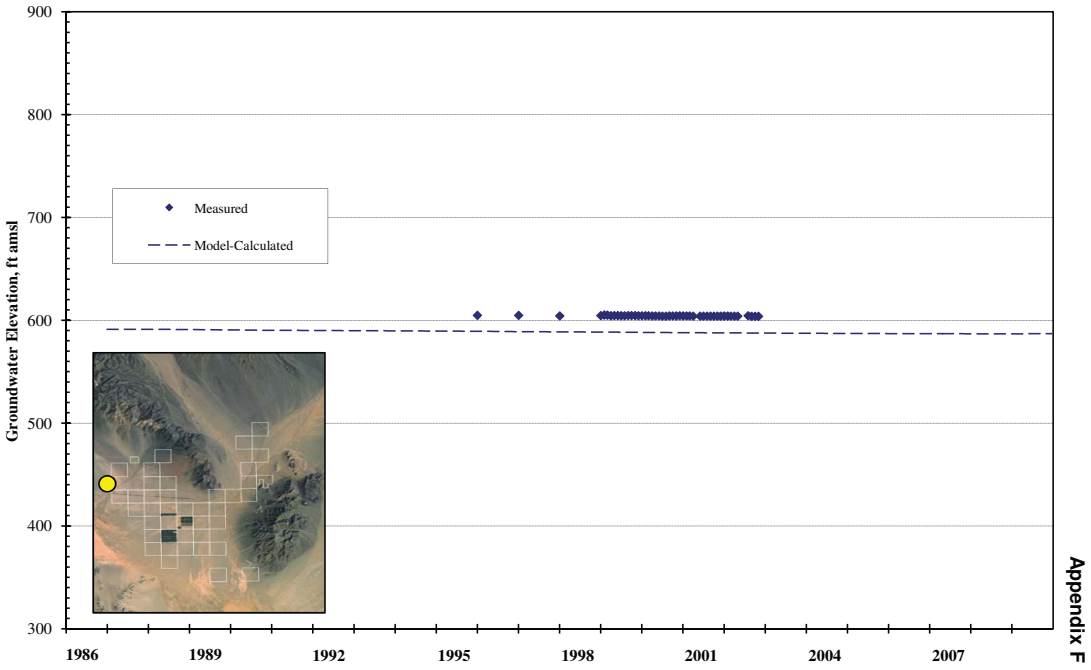
Appendix F

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



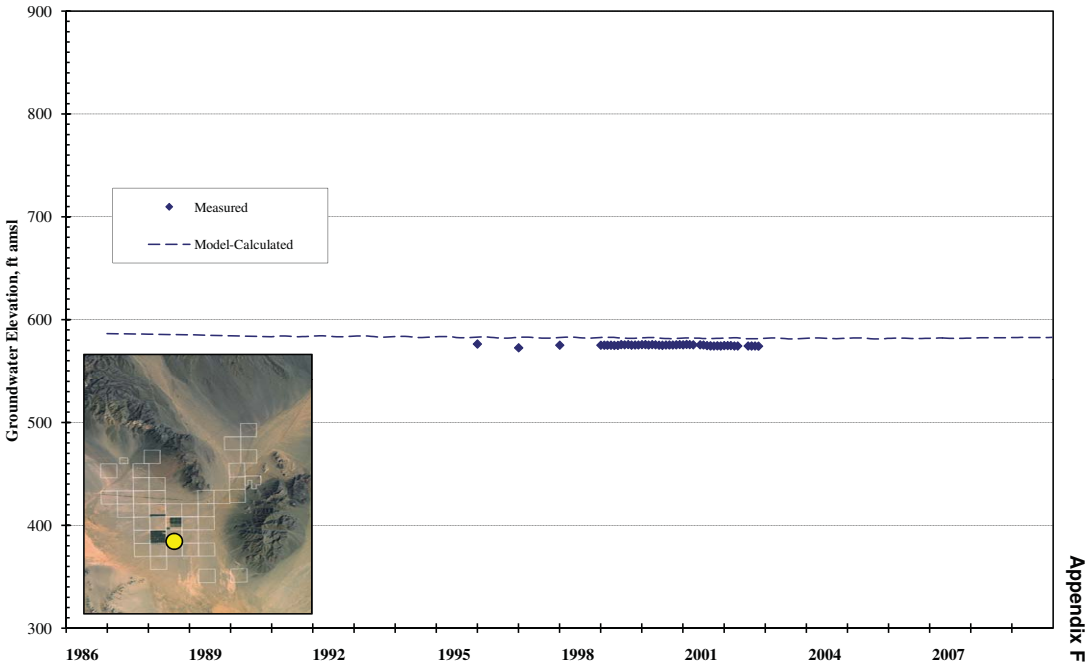
Appendix F

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



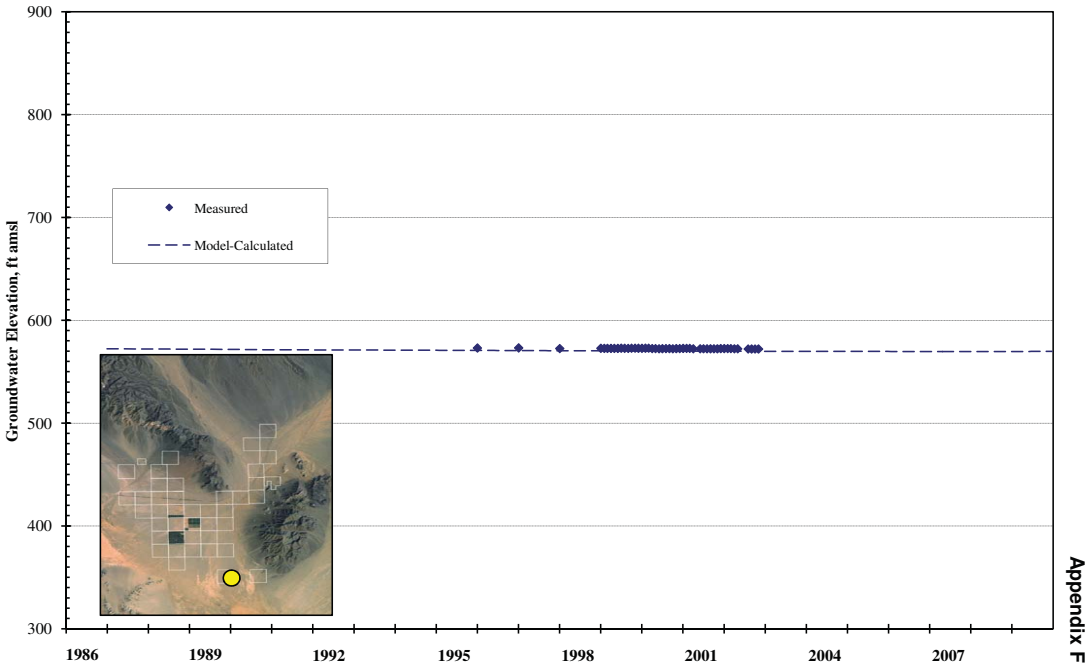
Appendix F

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



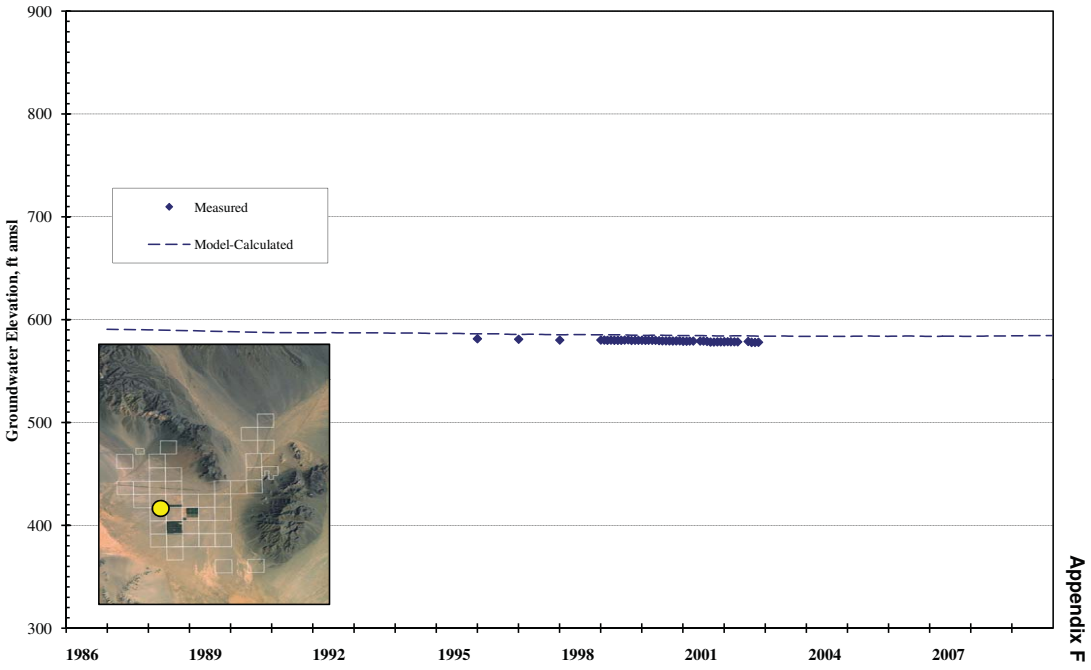
Appendix F

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



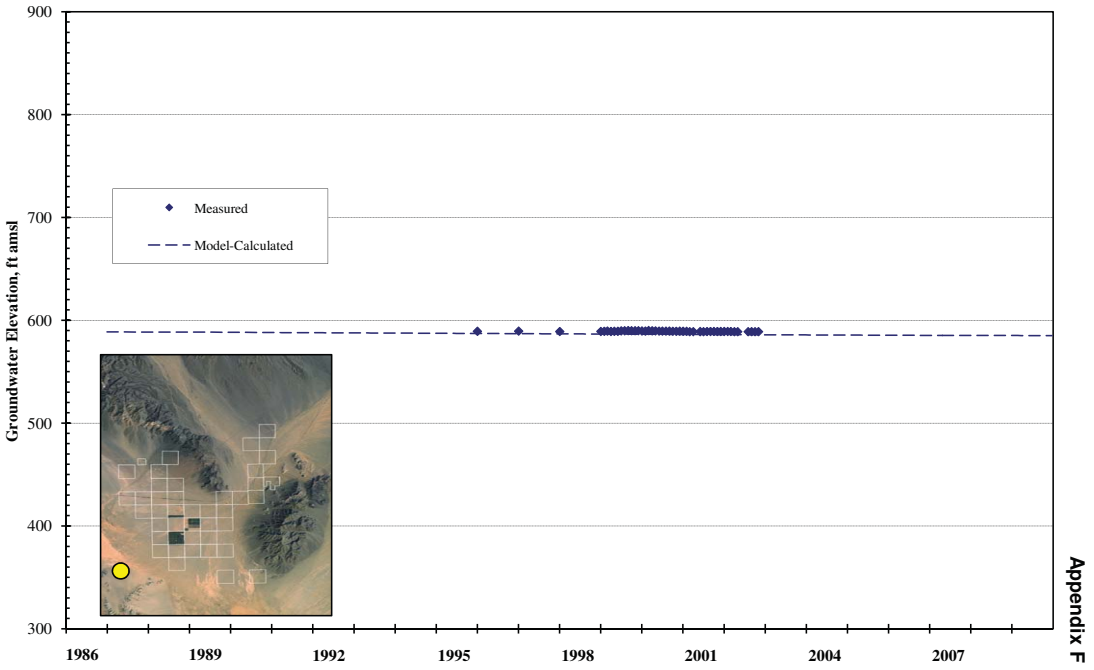
Appendix F

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



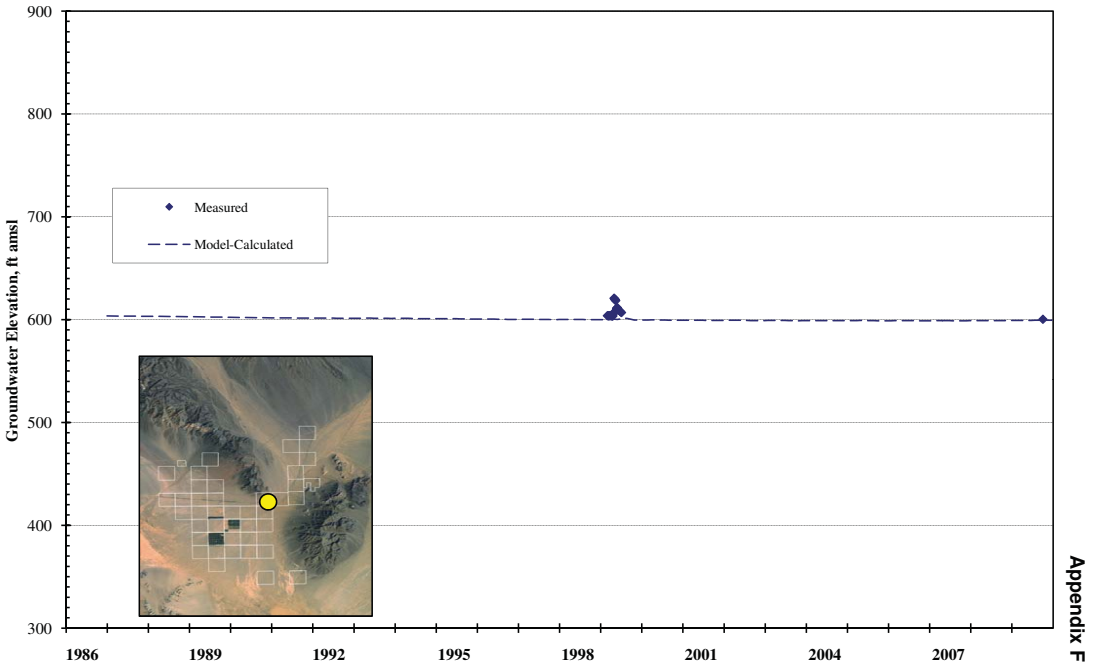
Appendix F

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



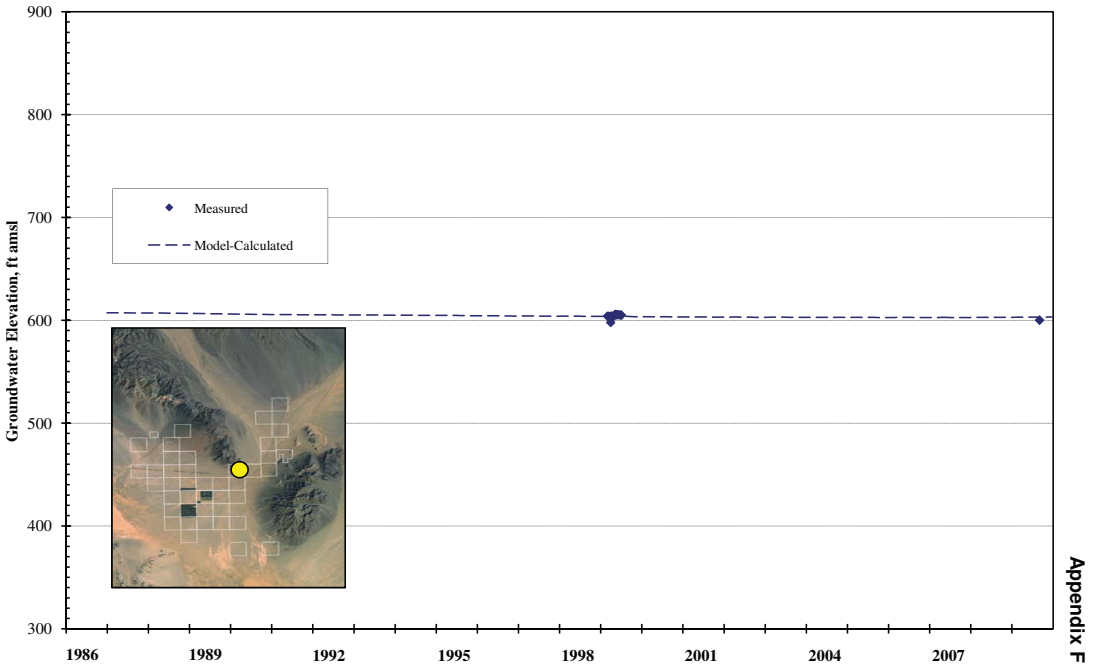
Appendix F

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



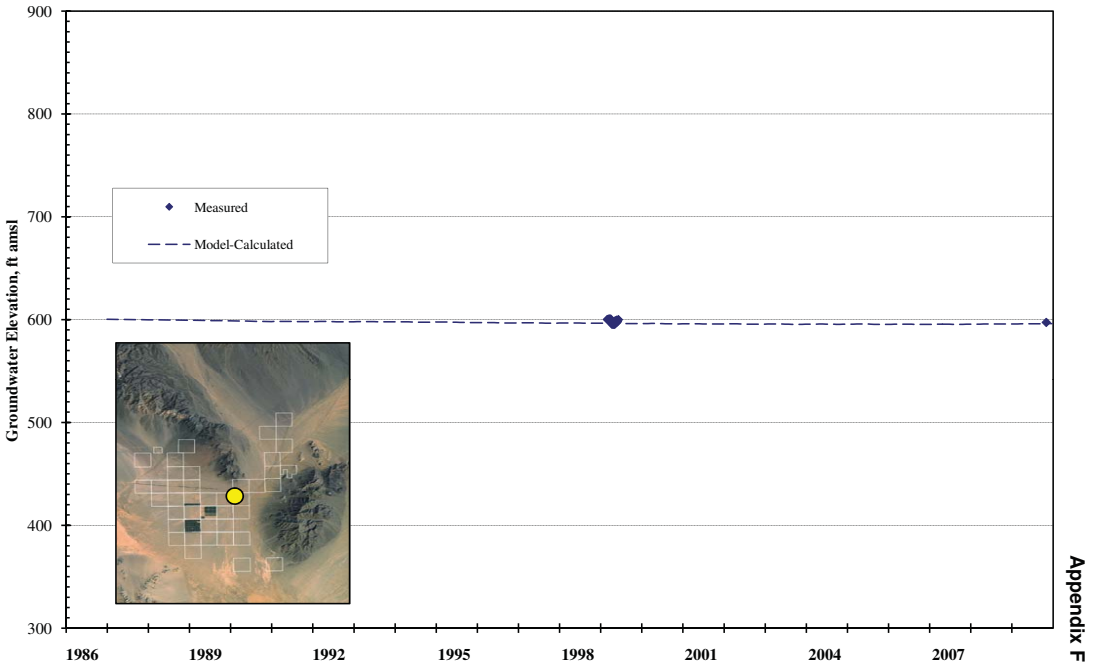
Appendix F

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



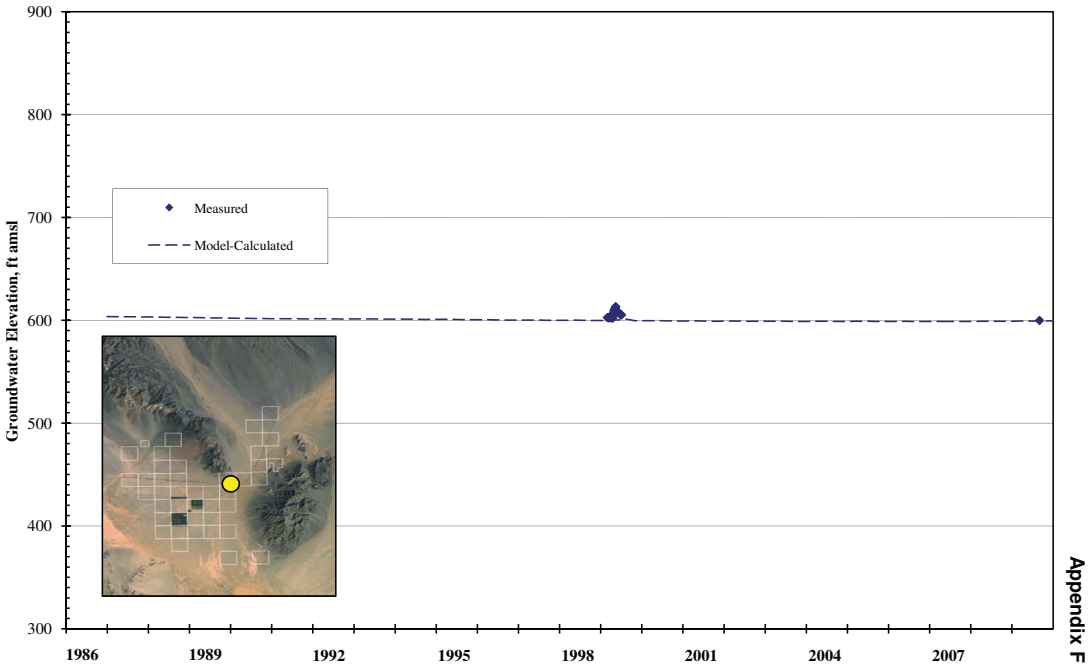
Appendix F

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



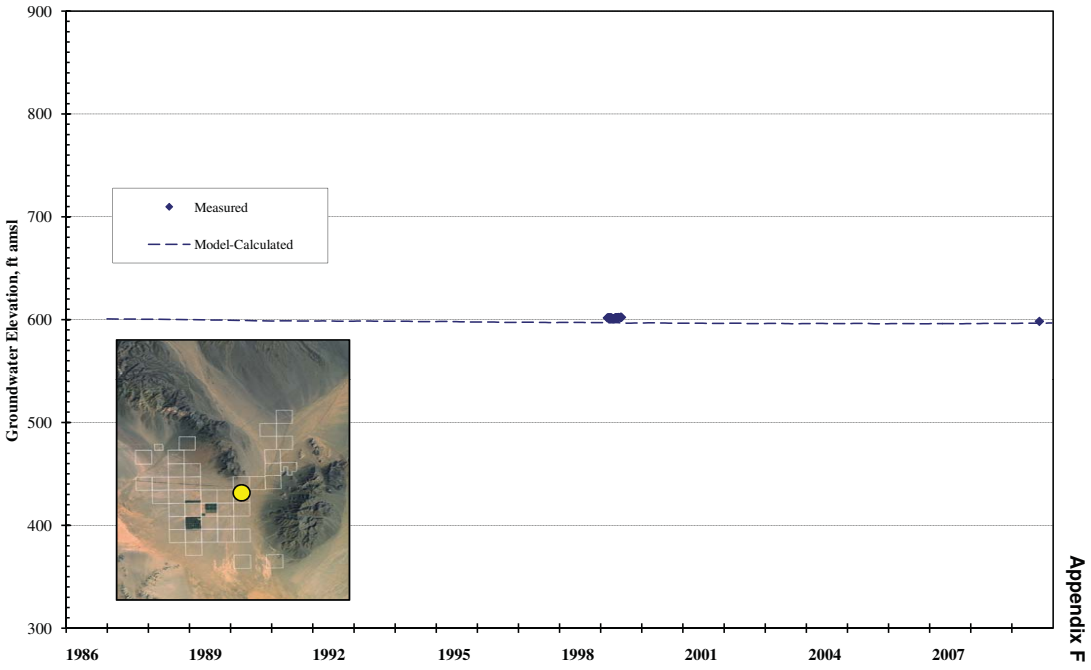
Appendix F

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



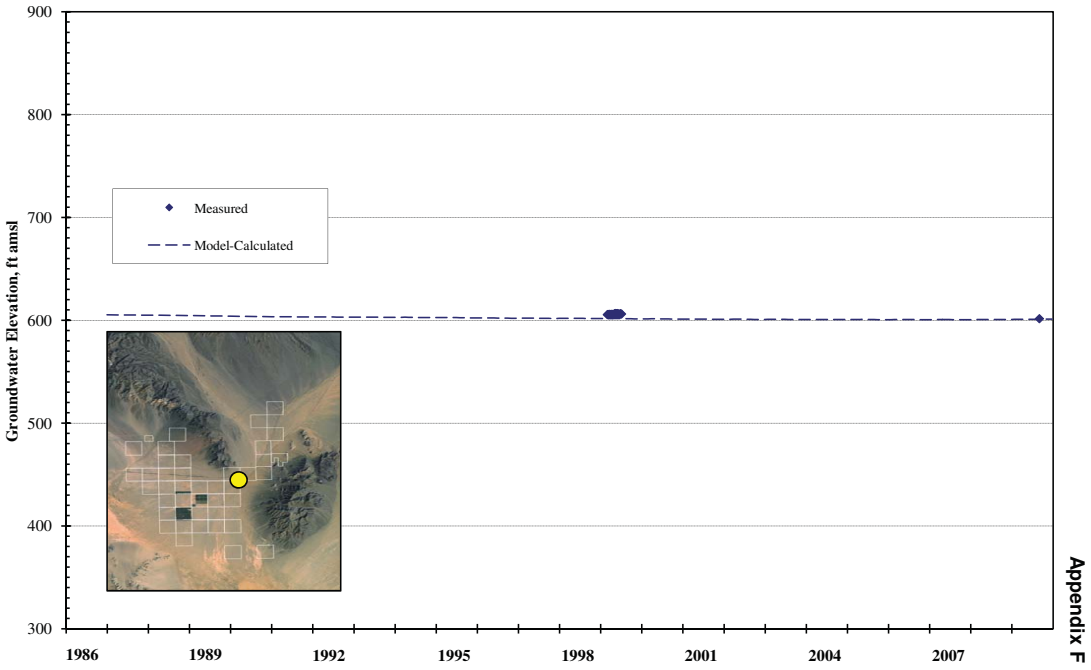
Appendix F

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



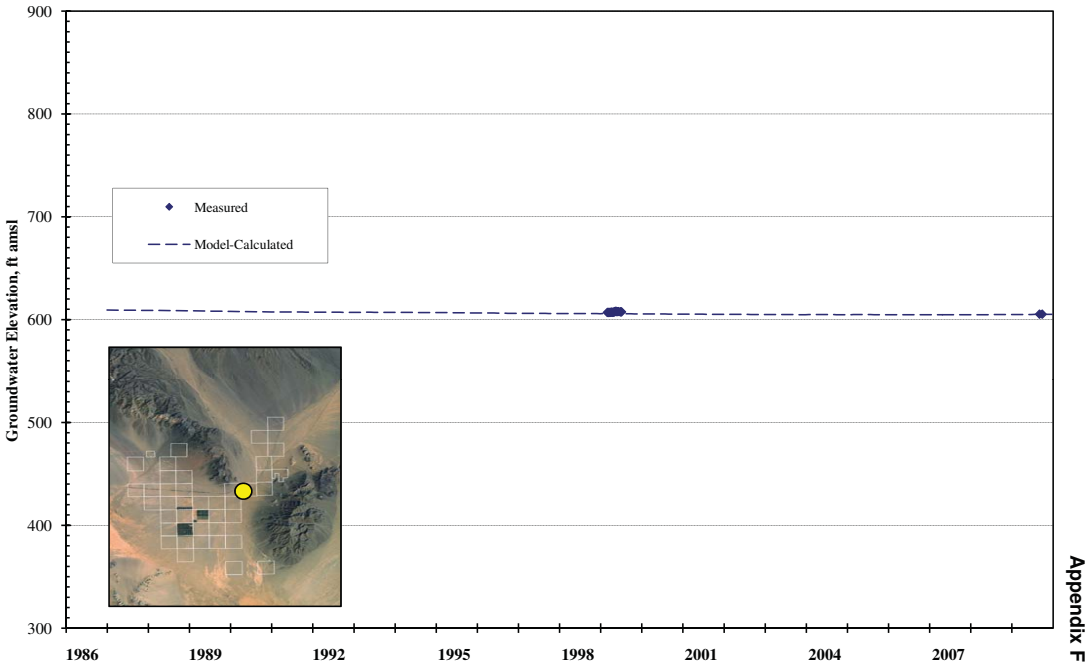
Appendix F

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



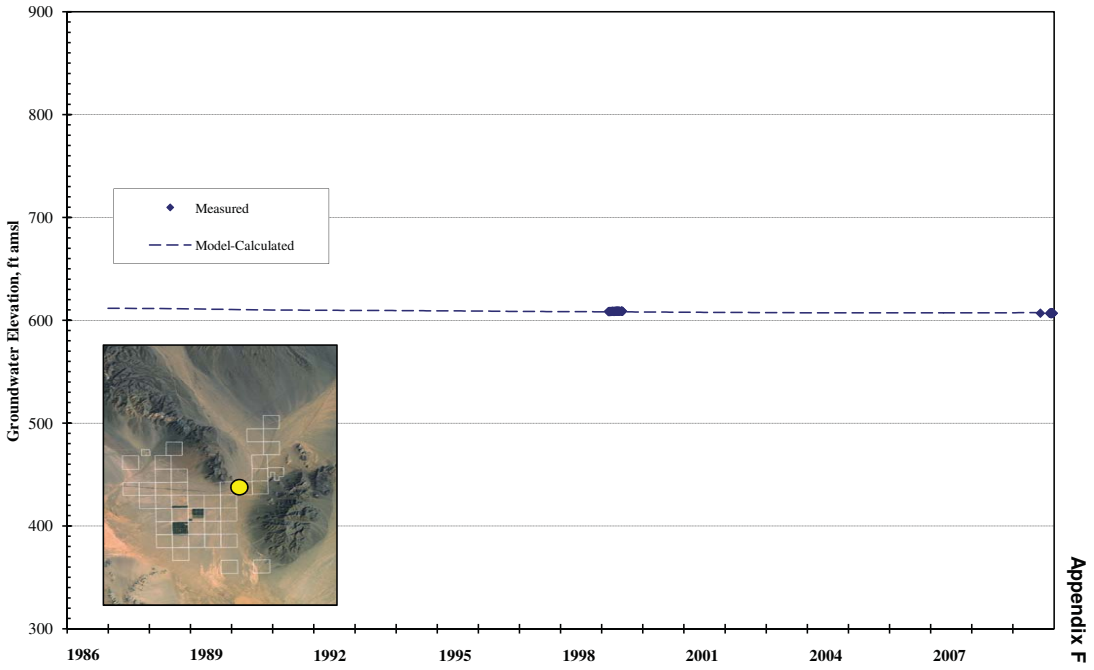
Appendix F

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



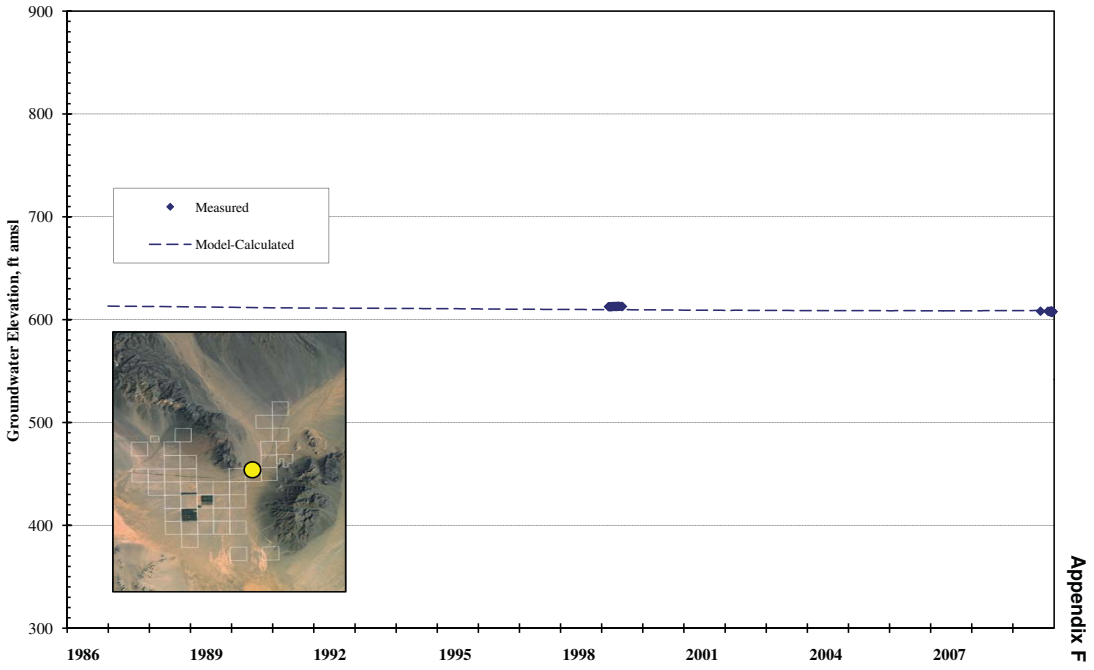
Appendix F

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



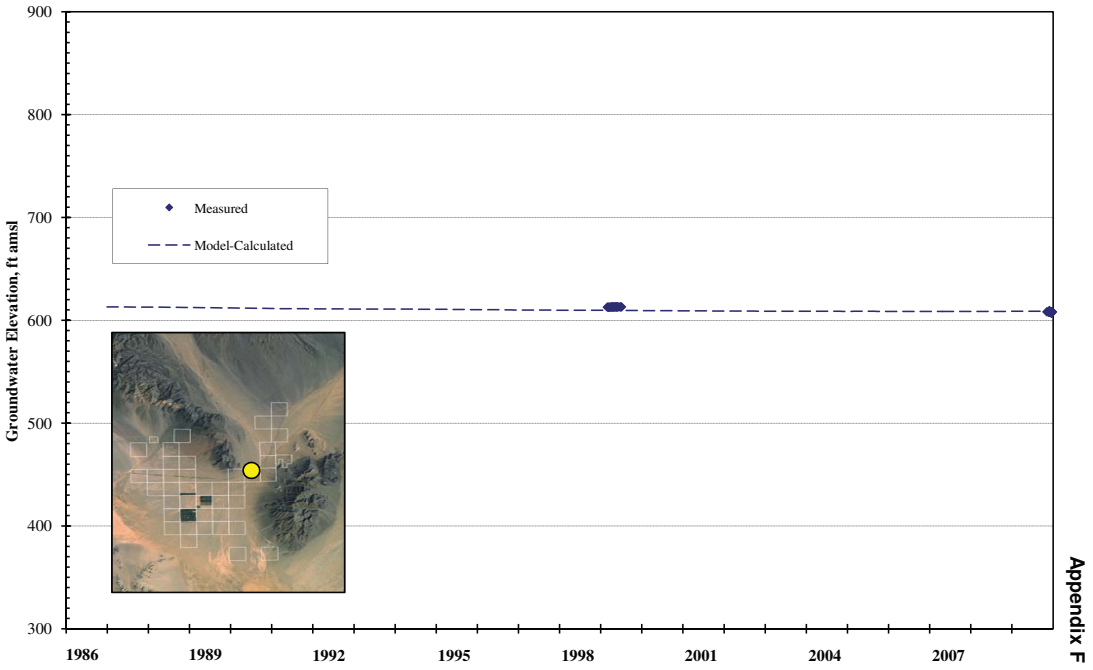
Appendix F

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



Appendix F

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 16,000 acre-ft/yr)



Appendix F

APPENDIX G

Hydrographs for Transient Model Calibration

With Natural Recharge of 5,000 acre-ft/yr

GEOSCIENCE

APPENDIX G

HYDROGRAPHS FOR TRANSIENT MODEL CALIBRATION

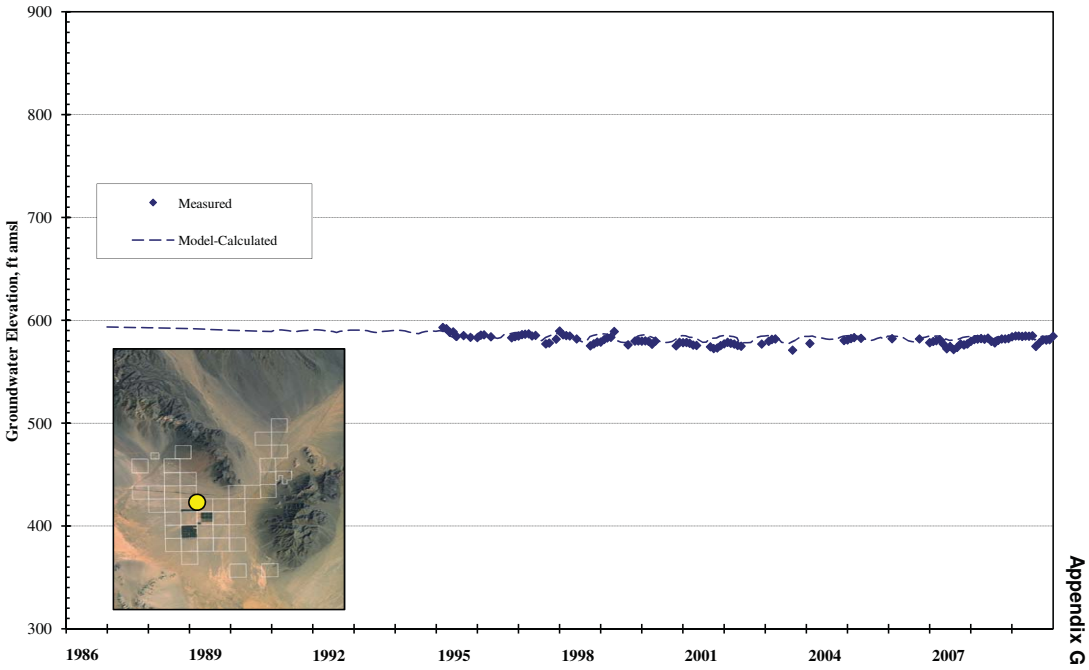
WITH NATURAL RECHARGE OF 5,000 acre-ft/yr

CONTENTS

Hydrograph for Cadiz Well 21N G-1
Hydrograph for Cadiz Well 21S G-2
Hydrograph for Cadiz Well 22 ..... G-3
Hydrograph for Cadiz Well 27N G-4
Hydrograph for Cadiz Well 27S G-5
Hydrograph for Cadiz Well 28 ..... G-6
Hydrograph for Cadiz Well 33 ..... G-7
Hydrograph for Cadiz Dorm Well G-8
Hydrograph for Cadiz Labor Well G-9
Hydrograph for Cadiz Park Well G-10
Hydrograph for Cadiz Well 6N/15E-01 ..... G-11
Hydrograph for Cadiz Well 6N/15E-29 ..... G-12
Hydrograph for Cadiz Well 5N/14E-13 ..... G-13
Hydrograph for Well SCE 5 ..... G-14
Hydrograph for Well SCE 9 ..... G-15
Hydrograph for Well SCE 10 ..... G-16
Hydrograph for Well SCE 11 ..... G-17
Hydrograph for Well SCE 17 ..... G-18
Hydrograph for Well SCE 18 ..... G-19
Hydrograph for Well CI 1 ..... G-20
Hydrograph for Well CI 2 ..... G-21

Hydrograph for Well CI 3 .....G-22
Hydrograph for Well MW 1 .....G-23
Hydrograph for Well MW 2 .....G-24
Hydrograph for Well MW 3 .....G-25
Hydrograph for Well MW 5 .....G-26
Hydrograph for Well MW 6 .....G-27
Hydrograph for Well MW 7 .....G-28
Hydrograph for Well MW 7A G-29

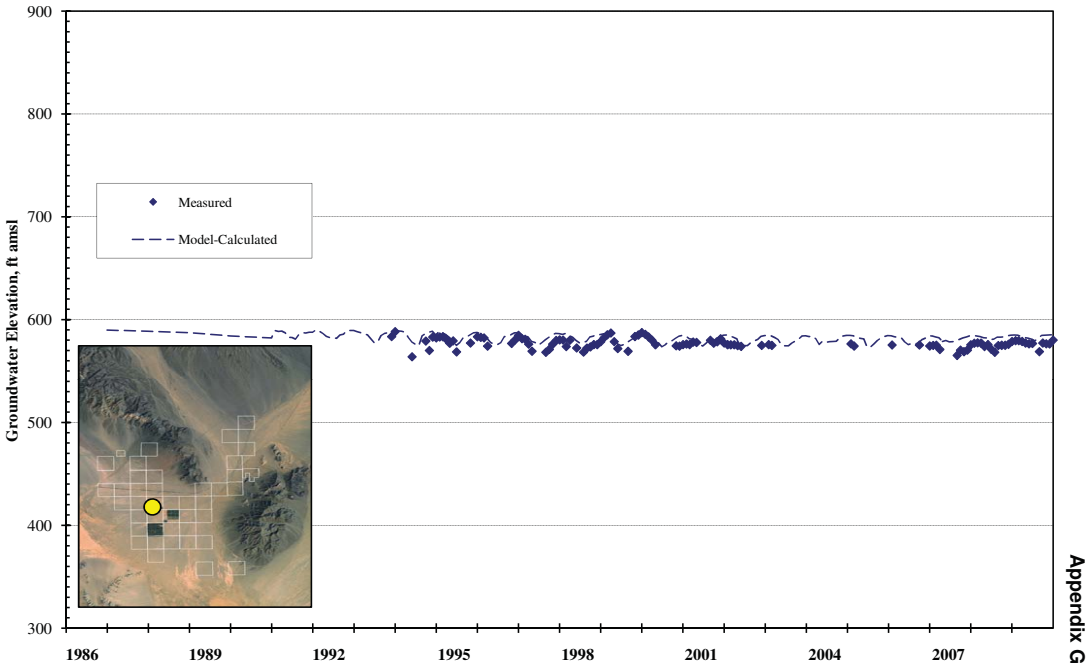
Hydrograph for Cadiz Well 21N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



Appendix G

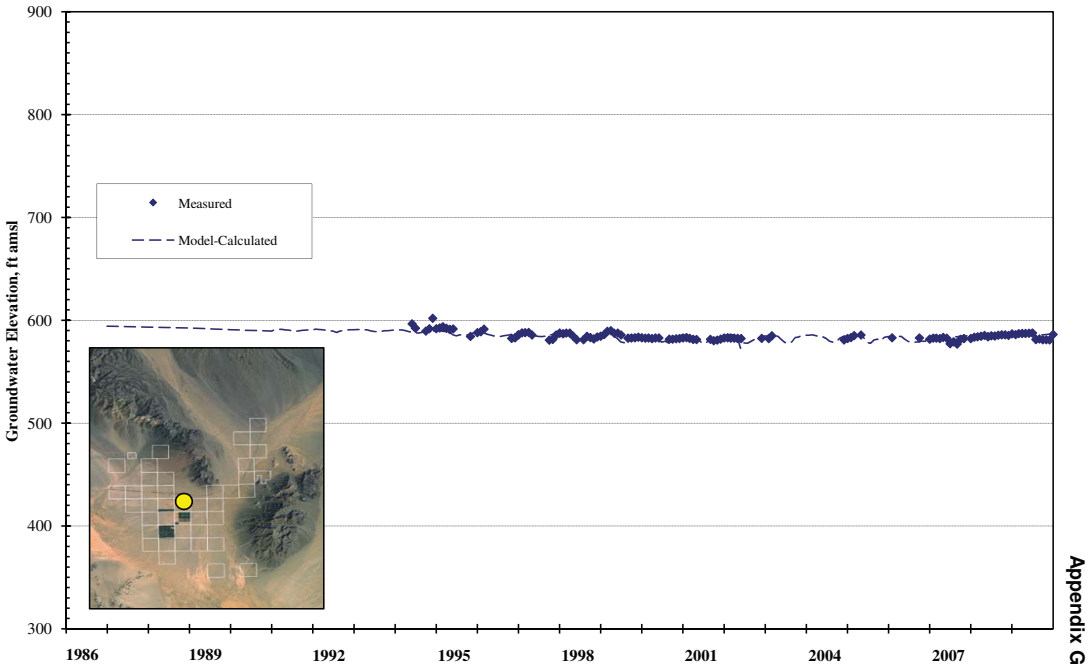
Brownstein Hyatt Farber Schreck, LLP
Cadiz Groundwater Modeling and Impact Analysis

Hydrograph for Cadiz Well 21S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



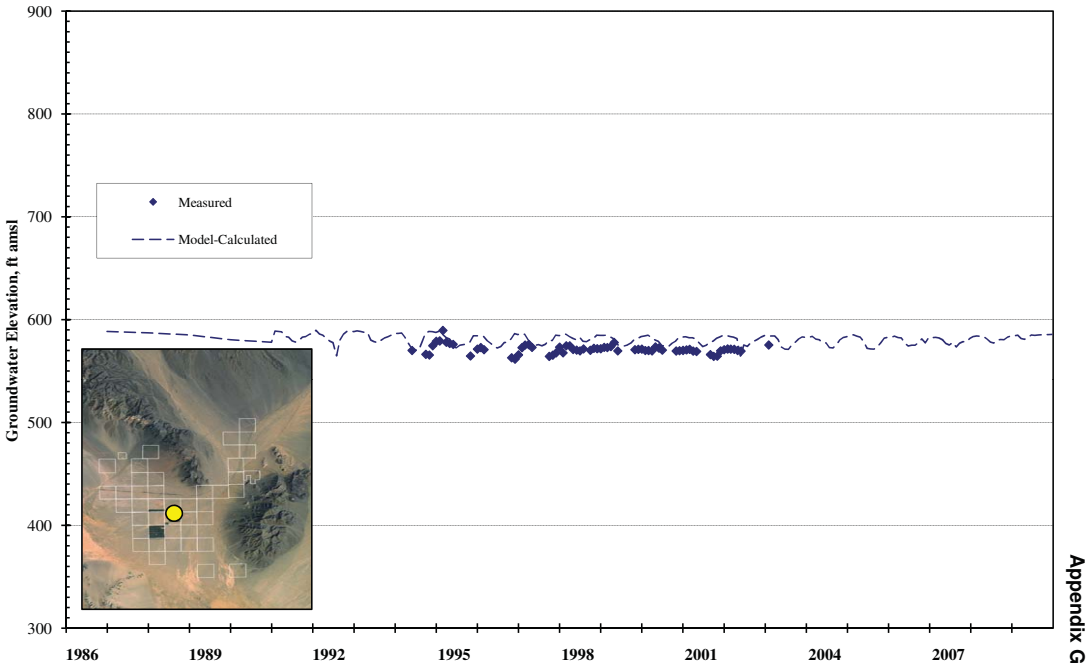
Appendix G

Hydrograph for Cadiz Well 22
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



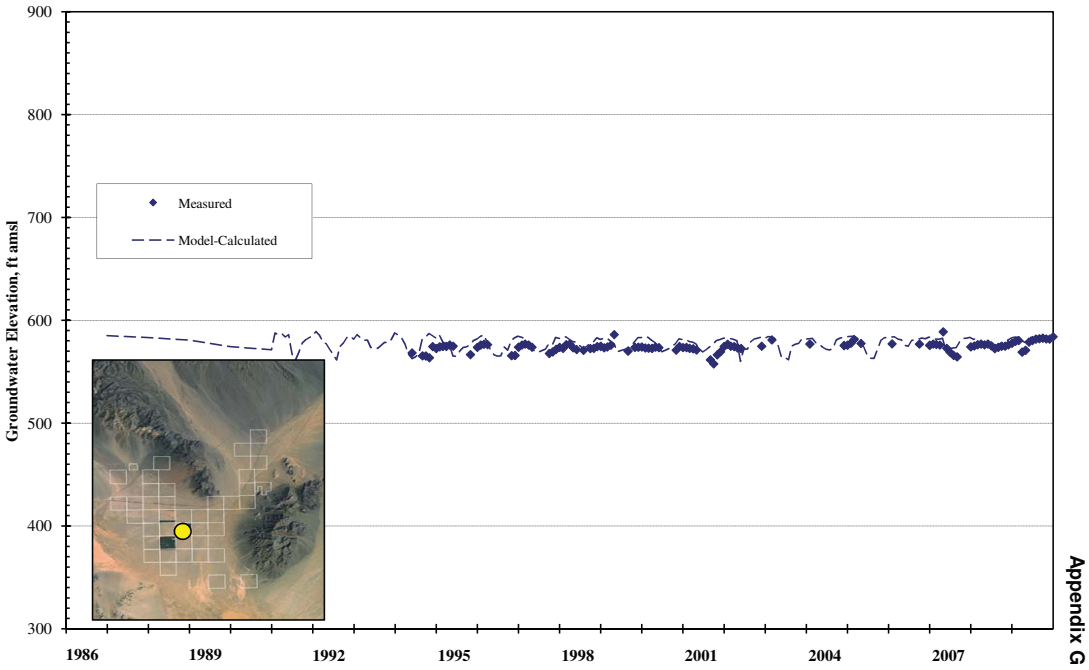
Appendix G

Hydrograph for Cadiz Well 27N
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



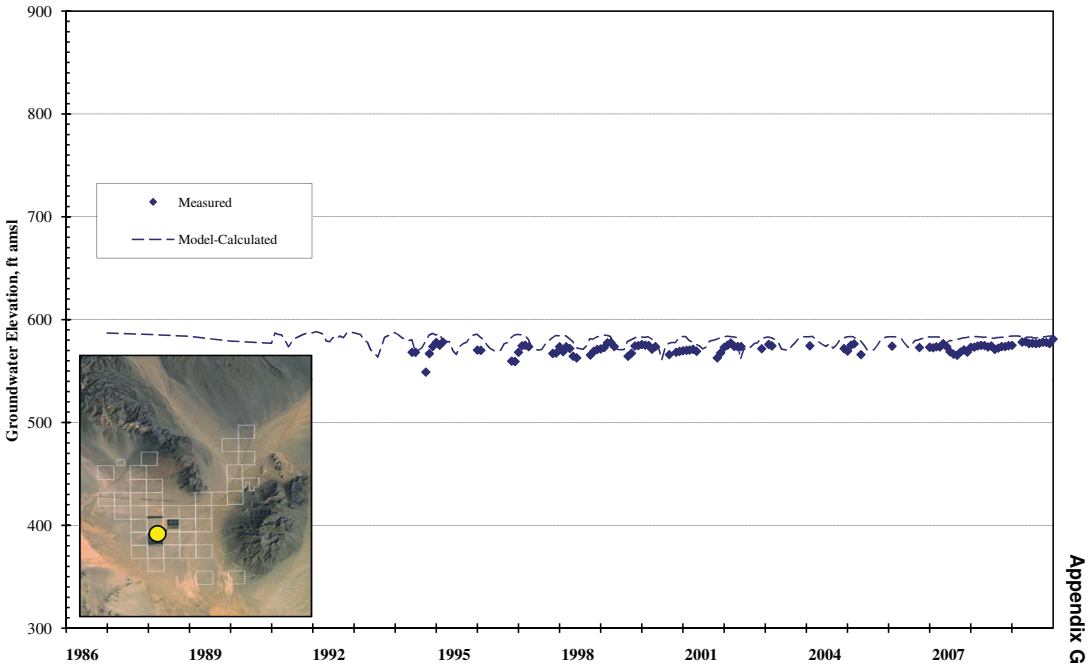
Appendix G

Hydrograph for Cadiz Well 27S
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



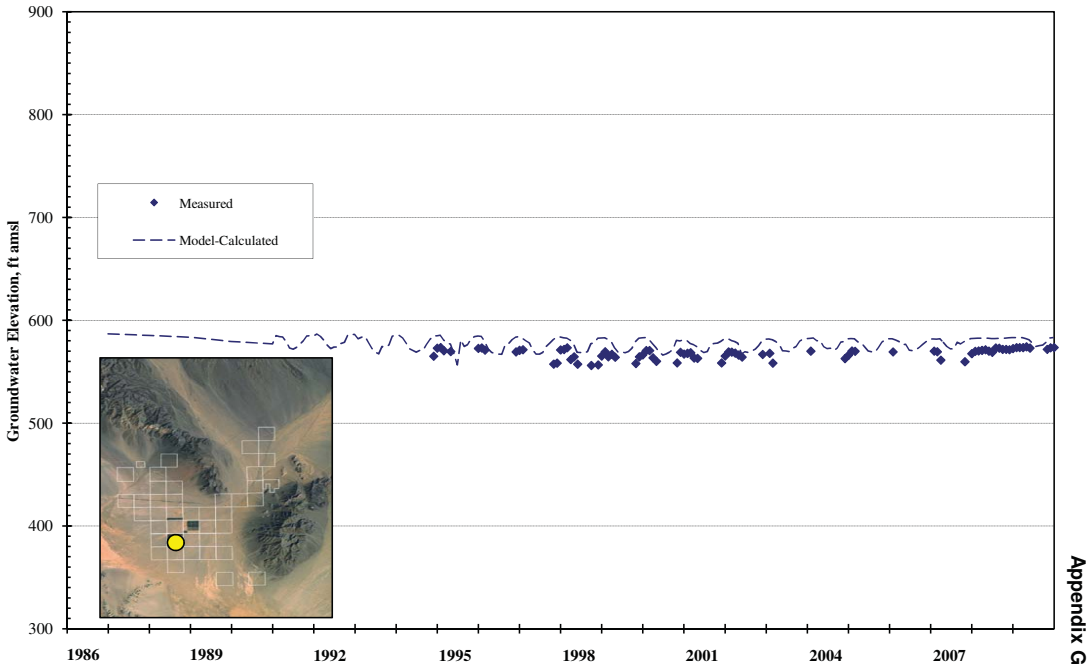
Appendix G

Hydrograph for Cadiz Well 28
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



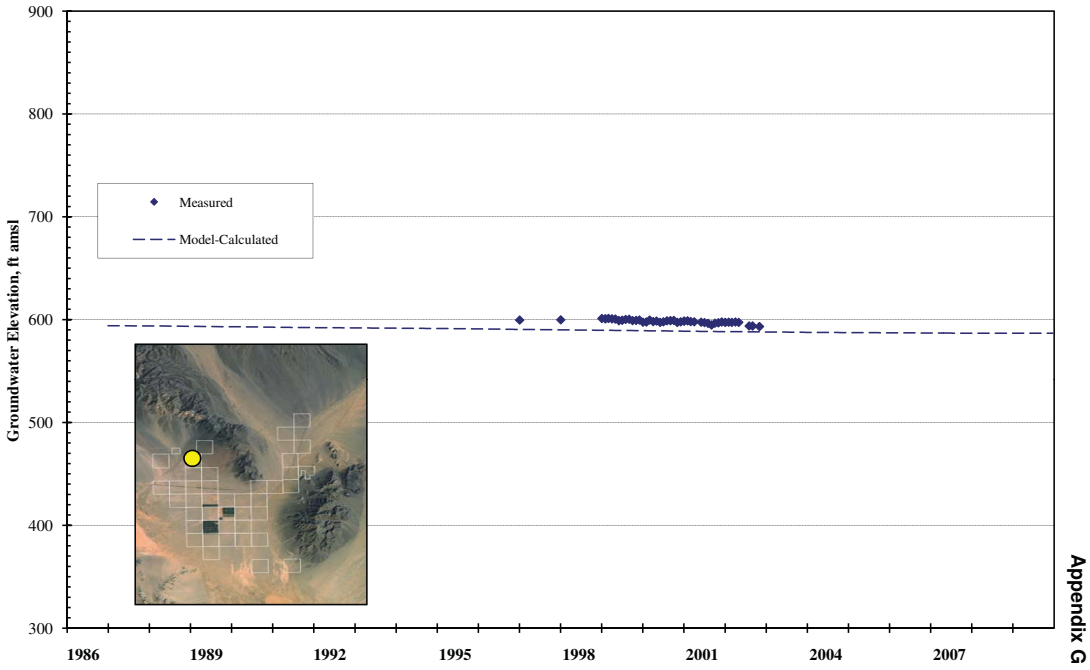
Appendix G

Hydrograph for Cadiz Well 33
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



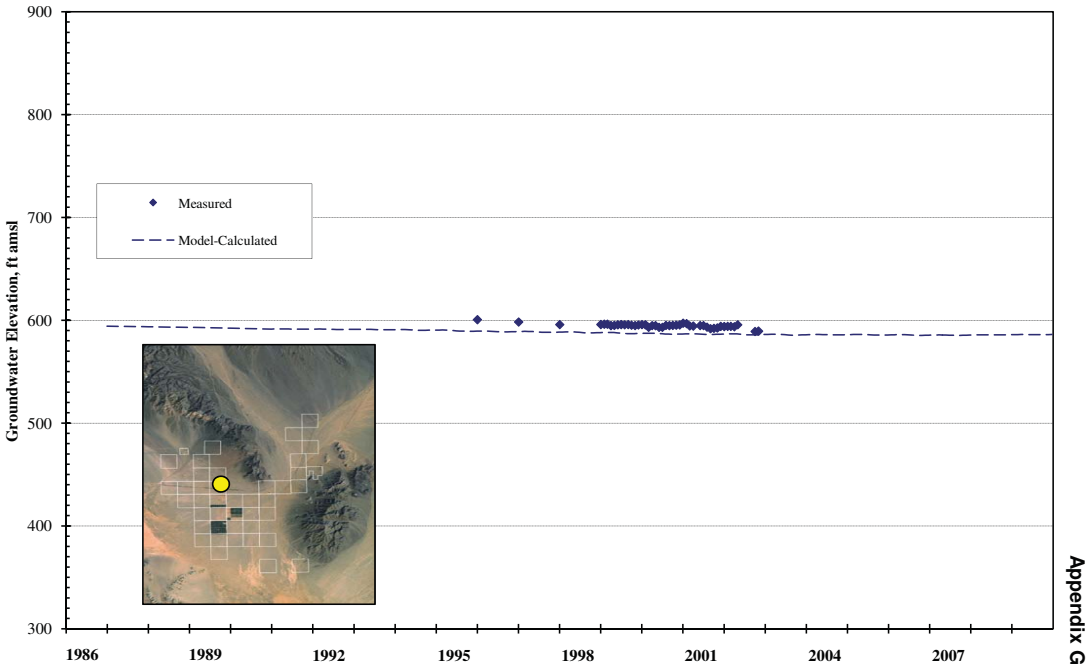
Appendix G

Hydrograph for Cadiz Dorm Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



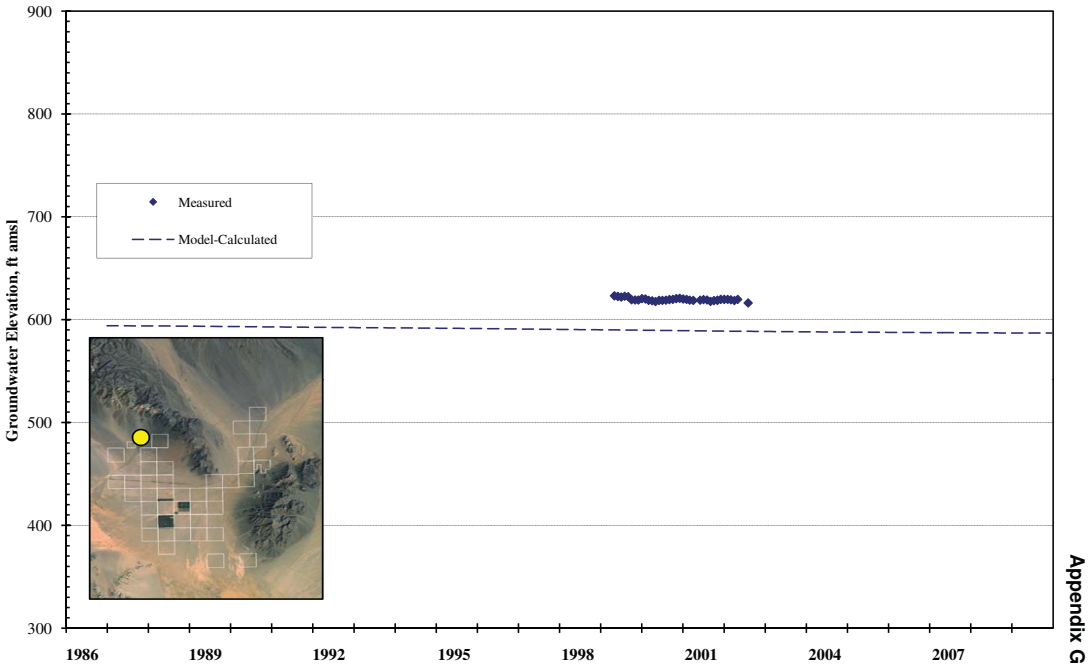
Appendix G

Hydrograph for Cadiz Labor Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



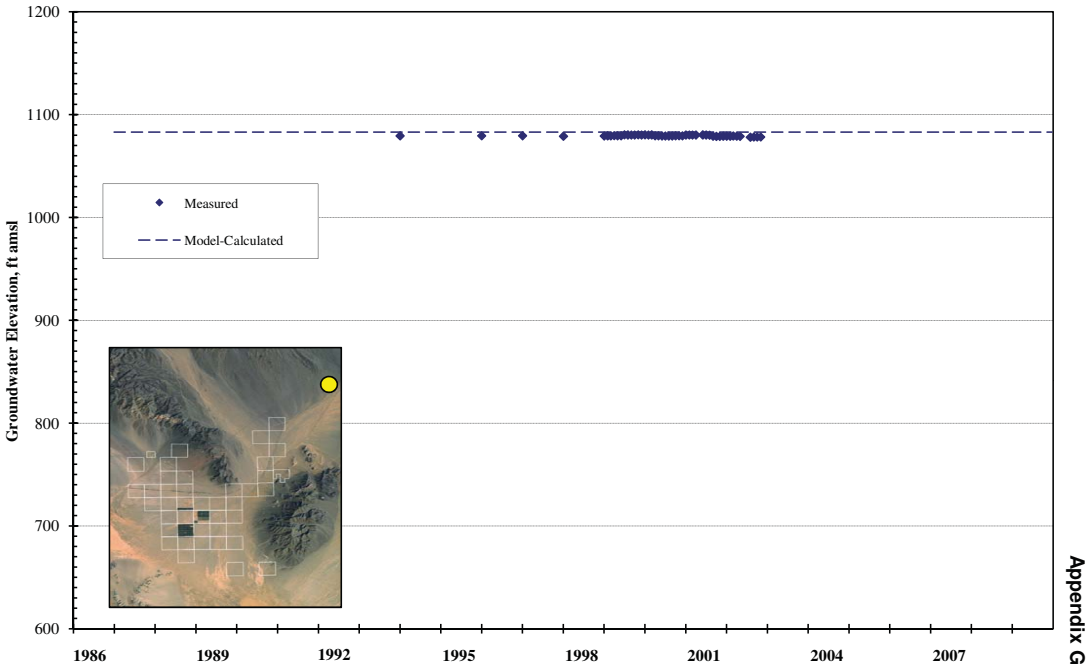
Appendix G

Hydrograph for Cadiz Park Well
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



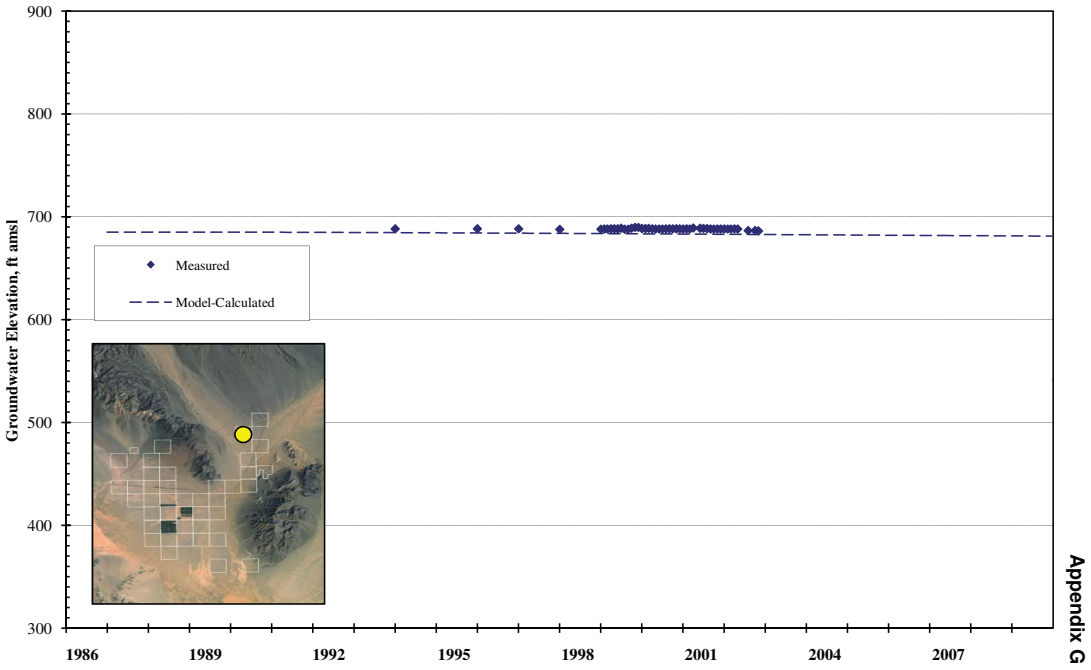
Appendix G

Hydrograph for Well 6N/15E-01
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



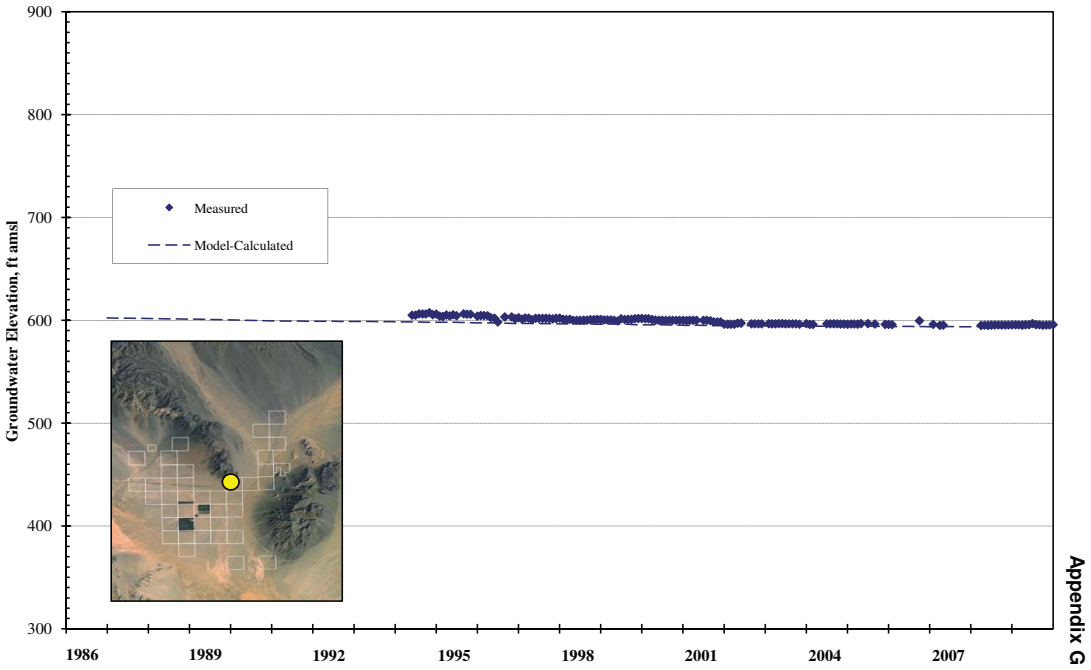
Appendix G

Hydrograph for Well 6N/15E-29
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



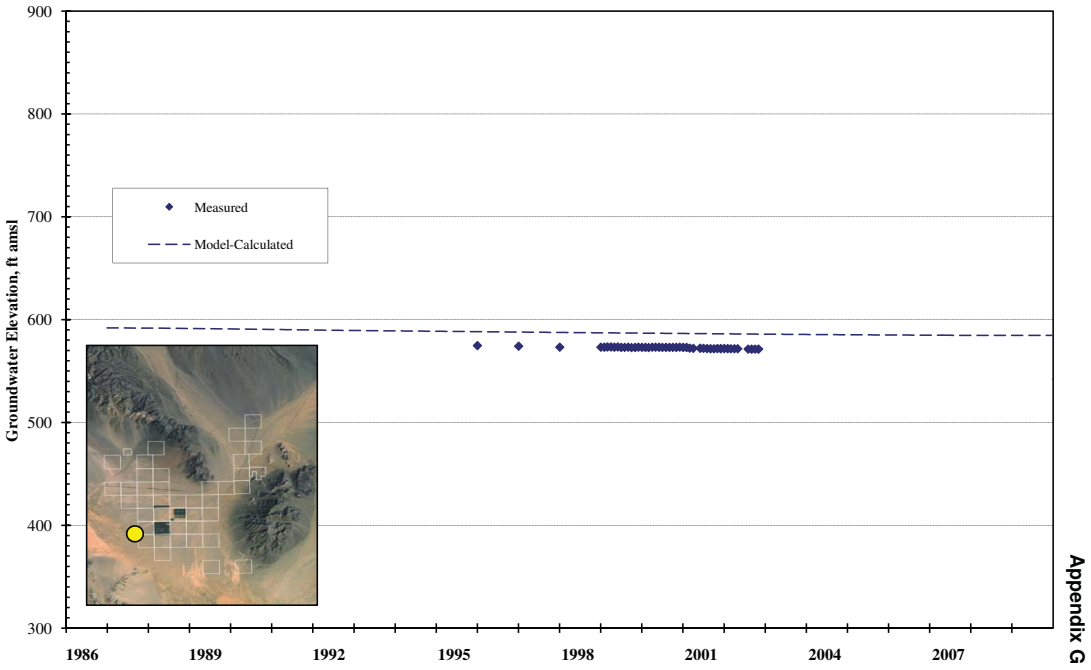
Appendix G

Hydrograph for Well 5N/14E-13
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



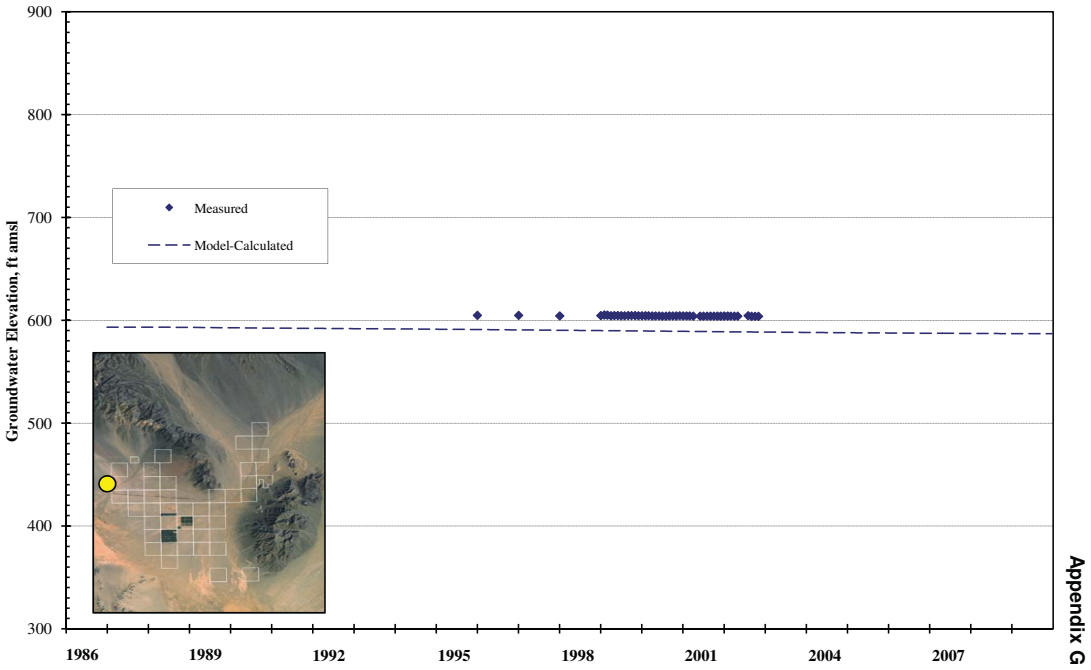
Appendix G

Hydrograph for Well SCE 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



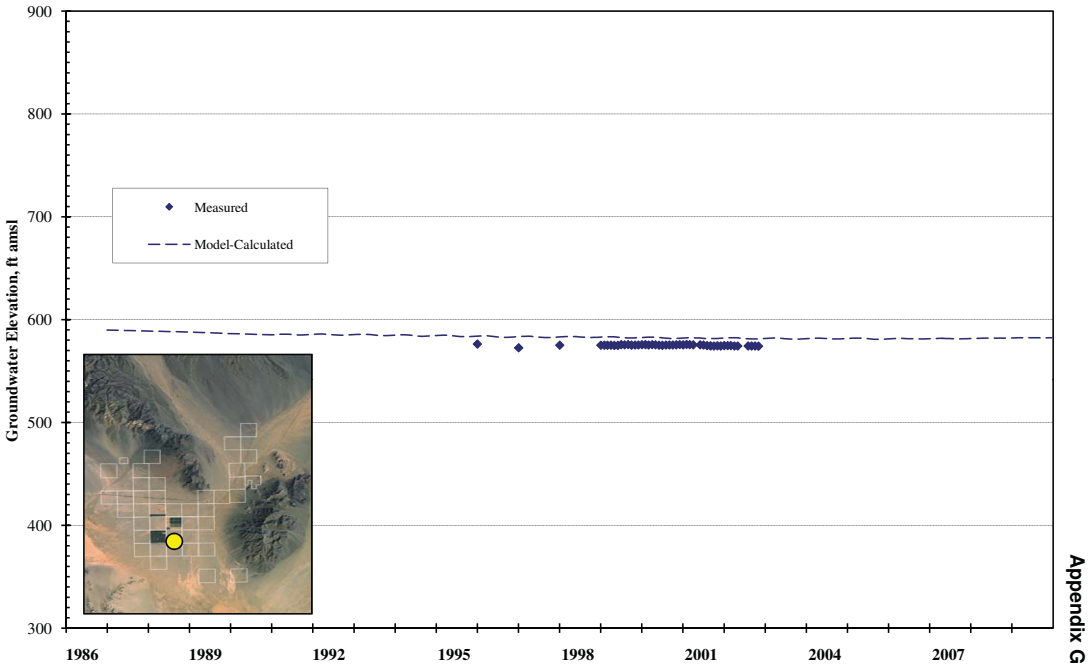
Appendix G

Hydrograph for Well SCE 9
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



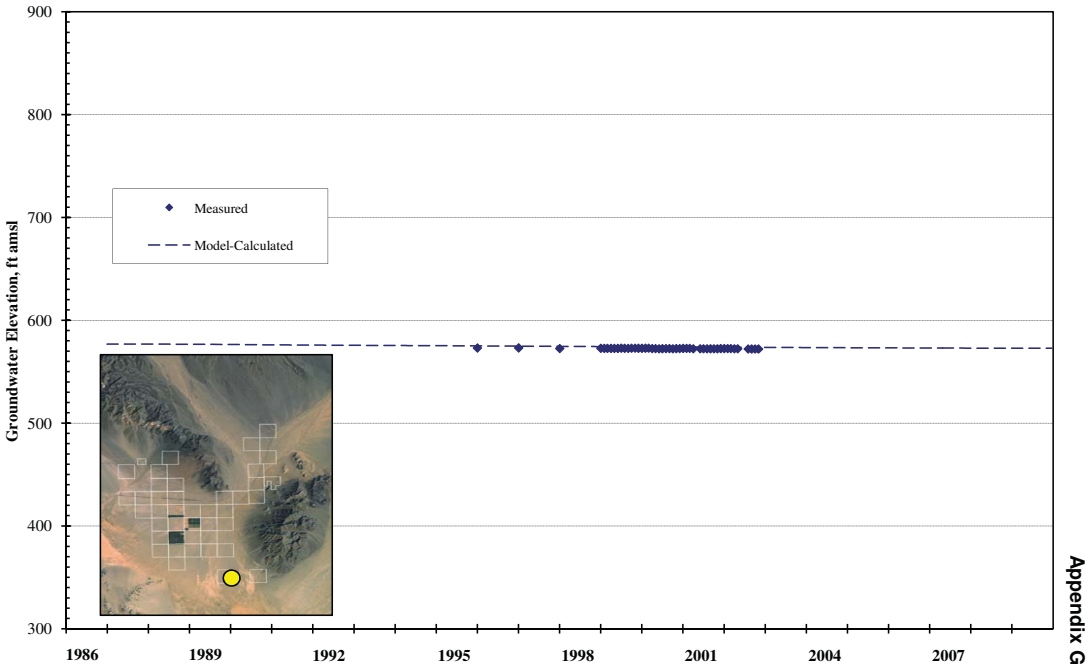
Appendix G

Hydrograph for Well SCE 10
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



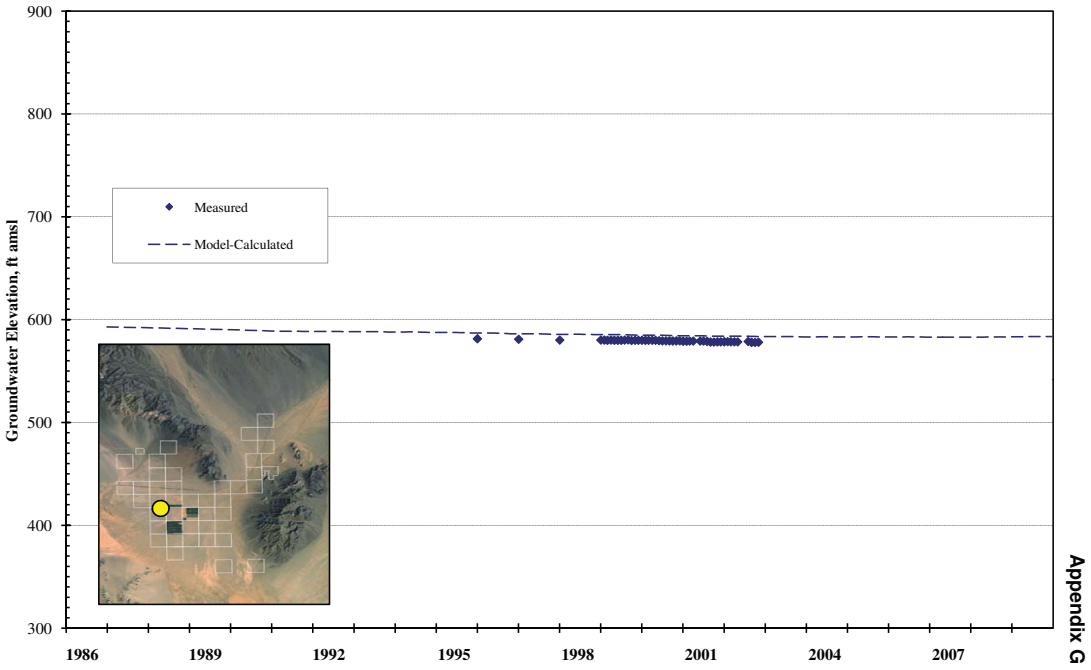
Appendix G

Hydrograph for Well SCE 11
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



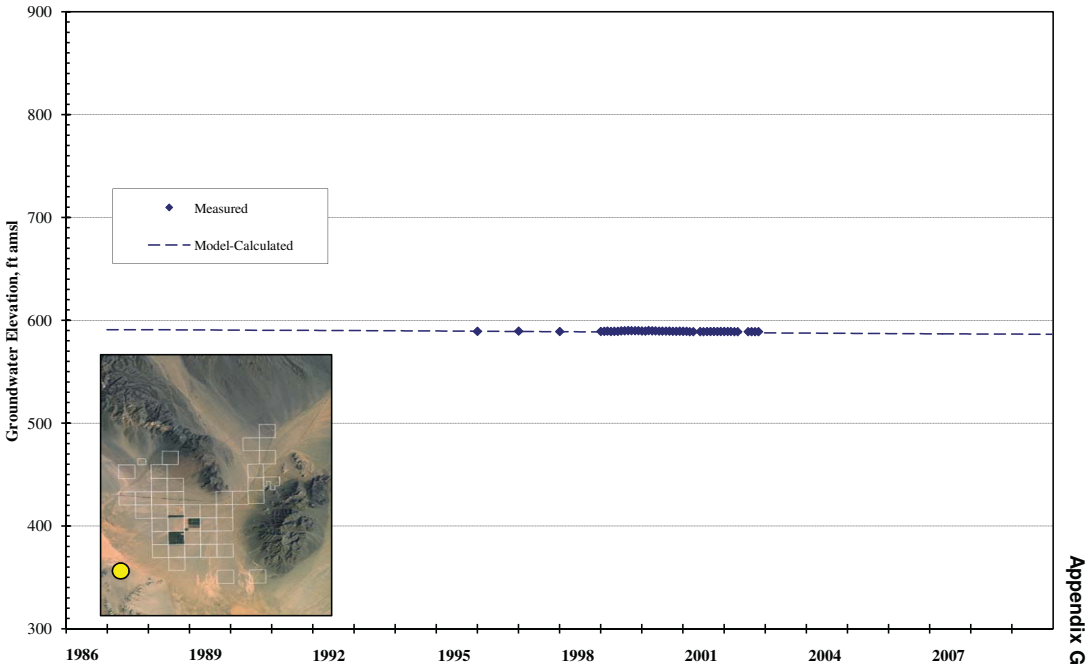
Appendix G

Hydrograph for Well SCE 17
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



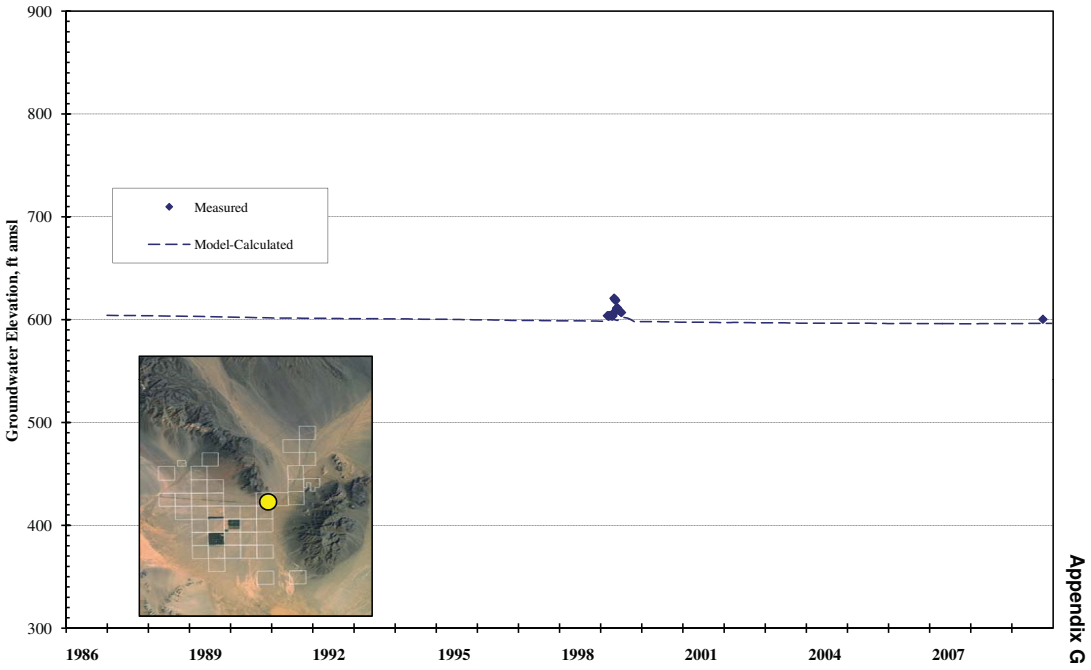
Appendix G

Hydrograph for Well SCE 18
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



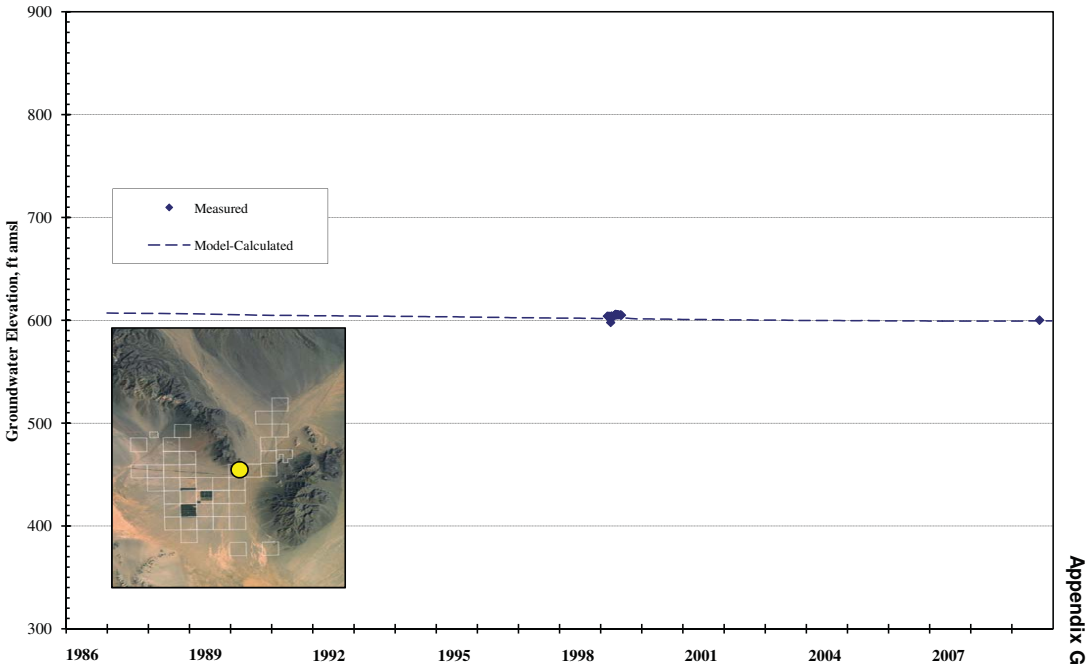
Appendix G

Hydrograph for Well CI 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



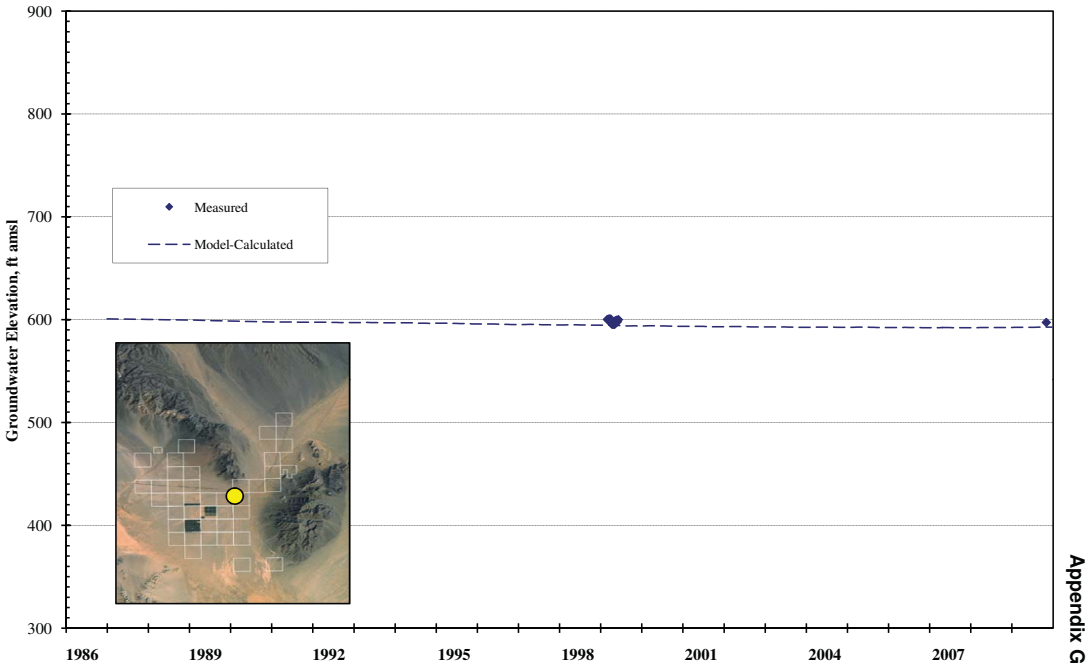
Appendix G

Hydrograph for Well CI 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



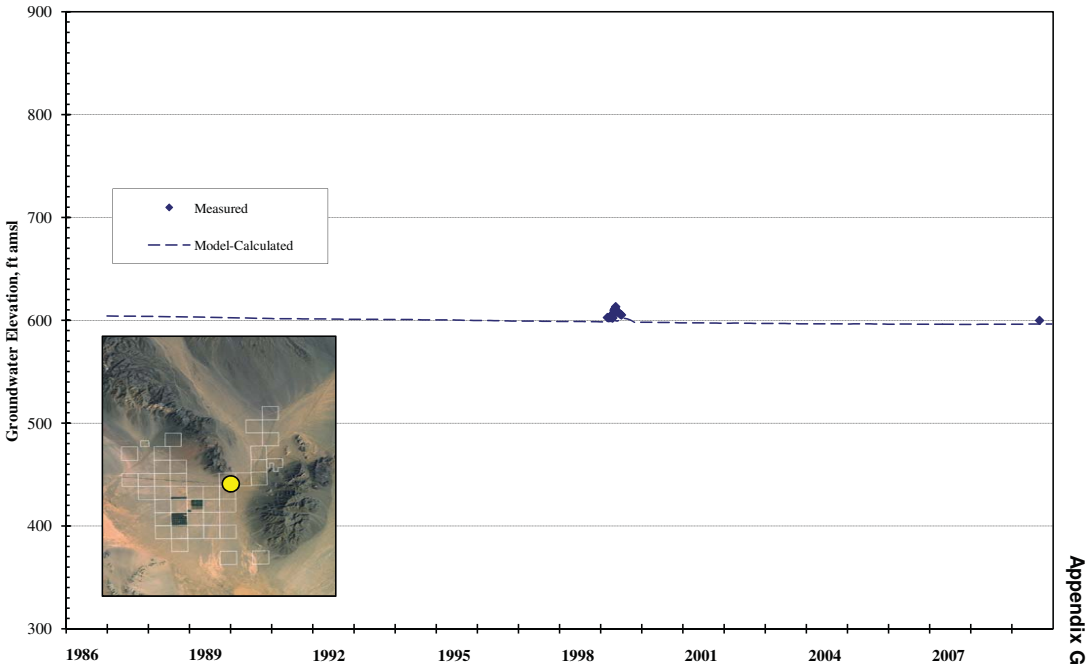
Appendix G

Hydrograph for Well CI 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



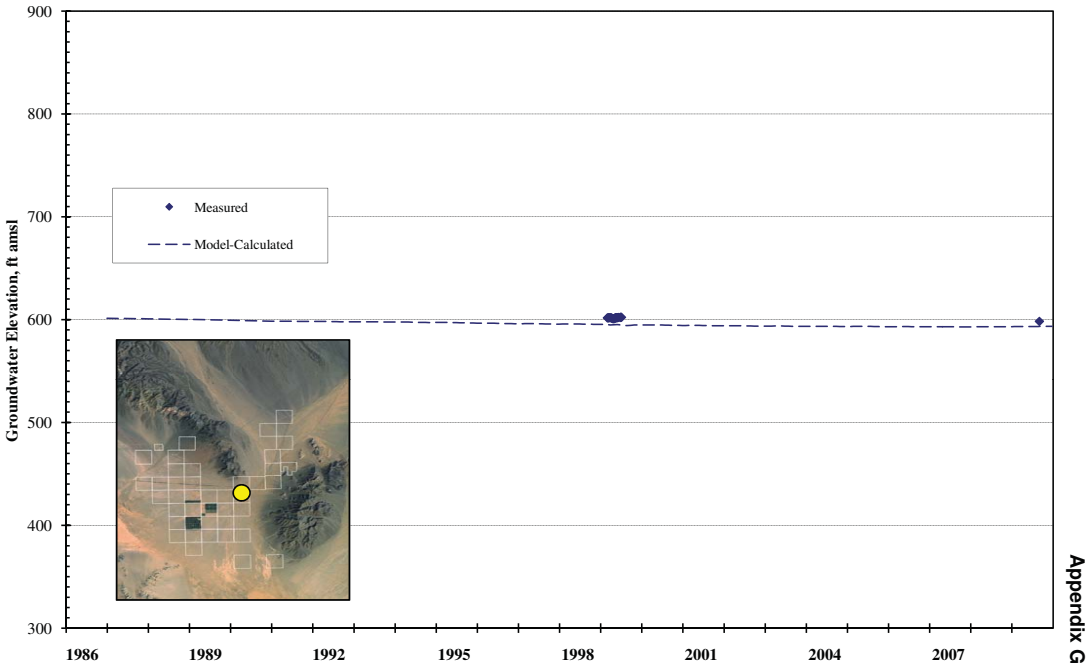
Appendix G

Hydrograph for Well MW 1
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



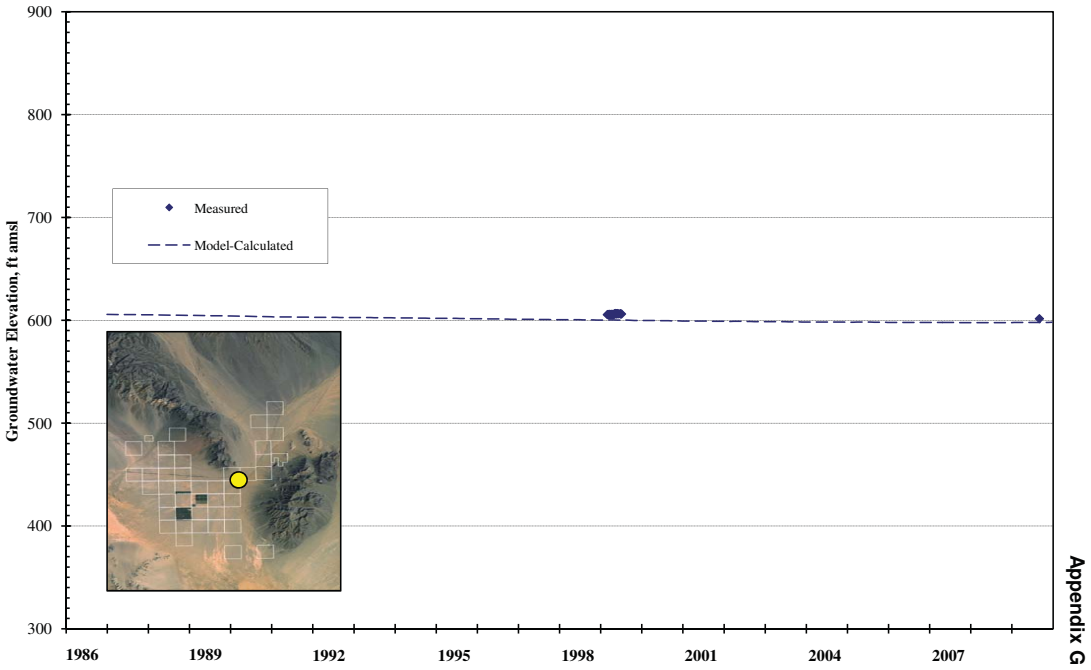
Appendix G

Hydrograph for Well MW 2
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



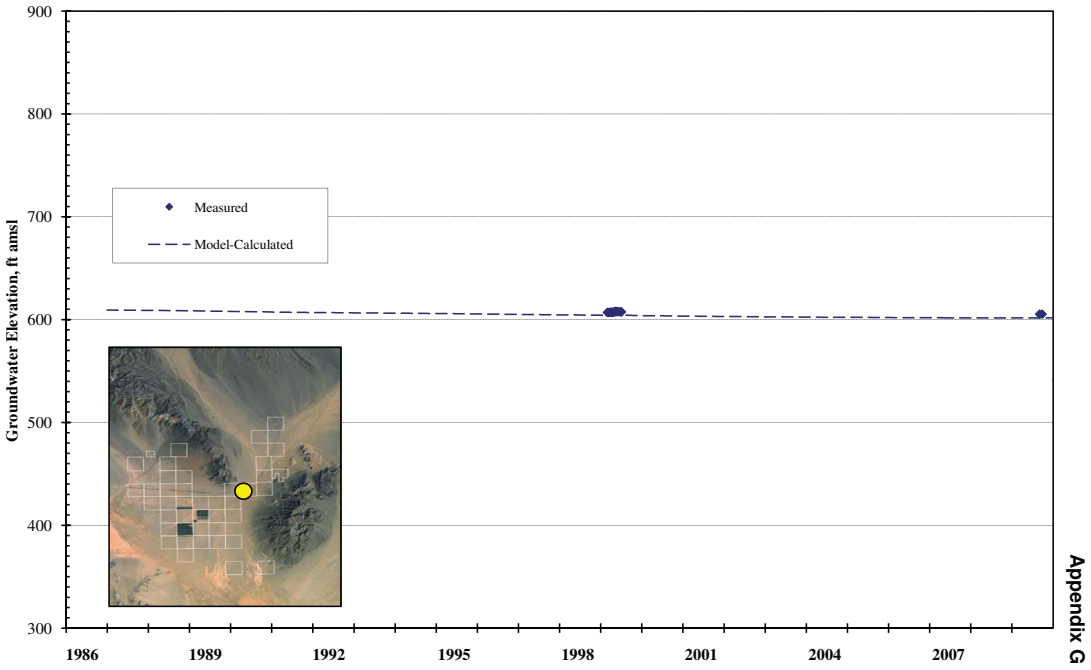
Appendix G

Hydrograph for Well MW 3
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



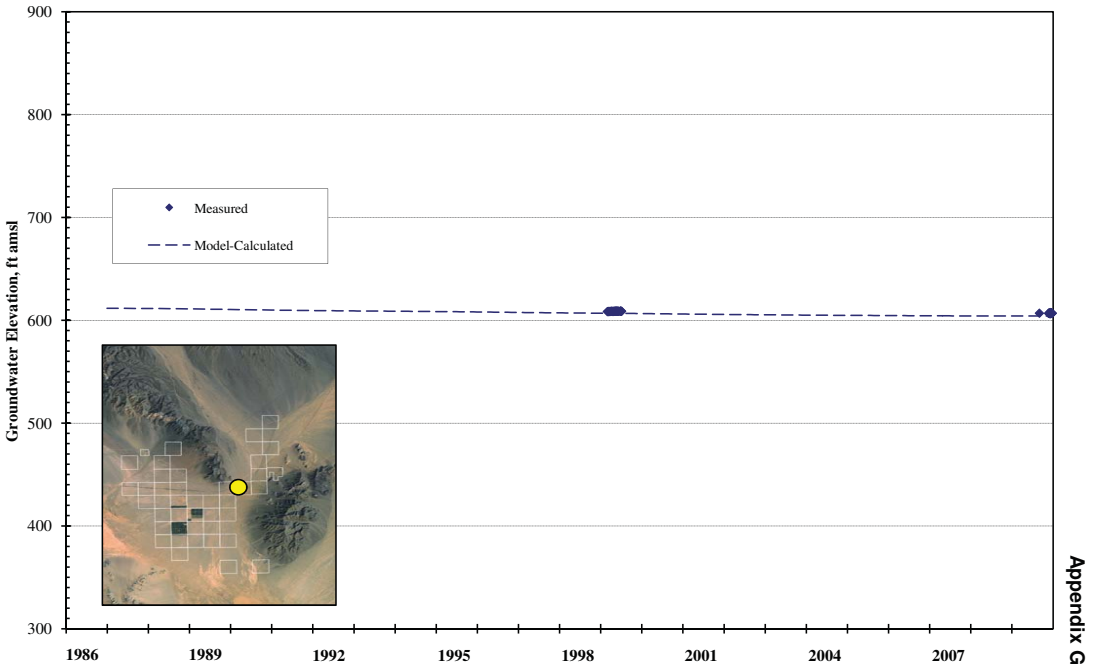
Appendix G

Hydrograph for Well MW 5
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



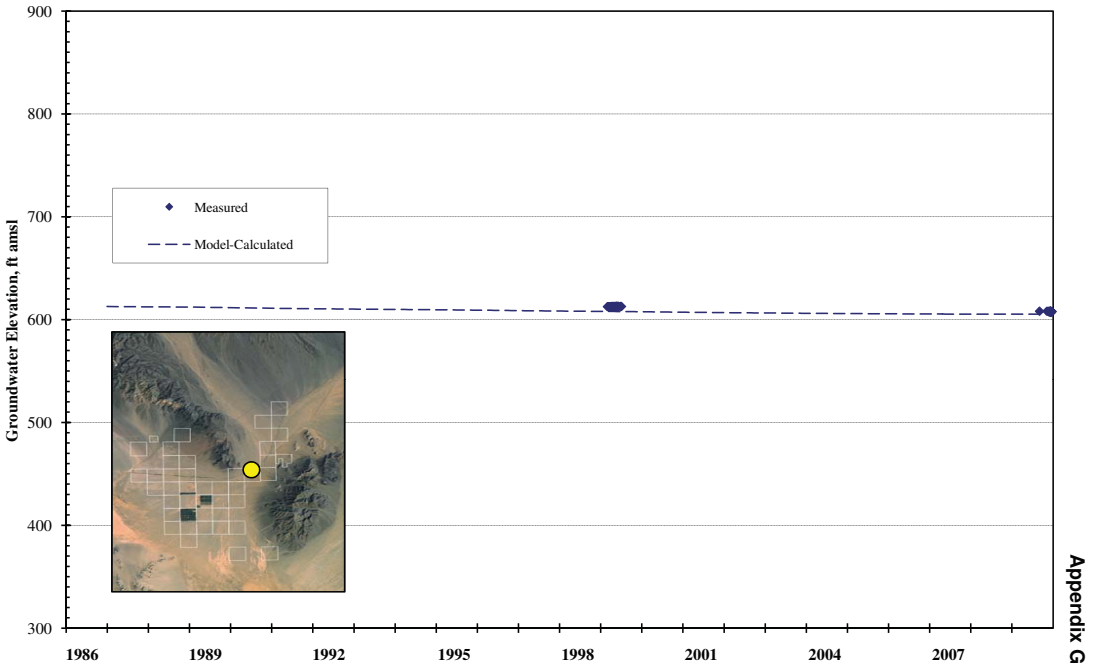
Appendix G

Hydrograph for Well MW 6
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



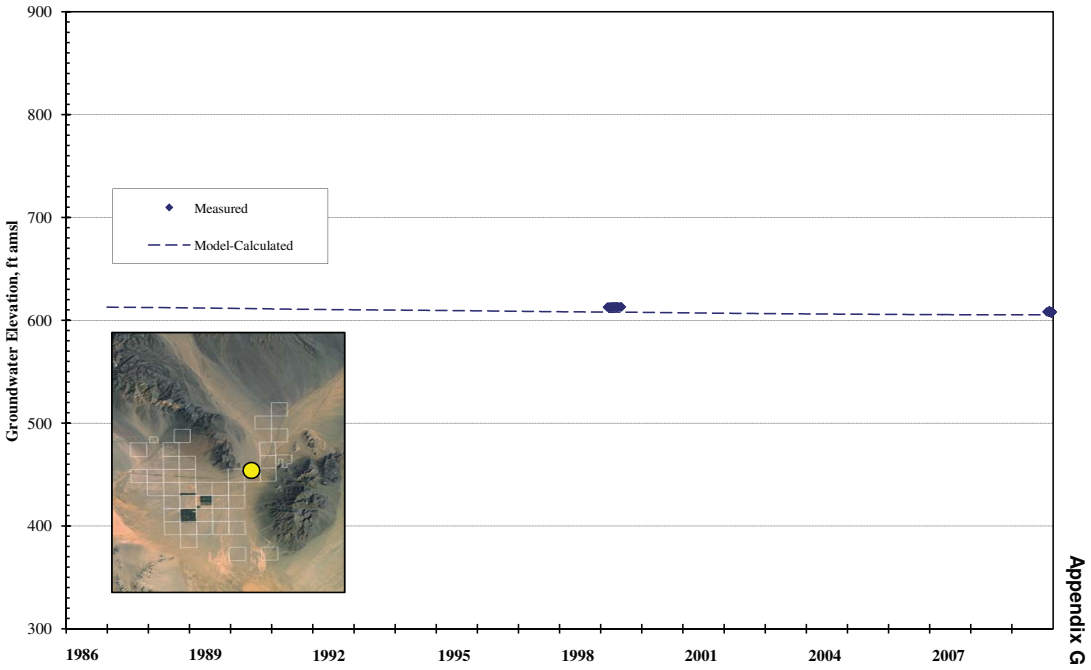
Appendix G

Hydrograph for Well MW 7
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



Appendix G

Hydrograph for Well MW 7A
Transient Model Calibration 1986 - 2009 (Natural Recharge = 5,000 acre-ft/yr)



Appendix G